

CHAPTER 3

FACILITY REQUIREMENTS

Proper airport planning requires the translation of forecasted aviation demand into the specific types and quantities of facilities that can adequately serve the identified demand. This chapter analyzes the existing capacities of facilities at Glendale Regional Airport (GEU). The existing capacities will then be compared to the forecasted activity levels prepared in Chapter Two to determine the adequacy of existing facilities and identify whether deficiencies currently exist or may be expected to materialize in the future. This chapter presents the following elements:

- Planning horizon activity levels
- Airfield capacity
- Airport physical planning criteria
- Airside and landside facility requirements

The objective of this effort is to identify the adequacy of existing airport facilities, outline what new facilities may be needed, and determine when these may be needed to accommodate forecasted demands. Once these facility requirements are established, alternatives for providing the facilities will be evaluated to determine the most practical, cost-effective, and efficient means for implementation.

The facility requirements for GEU were evaluated using guidance contained in several Federal Aviation Administration (FAA) publications, including the following:

- Advisory Circular (AC) 150/5300-13B, *Airport Design*, Change 1
- AC 150/5060-5, *Airport Capacity and Delay*
- AC 150/5325-4B, *Runway Length Requirements for Airport Design*
- Federal Aviation Regulation (FAR) Part 77, *Objects Affecting Navigable Airspace*

DEMAND-BASED PLANNING HORIZONS

An updated set of aviation demand forecasts for GEU was developed and presented in Chapter Two. These forecasts encompass annual aircraft operations, based aircraft, fleet mix, and peak activity characteristics. Using these projections, the capacity and adequacy of the airfield and landside systems can be assessed to determine their ability to accommodate anticipated future aviation demand.

Cost-effective, efficient, and orderly airport development should be guided primarily by actual and projected aviation demand rather than by fixed, time-based milestones. Accordingly, this master plan is structured around demand-driven planning horizons that reflect the anticipated range of the aviation demand forecasts. These planning horizons consist of the short-term (years 1–5), intermediate-term (years 6–10), and long-term (years 11–20) periods, providing a flexible framework for implementing improvements as demand warrants.

It is important to consider that actual airport activity may vary from the annualized forecasts due to changes in aviation demand, economic conditions, or other unforeseen factors. By establishing planning horizons based on activity milestones rather than fixed timelines, the master plan provides the flexibility to respond to fluctuations in demand and implement improvements when they are operationally justified. This demand-driven approach allows development schedules to be accelerated or deferred as conditions warrant through the planning period. As a result, the master plan provides airport officials with a fiscally responsible, adaptable, and needs-based framework for future development. **Table 3A** presents the short-, intermediate-, and long-term planning horizon milestones for each aircraft activity level forecasted in Chapter Two.

TABLE 3A: Aviation Demand Planning Horizons

	Base Year (2025)	Short Term (1–5 Years)	Intermediate Term (6–10 Years)	Long Term (11–20 Years)
BASED AIRCRAFT				
Single-Engine	300	319	333	374
Multi-Engine	34	32	30	18
Turboprop	7	13	19	40
Jet	4	5	9	20
Helicopter	7	12	15	23
Other	3	4	6	10
TOTAL BASED AIRCRAFT:	**355**	**385**	**415**	**485**

(Table continues)

TABLE 3A (continued): Aviation Demand Planning Horizons

	Base Year (2025)	Short Term (1–5 Years)	Intermediate Term (6–10 Years)	Long Term (11–20 Years)
ANNUAL OPERATIONS				
Itinerant				
Air Carrier	0	0	0	0
Air Taxi	631	660	740	910
General Aviation	57,175	74,000	89,300	121,600
Military	1	1	1	1
Total Itinerant Operations:	**57,807**	**74,661**	**90,041**	**122,511**
Local				
General Aviation	71,513	77,700	81,800	90,500
Military	0	2	2	2
Total Local Operations:	**71,513**	**77,702**	**81,802**	**90,502**
TOTAL OPERATIONS:	**129,320**	**152,363**	**171,843**	**213,013**

Source: Coffman Associates analysis

AIRFIELD CAPACITY

An airport's airfield capacity is expressed in terms of its annual service volume (ASV). ASV is a reasonable estimate of the maximum level of aircraft operations that can be accommodated in a year without incurring significant delay factors. As aircraft operations near or surpass the ASV, delay factors increase exponentially. The airport's ASV was examined utilizing FAA AC 150/5060-5, *Airport Capacity and Delay*.

FACTORS AFFECTING ANNUAL SERVICE VOLUME

This analysis takes into account specific factors about the airfield in order to calculate the airport's ASV. These factors are depicted on **Exhibit 3A**. The following describes the input factors as they relate to GEU, including airfield layout, weather conditions, aircraft mix, and operations.

Runway Configuration

The existing airfield configuration consists of a single runway. Runway 2-20 is 7,150 feet long and 100 feet wide. Each runway end is equipped with instrument approach capabilities with visibility minimums down to 1-mile.

Runway Use

Runway use in capacity conditions is controlled by wind and/or airspace conditions. For GEU, the direction of takeoffs and landings is typically determined by the speed and direction of the wind or as directed by the airport traffic controller. It is generally safest for aircraft to take off and land into the wind, avoiding crosswind (wind blowing perpendicular to the travel of the aircraft) or tailwind components during these operations. Runway usage data sourced from the airport's automated weather observing system (AWOS) are summarized in **Table 3B**.

AIRFIELD LAYOUT

Runway Configuration



Runway Use



Number of Exits

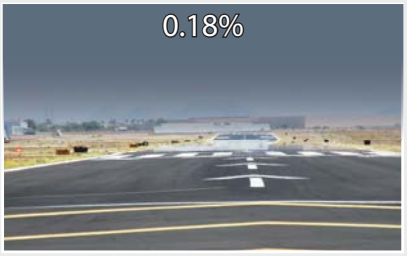


WEATHER CONDITIONS

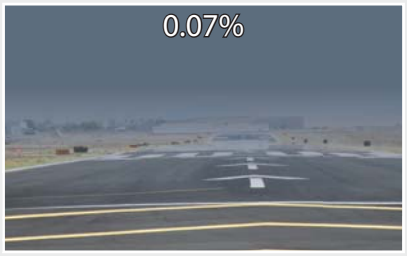
VMC (VFR)
Visual Meteorological Conditions



IMC (IFR)
Instrument Meteorological Conditions



PVC
Poor Visibility Conditions



AIRCRAFT MIX

Category A & B Aircraft (0-12,500 lbs)



Category C Aircraft (12,500-300,000 lbs)



Category D Aircraft (>300,000 lbs)



OPERATIONS

Arrivals



Departures



Touch-and-Go Operations



Total Annual Operations

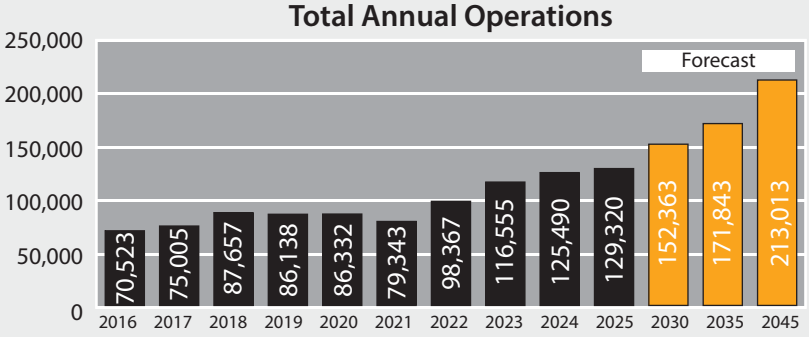


TABLE 3B: Runway Usage Data

	Runway		Calm Wind Runway
	1	19	
Operations Percentage	18.9%	39.3%	41.8%

Source: GEU, NOAA Station ID USW00053126

Exit Taxiways

Exit taxiways have a significant impact on airfield capacity because the number and locations of exits directly determine the occupancy time of an aircraft on the runway. The airfield capacity analysis gives credit to taxiway exits located within the prescribed range from a runway's threshold. This range is based on the mix index of the aircraft that use the runways. Based on mix, only exit taxiways between 2,000 feet and 4,000 feet from the landing threshold count in the exit rating at GEU. The exits must be at least 750 feet apart to count as separate exit taxiways. Utilizing these criteria, Runway 1 is credited with three exit taxiways and Runway 19 is credited with four exit taxiways.

Weather Conditions

Weather conditions can have a significant impact on airfield capacity. Airport capacity is usually highest in clear weather when flight visibility is best. Airfield capacity diminishes as weather conditions deteriorate and cloud ceilings and visibility are reduced. As weather conditions deteriorate, the spacing of aircraft must increase to provide allowable margins of safety and air traffic vectoring. The increased distance between aircraft reduces the number of aircraft that can operate at the airport during any given period, thus reducing overall airfield capacity.

According to local meteorological data, the airport operates under visual meteorological conditions (VMC) approximately 99.75 percent of the time. VMC exist whenever the cloud ceiling is greater than 1,000 feet above ground level (AGL) and visibility is greater than three statute miles. Instrument meteorological conditions (IMC) are defined when cloud ceilings are between 500 and 1,000 feet AGL or visibility is between one and three miles. Poor visibility conditions (PVC) apply for cloud ceilings below 500 feet and visibility minimums below one mile. **Table 3C** summarizes the weather conditions experienced at the airport over a 10-year period of time.

TABLE 3C: Weather Conditions

Condition	Cloud Ceiling	Visibility	Percent of Total
VMC	≥ 1,000' AGL	> 3 statute miles	99.75%
IMC	≥ 500' AGL to < 1,000' AGL	1–3 statute miles	0.18%
PVC	< 500' AGL	< 1 statute mile	0.07%

Source: Glendale Regional Airport, AZ US Station: USW00053126, 2016–2025

AGL = above ground level
IMC = instrument meteorological conditions
PVC = poor visibility conditions
VMC = visual meteorological conditions

Aircraft Mix

The aircraft mix for the capacity analysis is defined in terms of four aircraft classifications. Classes A and B consist of small- and medium-sized propeller aircraft and some jet aircraft, all of which weigh 12,500 pounds or less. These aircraft are primarily associated with general aviation (GA) activity but include some air taxi, air cargo, and commuter aircraft. Class C consists of aircraft that weigh between 12,500 pounds and 300,000 pounds. These aircraft include most business jets and some turboprop aircraft that utilize the airport on a regular basis. Class D consists of aircraft that weigh more than 300,000 pounds.

Most operations at GEU are by aircraft in Classes A and B. According to the FAA's Traffic Flow Management System Counts (TFMSC) data and OPSNET data for 2025, there were approximately 1,027 total operations by Class C aircraft at GEU, which represents approximately 0.8 percent of all operations. The remaining operations are within Classes A and B, which represent 99.2 percent of total operations. No operations by aircraft in Class D were conducted during 2025. It is anticipated that operations by aircraft in Classes A and B will continue to comprise the largest share of operations through the planning period.

Percent Arrivals

The percentage of arrivals as they relate to total operations of the airport is important in determining airfield capacity. Under most circumstances, the lower the percentage of arrivals, the higher the hourly capacity will be. The aircraft arrival/departure percentage split at general aviation airports is typically 50/50, which is the case at GEU.

Touch-and-Go Activity

A touch-and-go operation involves an aircraft making a landing and then an immediate takeoff without coming to a full stop or exiting the runway. As previously discussed in Chapter Two, these operations are normally associated with general aviation training activity and are classified as local operations. A high percentage of touch-and-go traffic normally results in a higher operational capacity because one landing and takeoff occurs within a shorter period than individual operations. Touch-and-go operations at GEU accounted for approximately 55 percent of total annual operations in 2025.

Peak Period Operations

Average daily operations and average peak hour operations during the peak month are utilized for the airfield capacity analysis and are based on operational data collected from the airport traffic control tower (ATCT), which is operational from 6:00 a.m. to 8:30 p.m. Monday through Friday and 7:00 a.m. to 7:00 p.m. Saturday and Sunday. Operations activity is important in the calculation of an airport's ASV, as peak demand levels occur sporadically. The peak periods used in the capacity analysis are representative of normal operational activity and can be exceeded at various times throughout the year. The forecasts for this master plan identified current average daily operations at 465 operations and current peak hour operations at 118 operations. By the long term, average daily operations are projected to grow to 782 and peak hour operations are projected to increase to 198. (Note: For capacity planning purposes, a standard 15 percent has been applied to the design day to determine generalized peak hour estimates.) This results in annual operations to average daily demand ratios of 278 in 2025 and 273 by 2045. The ratio of average daily operations to peak hour operations is 6.7 through the planning period.

CALCULATION OF ANNUAL SERVICE VOLUME

The preceding information was used in conjunction with the airfield capacity methodology developed by the FAA to determine airfield capacity for GEU.

Hourly Runway Capacity

The first step in determining ASV involves the computation of the hourly capacity of the runway configuration. The percentage use of the runway, the amount of touch-and-go activity, and the number and locations of runway exits are the important factors in determining hourly capacity.

As the operational mix of aircraft at the airport changes to include a higher percentage of Class C aircraft that weigh over 12,500 pounds, the hourly capacity of the system slightly declines. This is a result of the additional spacing and time required by larger aircraft in the traffic pattern and on the runway.

The current and future weighted hourly capacities are presented in **Table 3D**. Weighted hourly capacity is the measure of the maximum number of aircraft operations that can be accommodated on the airfield in a typical hour. It is a composite of estimated hourly capacities for different airfield operating configurations adjusted to reflect the percentage of time in an average year that the airfield operates under each specific configuration. The current weighted hourly capacity on the airfield is 134 operations; the capacity is expected to decline slightly to 132 operations by the long-term horizon.

TABLE 3D: Airfield Capacity Summary

	Base Year (2025)	Short Term (1–5 Years)	Intermediate Term (6–10 Years)	Long Term (11–20 Years)
Operational Demand				
Annual	129,320	152,363	171,843	213,013
Capacity				
Annual Service Volume	249,000	244,000	242,000	239,000
Percent Capacity	51.9%	62.4%	71.0%	89.1%
Weighted Hourly Capacity	134	134	133	132

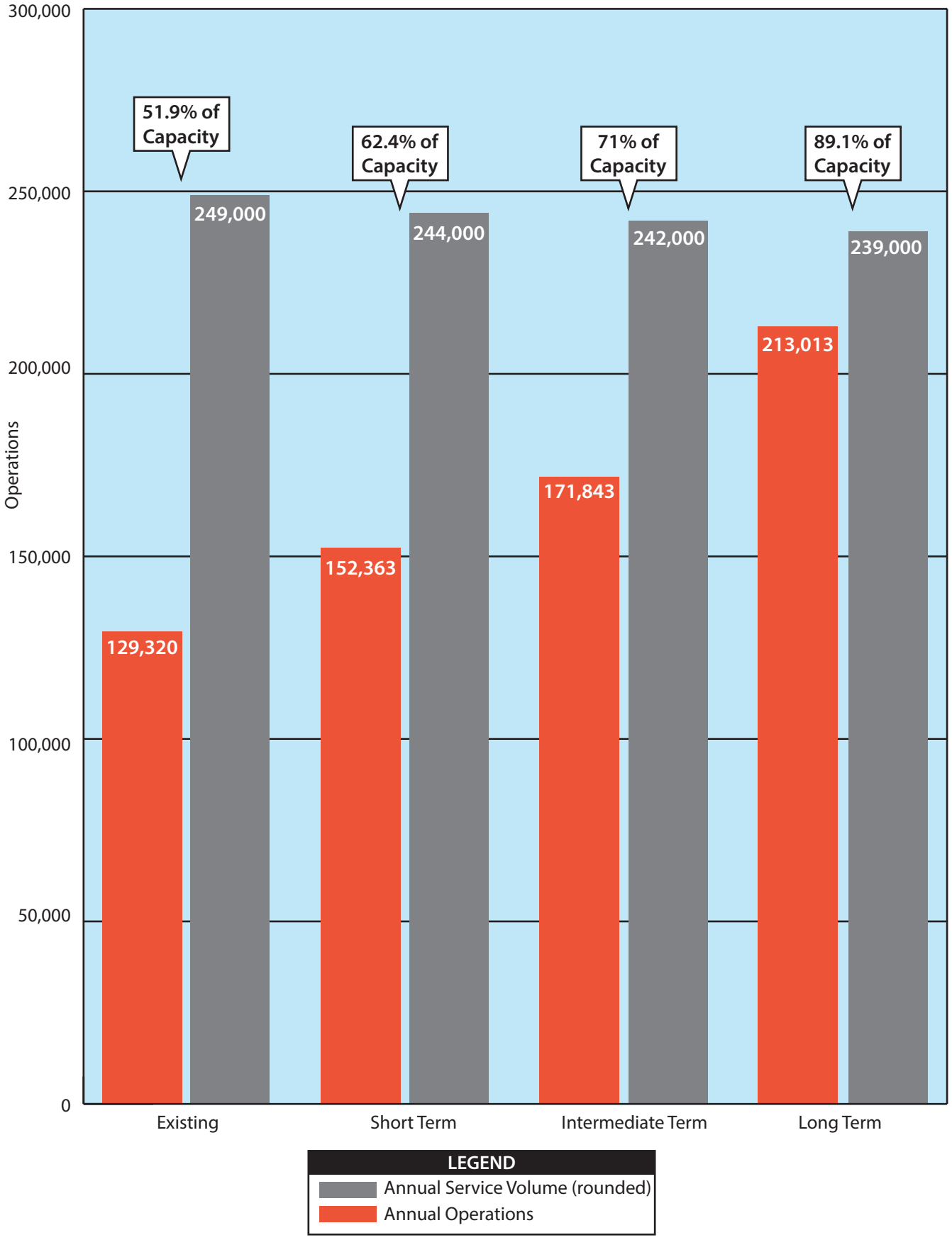
Sources: FAA AC 150/5060-5, Airport Capacity and Delay; Coffman Associates analysis

Annual Service Volume

The ASV is determined by the following equation:

Annual Service Volume = C x D x H
C = weighted hourly capacity
D = ratio of annual demand to the average daily demand during the peak month
H = ratio of average daily demand to the design hour demand during the peak month

The current ASV for the airfield has been estimated at 249,000 operations, dropping to approximately 239,000 operations by the end of the planning period. With 129,320 operations recorded in 2025, the airport is currently at 51.9 percent of its ASV. By the long-term horizon, annual operations are forecasted to reach 213,013, which accounts for 89.1 percent of the ASV. **Table 3D** and **Exhibit 3B** summarize and compare the airport's ASV and projected annual operations over the short-, intermediate-, and long-term planning horizons.


300,000
250,000
200,000
150,000
100,000
50,000
0
Operations
51.9% of Capacity
62.4% of Capacity
71% of Capacity
89.1% of Capacity
249,000
244,000
242,000
239,000
213,013
171,843
152,363
129,320
Existing
Short Term
Intermediate Term
Long Term
LEGEND
Annual Service Volume (rounded)
Annual Operations

AIRCRAFT DELAY

The effect the anticipated ratio of demand to capacity will have on users of GEU can be measured in terms of delay. As the number of annual aircraft operations approaches the airfield's capacity, increasing operational delays begin to occur. Delays to arriving and departing aircraft occur in all weather conditions. Arriving aircraft delays result in aircraft holding outside the airport traffic pattern area. Departing aircraft delays result in aircraft holding at the runway end until they can safely take off.

Aircraft delay can vary depending on different operational activities at an airport. At airports where large air carrier aircraft dominate, delay can be greater due to the amount of time these aircraft require in the traffic pattern and on approach to land. For airports that accommodate primarily general aviation aircraft, such as GEU, experienced delay is typically lower because these aircraft are more maneuverable and require less time in the airport traffic pattern.

Table 3E summarizes the potential aircraft delay for GEU. Estimates of delay provide insight into the impacts steady increases in aircraft operations have on the airfield and signify the airport's ability to accommodate projected annual aircraft operations. The delay per operation represents an average delay per aircraft. It should be noted that delays of five to 10 times the average could be experienced by individual aircraft during peak periods. As an airport's percent capacity increases toward the ASV, delay exponentially increases. Furthermore, complexities in the airspace system that surrounds an airport can also factor into additional delay experienced at the facility.

TABLE 3E: Airfield Delay Summary

	Base Year (2025)	Short Term (1–5 Years)	Intermediate Term (6–10 Years)	Long Term (11–20 Years)
Percent Capacity	51.9%	62.4%	71.0%	89.1%
Delay				
Per Operation (Seconds)	24	36	42	54
Total Annual (Hours)	862	1,524	2,005	3,195

Sources: FAA AC 150/5060-5, Airport Capacity and Delay; Coffman Associates analysis

Current annual delay is estimated at 24 seconds per aircraft operation, or 862 total annual hours. Analysis of delay factors for the long-term planning horizon indicates that annual delays can be expected to reach 54 seconds per aircraft operation, or 3,195 annual hours.

CAPACITY ANALYSIS CONCLUSION

FAA Order 5090.3C, *Field Formulation of the National Plan of Integrated Airport Systems (NPIAS)*, indicates that improvements for airfield capacity purposes should be considered when operations reach 60 to 75 percent of the ASV. This is an approximate level to begin the detailed planning of capacity improvements. When 80 percent of the ASV is reached, capacity improvement projects should become higher-priority capital improvements. According to this analysis, operations levels at GEU currently exceed the 50 percent threshold and are expected to reach 89.1 percent by the long-term planning horizon. Based on the previously mentioned 80 percent threshold, capacity enhancements at GEU should be considered within the short and intermediate terms of the planning period. A variety of projects can be pursued to increase capacity, such as construction of a parallel runway, a second parallel taxiway, or additional exits, among others, which will be considered in the next chapter.

AIRSIDE FACILITY REQUIREMENTS

Airside facilities include those facilities related to the arrival, departure, and ground movement of aircraft. Airside facility requirements are based primarily on the runway design code (RDC) for each runway. Analysis in Chapter Two identified the existing RDC for Runway 2-20 as B-II-5000 and the future/ultimate RDC as C-II-5000.

RUNWAY ORIENTATION

According to FAA Order 5100.38D, *Airport Improvement Handbook*, only one runway at any NPIAS airport is eligible for ongoing maintenance and rehabilitation funding unless the FAA Airports District Office (ADO) has made a specific determination that a crosswind or secondary runway is justified. A runway that is not a primary runway, crosswind runway, or secondary runway is an "additional" runway, which is not eligible for FAA funding. It is not unusual for a two-runway airport to have a primary runway and an additional runway, and no crosswind or secondary runway. **Table 3F** presents the eligibility requirements for runway types.

TABLE 3F: Runway Eligibility

The following runway type…	Must meet all of the following criteria…	And is…
Primary Runway	1. A single runway at an airport is eligible for development consistent with FAA design and engineering standards.	Eligible
Crosswind Runway	1. The wind coverage on the primary runway is less than 95%.	Eligible if justified
Secondary Runway	1. There is more than one runway at the airport. 2. The non-primary runway is not a crosswind runway. 3. Either of the following: a. The primary runway is operating at 60% or more of its annual capacity. b. The FAA has made a specific determination that the runway is required.	Eligible if justified
Additional Runway	1. There is more than one runway at the airport. 2. The non-primary runway is not a crosswind runway. 3. The non-primary runway is not a secondary runway.	Ineligible

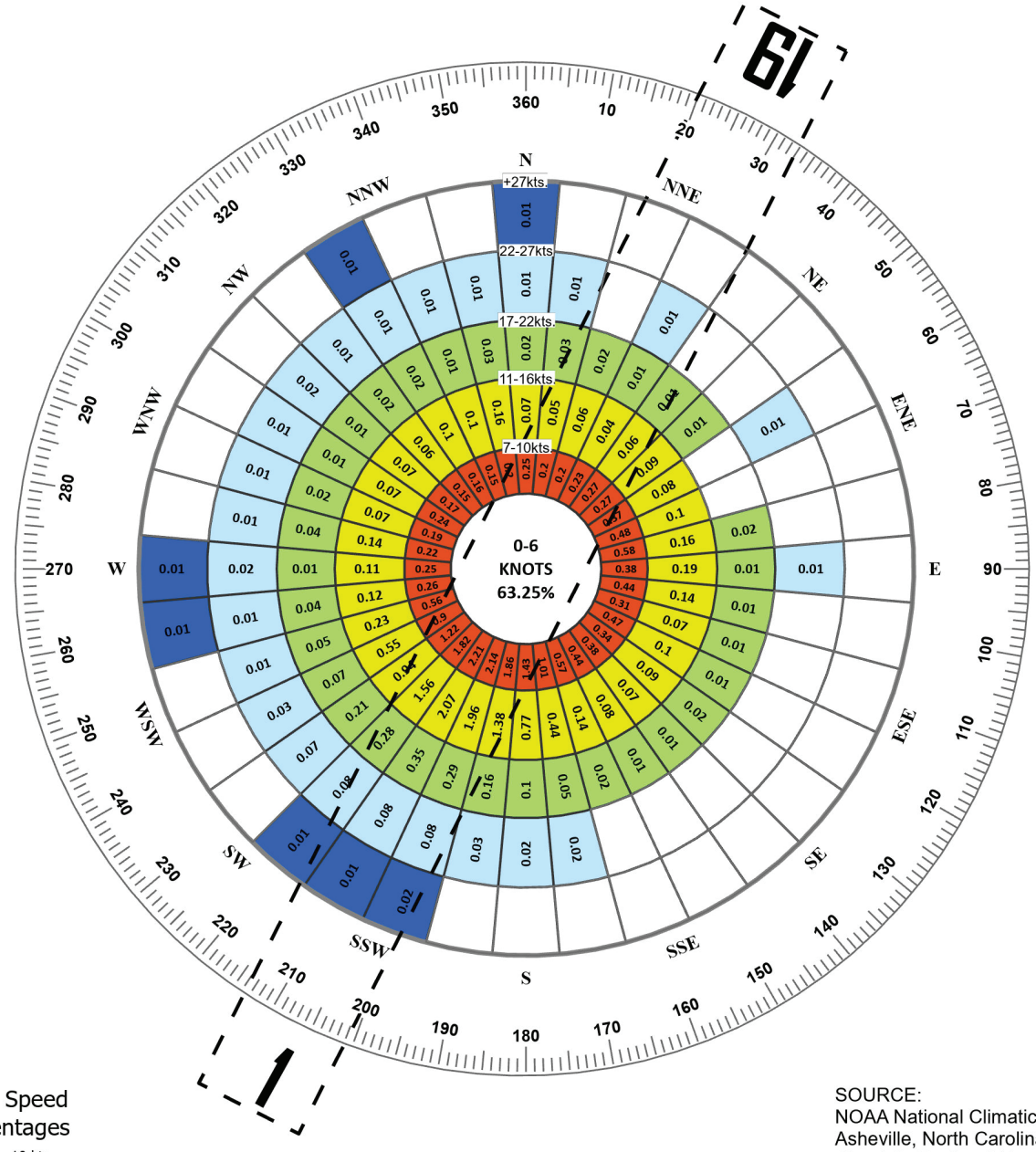
Source: FAA Order 5100.38D, AIP Handbook

FAA AC 150/5300-13B, *Airport Design*, Change 1 recommends that a crosswind runway should be made available when the primary runway orientation provides less than 95 percent wind coverage for any aircraft forecasted to use the airport on a regular basis. The 95 percent wind coverage is computed on the basis of the crosswind component not exceeding 10.5 knots (12 miles per hour [mph]) for airport reference code (ARC) A-I and B-I; 13 knots (15 mph) for ARC A-II and B-II; 16 knots (18mph) for ARC A-III, B-III, and C-I through D-II; and 20 knots (23 mph) for ARC C-III through D-IV.

As shown on **Exhibit 3C**, wind data obtained from the on-site AWOS show the orientation of Runway 2-20 provides 97.7 percent or greater coverage for all applicable crosswind components; thus, the current orientation of the runway at GEU provides adequate wind coverage for all-weather conditions and a crosswind runway is not warranted.

For GEU to qualify for the construction and maintenance of a parallel runway, the airfield must operate at 60 percent or greater of its ASV. As previously stated, GEU is projected to exceed 60 percent of its ASV,

ALL WEATHER WIND COVERAGE				
Runways	10.5 Knots	13 Knots	16 Knots	20 Knots
Runway 01-19	97.70%	98.77%	99.59%	99.82%

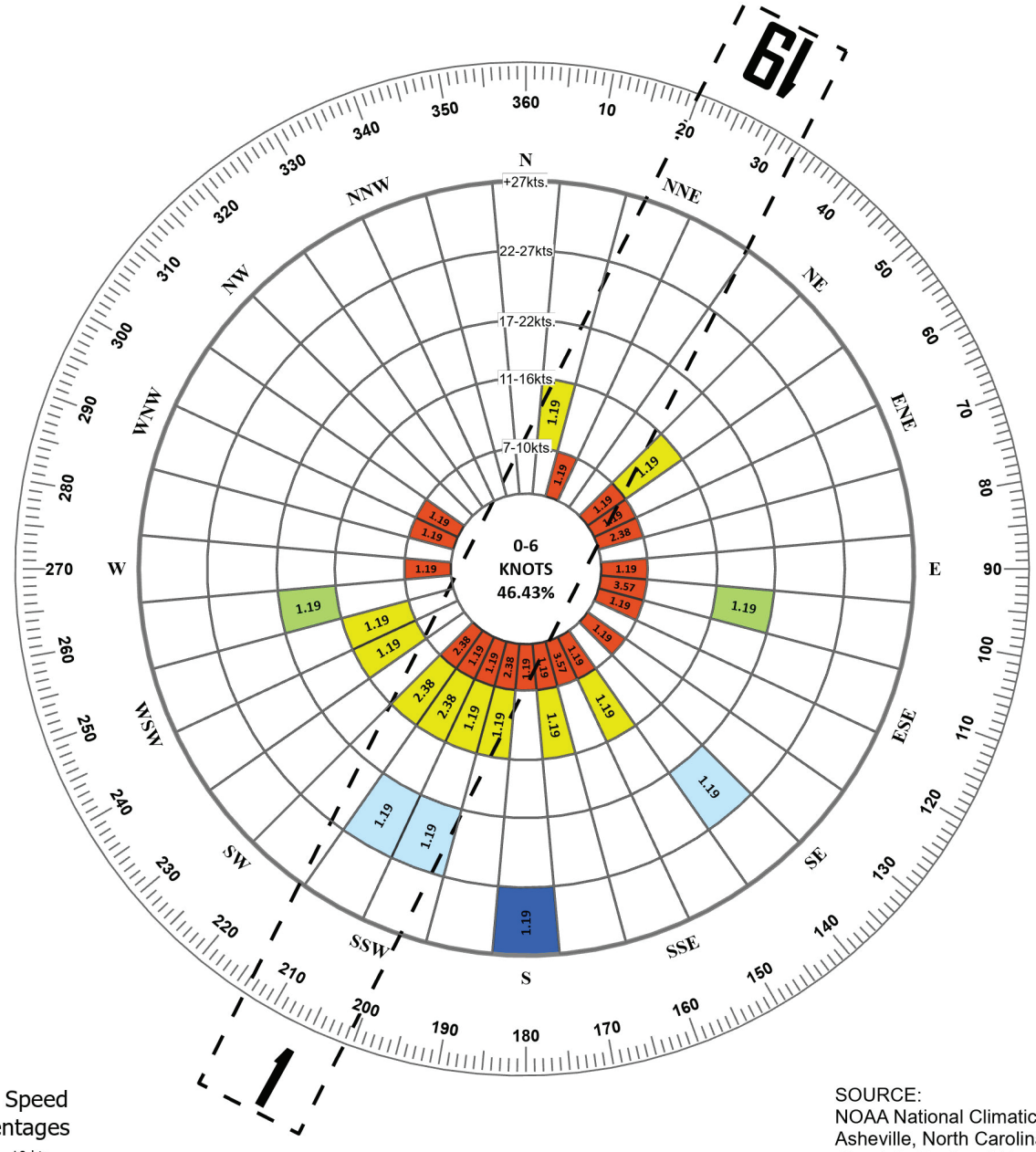


Wind Speed Percentages
- 7 - 10 kts.
- 11 - 16 kts.
- 17 - 22 kts.
- 23 - 27 kts.
- + 27 kts.

SOURCE:
NOAA National Climatic Center
Asheville, North Carolina
Glendale Regional Airport
Glendale, Arizona

OBSERVATIONS:
30,700 All Weather Observations
Jan. 1, 2016 - Dec, 31 2025

IFR WIND COVERAGE				
Runways	10.5 Knots	13 Knots	16 Knots	20 Knots
Runway 01-19	90.92%	92.66%	94.82%	97.47%



Wind Speed Percentages
- 7 - 10 kts.
- 11 - 16 kts.
- 17 - 22 kts.
- 23 - 27 kts.
- + 27 kts.

SOURCE:
NOAA National Climatic Center
Asheville, North Carolina
Glendale Regional Airport
Glendale, Arizona

OBSERVATIONS:
86 IFR Weather Observations
Jan. 1, 2016 - Dec, 31 2025

potentially within the next five years (short-term). Capacity-enhancing projects, including the addition of a parallel runway, will be considered in the next chapter; however, additional analysis and justification would be necessary to justify the construction of a secondary (parallel) runway.

RUNWAY DESIGNATIONS

A runway's designation is based on its magnetic headings, which are determined by the magnetic declination for the area. The magnetic declination near GEU is 9° 46' E ± 0° 5' W per year. The runway at GEU has a true heading of 26°/206°. Adjusting for magnetic declination, the current magnetic heading of the runway is 16°/196°, which would result in a designation of 2-20. The process to redesignate the runway at GEU to 2-20 has already begun, as indicated in Chapter One. During a recent pavement rehabilitation project, the runway was re-marked from 2-20 to 2-20, and FAA publications are expected to reflect this change in the coming months.

RUNWAY LENGTH

There are three methodologies for determining runway length requirements, which are based on the maximum takeoff weight (MTOW) of the critical aircraft or the airplane group for each runway. The airplane group consists of multiple aircraft with similar design characteristics. The three weight classifications are those airplanes with an MTOW of 12,500 pounds or less, those that weigh between 12,500 and 60,000 pounds, and those that weigh 60,000 pounds or more. **Table 3G** shows these classifications and the appropriate methodologies to use in runway length determination.

TABLE 3G: Airplane Weight Classification for Runway Length Requirements

Airplane Weight Category (MTOW)	Design Approach	Methodology
12,500 pounds or less and approach speeds of less than 30 knots	Family grouping of small airplanes	Chapter 2: para. 203
12,500 pounds or less and approach speeds of at least 30 knots but less than 50 knots	Family grouping of small airplanes	Chapter 2: para. 204
12,500 pounds or less and approach speeds of 50 knots or more with fewer than 10 passenger seats	Family grouping of small airplanes	Chapter 2: para. 205, Figure 2-1
12,500 pounds or less and approach speeds of 50 knots or more with 10 or more passenger seats	Family grouping of small airplanes	Chapter 2: para. 205, Figure 2-2
Over 12,500 pounds but less than 60,000 pounds	Family grouping of large airplanes	Chapter 3: Figures 3-1 or 3-2 and Tables 3-1 or 3-2
60,000 pounds or more, or regional jets	Individual large airplanes	Chapter 4: *Airplane Performance Manuals*

Source: FAA AC 150/5325-4B, Runway Length Requirements for Airport Design

The determination of runway length requirements for the airport is based on five primary factors:

- Mean maximum temperature of the hottest month
- Airport elevation
- Runway gradient
- Critical aircraft type expected to use the runway
- Stage length of the longest nonstop destination (specific to larger aircraft)

The mean maximum daily temperature of the hottest month for GEU is 106.5 degrees Fahrenheit (°F), which occurs in July. The airport elevation is 1,071.3 feet above mean sea level (MSL). Runway 2-20 has a gradient of 0.42 percent.

Small General Aviation Aircraft (≤12,500 pounds)

Most operations at GEU are conducted using smaller GA aircraft that weigh less than 12,500 pounds. Following guidance from AC 150/5325-4B, to accommodate 95 percent of these small aircraft with fewer than 10 passenger seats, a runway length of 3,700 feet is recommended. For 100 percent of these small aircraft, a runway length of 4,300 feet is recommended. For small aircraft with 10 or more passenger seats, 4,700 feet of runway length is recommended.

Small and Mid-Size Turbine Aircraft (12,500–60,000 pounds)

Turbine operations comprise a smaller percentage of GEU operations, but this category of activity is projected to experience strong growth over the planning period. Runway length requirements for this classification of aircraft utilize charts from AC 150/5325-4B and take into consideration the runway gradient and landing length requirements for contaminated (wet) runways. Business jets tend to need greater runway length when landing on wet surfaces because of their increased approach speeds. AC 150/5325-4B stipulates that runway length determination for business jets should consider a grouping of airplanes with similar operating characteristics. The AC provides two separate family groupings of airplanes, each of which is based on its representative percentage of aircraft in the national fleet. The first grouping is business jets that comprise 75 percent of the national fleet, and the second grouping is those that comprise 100 percent of the national fleet. **Table 3H** shows example aircraft for both groups.

TABLE 3H: Aircraft Categories for Runway Length Determination

0–75 Percent of the National Fleet	MTOW (pounds)	75–100 Percent of the National Fleet	MTOW (pounds)
Challenger 300	38,850	Lear 55	21,500
Lear 40/45	20,500	Lear 60	23,500
Cessna 550 Citation II	14,100	Hawker 800XP	28,000
Cessna 560XL Excel	20,000	Hawker 1000	31,000
Cessna 650 VII	22,000	Cessna 650 III/IV	22,000
Cessna 680 Sovereign	30,775	Cessna 750X	35,700
Beechjet 400	15,800	Challenger 604	47,600
Falcon 50	18,500	Falcon 2000	42,800

Source: FAA AC 150/5325-4B, Runway Length Requirements for Airport Design

MTOW = maximum takeoff weight

The following is the five-step process for determining the recommended runway length for aircraft with MTOWs between 12,500 pounds and 60,000 pounds.

Step #1: Identify the critical aircraft or aircraft group.

This runway length analysis assumes the critical aircraft is a mid-sized business jet that weighs less than 60,000 pounds at MTOW. There are more than 500 annual operations by these types of aircraft at GEU. In this case, the appropriate runway length methodology is to examine the general runway length tables from Chapter 3 of AC 150/5325-4B for aircraft that weigh between 12,500 pounds and 60,000 pounds.

Step #2: Identify the aircraft or aircraft group that will require the longest runway length at MTOW.

Business jets typically require the longest runway lengths; therefore, the runway length curves in Chapter 3 of AC 150/5325-4B is examined for future conditions.

Step #3: Determine which of the three methods described in the AC will be used for establishing the runway length.

In consideration of the growing number of business jets, it is necessary to select the specific methodology to use for the business jets. Chapter 3 of the AC groups business jets that weigh over 12,500 pounds but less than 60,000 pounds into the following two categories:

- 75 percent of the fleet
- 100 percent of the fleet

The AC states that airplanes in the 75 percent of the fleet category generally need 5,000 feet or less of runway at MSL and standard day temperature (59°F), while those in the 100 percent of the fleet category need more than 5,000 feet of runway under the same conditions.

The AC indicates that the airport designer must determine which category to use for runway length determination. GEU experiences significant levels of business jet activity from the full range of the business jet fleet.

Two runway length curves are presented in the AC under the 75–100 percent category:

- 60 percent useful load
- 90 percent useful load

The useful load is the difference between the maximum allowable structural weight and the operating empty weight (OEW). The useful load consists of passengers, cargo, and usable fuel. The determination of which useful load category to use will have a significant impact on the recommended runway length, but it is inherently difficult to determine because of the variable needs of each aircraft operator. For shorter flights, pilots may take on less fuel; however, pilots may choose to ferry fuel so they do not have refuel as frequently. Because of the variability in aircraft weights and haul lengths, the 60 percent useful load category is typically considered the default, unless there are specific known operations that would suggest using the 90 percent useful load category. For GEU, there are minimal long-haul operations that would suggest consideration of the 90 percent useful load classification; therefore, the 60 percent useful load classification will be utilized in the calculations for runway length requirements for business jets that weigh between 12,500 and 60,000 pounds.

Step #4: Select the recommended runway length from the appropriate methodology.

The next step is to examine the performance charts. These charts require the following inputs:

- Mean maximum daily temperature of the hottest month: 106.5°F
- Airport elevation: 1,071.3 feet above MSL

Step #5: Apply any necessary adjustments to the obtained runway length.

The raw runway lengths calculated in Step #4 are based on no wind, a dry runway surface, and zero effective runway gradient; therefore, the following criteria are applied:

- Wet runway surface (applies to landing operations only)
- 0.42 percent effective runway gradient; 29.9 feet of elevation difference for Runway 2-20 (applies to takeoff operations only)

To account for a wet/contaminated surface, the runway length obtained from the load performance chart used in Step #4 is increased by 15 percent, or up to 5,000 feet, for the 60 percent category and 7,000 feet for the 90 percent category (whichever is less).

The runway length obtained from Step #4 is also increased at a rate of 10 feet for each foot of elevation difference between the high and low points of the runway centerline. At GEU, this equates to an additional 300 feet of runway length.

Table 3J presents the results of the runway length analysis for business jets that weigh between 12,500 and 60,000 pounds, which was developed following the guidance outlined in the steps above. This analysis shows the existing length of Runway 2-20 meets the recommended length for 75 percent of the business jet fleet at 60 percent useful load but falls short by 50 feet to meet the needs of 100 percent of the fleet at 60 percent useful load.

TABLE 3J: Runway Length Requirements – Aircraft Between 12,500 and 60,000 Pounds

Airport Elevation	1071.3' feet above mean sea level			
Average High Monthly Temp.	106.5°F (July)			
Runway Gradient	0.42% Runway 2-20 (29.9')			
Fleet Mix Category	**Raw Runway Length from FAA AC**	**Runway Length with Gradient Adjustment**	**Wet Surface Landing Length for Jets (+15%)***	**Final Runway Length**
75% of fleet at 60% useful load	5,176'	5,476'	5,500'	5,500'
100% of fleet at 60% useful load	6,901'	7,201'	5,500'	7,200'
75% of fleet at 90% useful load	8,137'	8,437'	7,000'	8,500'
100% of fleet at 90% useful load	11,000'	11,300'	7,000'	11,300'

Source: FAA AC 150/5325-4B, Runway Length Requirements for Airport Design

*Maximum 5,500' for 60% useful load and maximum 7,000' for 90% useful load in wet conditions

Supplemental Runway Length Analysis

Another method to determine runway length requirements for aircraft at GEU is to examine aircraft flight planning manuals under conditions specific to the airport. **Table 3K** provides a detailed runway length analysis for several of the most common airplane design group (ADG) C and D turbine aircraft in the national fleet. This data was obtained from UltraNav software, which computes operational parameters for specific aircraft based on flight manual data. The analysis includes the allowable MTOW and the percent useful load from 60 percent to 100 percent.

The analysis shows that most jets examined can operate at GEU during the hottest periods of the summer at useful loads up to 80 percent, except the Challenger 601. The critical aircraft, which are the Citation V (existing) and Challenger 300 (future/ultimate), are capable of operating at 100 percent (Citation V) and 90 percent (Challenger 300) useful loads.

TABLE 3K: Supplemental Business Aircraft Takeoff Length Requirements

		TAKEOFF LENGTH REQUIREMENTS (feet)				
		Useful Load				
Aircraft	MTOW	60%	70%	80%	90%	100%
Citation V (Model 560)	**15,900**	**3,254**	**3,542**	**3,852**	**4,177**	**4,524**
Citation X	35,700	5,515	6,041	6,636	7,181	7,181
Citation Encore	16,630	3,629	3,978	4,367	4,829	5,330
Citation Ultra	16,300	3,235	3,519	3,811	4,126	4,466
Challenger 300	**38,850**	**5,224**	**5,726**	**6,253**	**6,812**	**7,415**
Challenger 601	45,100	5,720	6,390	7,180	8,110	9,150
Challenger 604/605	48,200	5,636	6,230	6,906	7,627	8,355
Falcon 900A	46,500	5,330	6,100	6,990	7,000	7,000
Falcon 900B	46,500	4,800	5,450	6,170	6,960	7,660
Falcon 900EX	49,200	4,920	5,620	6,350	7,070	7,710
Falcon 2000	35,800	5,677	6,272	6,887	7,562	8,404
Global Express	98,000	5,349	5,956	6,681	7,401	7,501
King Air 200 GT	12,500	3,728	3,876	4,026	4,156	4,272

Source: UltraNav software

Red figures are greater than 7,150 feet.
Existing and future/ultimate critical aircraft are in **bold**.
Runway length calculation assumptions: 1,071.3' MSL field elevation; 106.5°F ambient temperature; 0.42% runway grade
MTOW = maximum takeoff weight

Table 3L presents the runway length required for landing under three operational categories: Title 14 Code of Federal Regulations (CFR) Part 91, CFR Part 135, and CFR Part 91k.

TABLE 3L: Supplemental Business Aircraft Landing Length Requirements

		LANDING LENGTH REQUIREMENTS (feet)					
		Dry Runway Condition			Wet Runway Condition		
Aircraft	MLW	Part 91	80% Rule	60% Rule	Part 91	80% Rule	60% Rule
Citation V (Model 560)	**15,200**	**3,153**	**3,941**	**5,255**	**4,677**	**5,846**	**7,795**
Citation X	31,800	3,883	4,854	6,472	5,539	6,924	9,232
Citation Encore	15,200	3,087	3,859	5,145	4,637	5,796	7,728
Citation Ultra	15,200	3,123	3,904	5,205	4,639	5,799	7,732
Challenger 300	**33,750**	**2,660**	**3,325**	**4,433**	**5,099**	**6,374**	**8,498**
Challenger 601	36,000	3,409	4,261	5,682	6,818	8,523	11,363
Challenger 604/605	38,000	2,858	3,573	4,763	4,513	5,641	7,522
Falcon 900A	42,000	3,600	4,500	6,000	4,140	5,175	6,900
Falcon 900B	42,000	3,600	4,500	6,000	4,140	5,175	6,900
Falcon 900EX	44,500	3,750	4,688	6,250	4,312	5,390	7,187
Falcon 2000	33,000	3,193	3,991	5,322	3,672	4,590	6,120
Global Express	78,600	2,722	3,403	4,537	3,130	3,913	5,217
King Air 200 GT	12,500	1,263	1,579	2,105	No Data	No Data	No Data

Source: UltraNav software

Red figures are greater than 7,150 feet.
Existing/ultimate critical aircraft are in **bold**.
Runway length calculation assumptions: 1,071.3' MSL field elevation; 106.5°F ambient temperature; 0.42% runway grade
MLW = maximum landing weight

CFR Part 91 operations are those conducted by individuals or companies that own their aircraft and are operating privately. CFR Part 135 applies to all for-hire charter operations, including most fractional ownership operations. CFR Part 91k includes operations in fractional ownership that utilize their own aircraft under the direction of pilots specifically assigned to said aircraft. Part 91k and Part 135 rules regarding landing operations require an operator to land at the destination airport within 60 percent of the effective runway length. An additional rule allows an operator to land within 80 percent of the effective runway length if the operator has an approved destination airport analysis in the aircraft's program operating manual. The landing length analysis conducted accounts for both scenarios.

The landing length analysis shows that all jets examined are capable of landing at GEU during dry runway conditions. During wet runway conditions, the two critical aircraft can land at GEU in all but the 60 percent rule condition when landing at maximum landing weight during the hottest period of the year.

Commercial/Charter Aircraft Runway Length Analysis

Scenario-based forecasts for commercial service operations at GEU were presented in the previous chapter. As stated, the greatest potential for establishing this type of service lies with a non-traditional operator rather than legacy airlines, which are already well-served by Phoenix Sky Harbor International Airport. Given this potential, takeoff length requirements for several of these types of aircraft were also calculated using aircraft planning manuals and are detailed in **Table 3M**.

TABLE 3M: Potential Commercial/Charter Aircraft Takeoff Length Requirements

		TAKEOFF LENGTH REQUIREMENTS (feet)				
		Useful Load				
Aircraft	MTOW	60%	70%	80%	90%	100%
CRJ-200	53,000	5,796	6,506	7,302	8,235	Climb Limited
Embraer 135	49,604	5,861	6,423	6,623	7,472	8,163
Pilatus PC-122	9,921	2,298	2,491	2,695	2,909	3,132
Embraer 170	79,344	3,600	4,100	4,400	4,900	5,400

Source: UltraNav software

Red figures are greater than 7,150 feet.
Runway length calculation assumptions: 1,071.3' MSL field elevation; 106.5°F ambient temperature; 0.42% runway grade
MTOW = maximum takeoff weight

Runway Length Summary

Many factors are considered when determining appropriate runway length for safe and efficient operations of aircraft at GEU. The airport should strive to accommodate business jets and turboprop aircraft to the greatest extent possible as demand dictates. Runway 2-20 is currently 7,150 feet long, which exceeds the FAA's recommended length for runways accommodating 75 percent of the business jet fleet that weigh between 12,500 and 60,000 pounds when operating at 60 percent useful load. The recommended length is 5,500 feet; however, the runway is 50 feet short of meeting the FAA-recommended length of 7,200 feet for accommodating 100 percent of the business jet fleet at 60 percent useful load. The existing runway length also does not meet the FAA recommended lengths for operating at 90 percent useful loads; however, as mentioned, utilization of the 90 percent category is generally not considered by the FAA unless there is a demonstrated need at an airport.

The supplemental runway length analysis shows that the available length accommodates takeoff operations by the majority of the aircraft examined, including the existing critical aircraft (at 100 percent MTOW) and the future/ultimate critical aircraft (at 90 percent MTOW). All of the aircraft analyzed can land during dry conditions, and the majority can also land during wet conditions unless the 60 percent rule is applied.

The most recent ALP update, which was conducted in 2018, reduced the length of Runway 2-20 to 6,935 feet. This was recommended to allow for the construction of engineered materials arresting system (EMAS) beds on each runway end, which is an alternative to providing a full safety area (to be discussed in greater detail in the next chapter). The runway length analysis confirms the existing length is sufficient to accommodate all of the small aircraft currently operating and projected to operate at GEU, as well as a majority of the turbine aircraft operating now and in the future. For this reason, the airside alternatives in the next chapter will not depict any options that include a significant runway extension.

Runway Width

For Runway 2-20, existing RDC B-II-5000 design criteria stipulate a runway width of 75 feet. For the future/ultimate RDC C-II-5000, design standards require a runway width of 100 feet. Runway 2-20 is currently 100 feet wide, which satisfies the design standard for both the existing and ultimate conditions.

Blast Pads

Blast pads are paved surfaces adjacent to the ends of runways that provide erosion protection from jet blast and propeller wash. According to the FAA, blast pads must always be paved, must extend across the full width of the runway plus the shoulders, and must be able to support the occasional passage of the most demanding aircraft, as well as maintenance and emergency response vehicles. Blast pad dimensions are detailed in FAA AC 150/5300-13B, Change 1, and are determined by the RDC of the critical design aircraft ARC. Each end of Runway 2-20 is currently equipped with blast pads that measure 150 feet long by 115 feet wide (Runway 1) and between 140 and 150 feet long by 117 feet wide (Runway 19). The blast pads should be maintained through the planning period.

Pavement Strength

An important feature of airfield pavement is its ability to withstand repeated use by aircraft. For Runway 2-20, the pavement should be designed to handle the heaviest business jets that routinely operate at GEU, including the ultimate critical aircraft, the Bombardier Challenger 300, which has an MTOW of 38,850 pounds on dual-wheel main landing gear.

As shown in **Table 3N**, the existing pavement strength of 40,000 pounds S (single wheel loading) and 60,000 pounds D (dual wheel loading) is adequate to accommodate the designated ultimate critical aircraft. It should be noted that strength ratings do not preclude aircraft that weigh more than the published strength rating from using the runway. All federally obligated airports must remain open to the public, and it is typically up to the pilot of an aircraft to determine if a runway can safely support their aircraft.

An airport sponsor cannot restrict an aircraft from using the runway because its weight exceeds the published strength rating; however, the airport sponsor has an obligation to properly maintain the runway and protect its useful life (typically 20 years). The strength rating of a runway can change over time. Regular usage by heavier aircraft can decrease the strength rating, while periodic runway resurfacing can increase the strength rating.

TABLE 3N: Pavement Strength Requirements

Runway	Single Wheel Loading (S) Rating	Dual Wheel Loading (D) Rating	Future Critical Aircraft MTOW	Additional Strength Needed?
Runway 2-20	40,000 pounds	60,000 pounds	38,850 pounds D (Challenger 300)	No

Source: Coffman Associates analysis

SAFETY AREA DESIGN STANDARDS

The FAA has established several imaginary surfaces to protect aircraft operational areas and keep them free from obstructions. These include the runway safety area (RSA), runway object free area (ROFA), runway obstacle free zone (ROFZ), and runway protection zone (RPZ).

The entire RSA, ROFA, and ROFZ must be under the direct ownership of the airport sponsor to ensure these areas remain free of obstacles and can be readily accessed by maintenance and emergency personnel. RPZs should also be under airport ownership; however, there are alternatives to outright ownership of the RPZ through the purchase of avigation easements (acquiring control of designated airspace within the RPZ) or having sufficient land use control measures in place that ensure the RPZ remains free of incompatible development. The various existing airport safety areas and their dimensions are presented on **Exhibit 3D** and additional information about each safety area is described in the following sections.

Declared distances have been implemented at GEU to mitigate some existing safety area deficiencies. Declared distances are used to define the effective runway length for landing and takeoff when a standard safety area cannot be achieved. The declared distances include the following:

- **Takeoff run available (TORA)**: the runway length declared available and suitable for the ground run of an aircraft taking off (factors in the positioning of the departure RPZ)

- **Takeoff distance available (TODA)**: the TORA plus the length of any remaining runway or clearway beyond the far end of the TORA; the full length of the TODA may need to be reduced because of obstacles in the departure area

- **Accelerate-stop distance available (ASDA)**: the runway plus stopway length declared available and suitable for the acceleration and deceleration of an aircraft aborting a takeoff (factors in the length of the RSA/ROFA beyond the runway end)

- **Landing distance available (LDA)**: the runway length declared available and suitable for landing an aircraft (factors in the length of the RSA/ROFA beyond the runway end and the positioning of the approach RPZ)

RDC: B-II-5000

LEGEND

- Airport Property Line
- A — Taxiway Designation
- Perimeter Fence
- RSA
- ROFA
- ROFZ
- RPZ
- Uncontrolled RPZ
- AWOS Critical Area

ROFZ Obstruction

Departure RPZ

Approach RPZ

0.8 Acres

0.2 Acres

N Glen Harbor Blvd

W Glendale Ave

R1 R2 R3 R4 R5

A

A1 A2 A3 A4 A6 A7 A8 A9

Runway 2-20 (7,150′ x 100′)

2

20

2.4 Acres

Public Road in RPZ

Perimeter Road

500′

Approach RPZ

Departure RPZ

New River Rd

Declared Distances	Runway 2	Runway 20
TORA	7,150′	7,150′
TODA	7,150′	7,150′
ASDA	6,980′	7,116′
LDA	6,279′	6,115′

RUNWAY 2

TORA, TODA - 7,150′

ASDA - 6,980′

LDA - 6,279′

LDA - 6,115′

ASDA - 7,116′

TORA/TODA - 7,150′

RUNWAY 20

New River

KEY

ASDA - Accelerate-Stop Distance Available
AWOS - Automated Weather Observing System
LDA - Landing Distance Available
RDC - Runway Design Code
RSA - Runway Safety Area
ROFA - Runway Object Free Area
ROFZ - Runway Obstacle Free Zone
RPZ - Runway Protection Zone
TODA - Takeoff Distance Available
TORA - Takeoff Run Available

N

0 800

SCALE IN FEET

Aerial Source: Google Earth 06/2026

Note: Acreages shown are approximate.

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The declared distances currently in effect at GEU are depicted on the bottom half of **Exhibit 3D**, and the following sections describe how the declared distances are currently applied at the airport.

Runway 1

- TORA/TODA: 7,150 feet
- ASDA: 6,980 feet – The ASDA for Runway 1 is reduced by 170 feet to account for the RSA deficiency that exists on the north end of the runway. The airport's perimeter road obstructs the RSA near Runway 19, allowing for only 130 feet of available safety area and resulting in a reduced ASDA.
- LDA: 6,279 feet – The LDA for Runway 1 is reduced to account for the 701-foot displacement and the 170-foot RSA deficiency to the north.

Runway 19

- TORA/TODA: 7,150 feet
- ASDA: 7,116 feet – The ASDA for Runway 19 is reduced by 34 feet to account for the RSA deficiency that exists on the south end of the runway. The airport's perimeter road obstructs the RSA near Runway 1, allowing for only 266 feet of available safety area and resulting in a reduced ASDA.
- LDA: 6,115 feet – The LDA for Runway 19 is reduced to account for the 1,001-foot displacement and the 34-foot RSA deficiency to the south.

Runway Safety Area

The RSA is defined in FAA AC 150/5300-13B, *Airport Design*, as a "surface surrounding the runway prepared or suitable for reducing the risk of damage to airplanes in the event of undershoot, overshoot, or excursion from the runway." The RSA is centered on the runway and dimensioned in accordance with the approach speed of the critical design aircraft using the runway. The FAA requires the RSA to be cleared and graded, drained by grading or storm sewers, capable of accommodating the design aircraft and fire and rescue vehicles, and free of obstacles not fixed by navigational purpose, such as runway edge lights or approach lights.

For existing B-II-5000 design standards on Runway 2-20, the FAA calls for the RSA to be 150 feet wide and extend 300 feet beyond the runway ends. Obstructions on both the north and south ends of the runway (airport perimeter road and fencing) restrict the ability to meet the full 300 feet of RSA beyond the runway ends in the existing condition; however, the reduced ASDA and LDA for each runway mitigate this non-standard condition.

For future/ultimate C-II-5000 design standards, the RSA dimensions increase to 500 feet wide and extend 1,000 feet beyond the runway ends; however, only 600 feet are needed prior to the landing threshold. Similar to the existing condition, obstructions would be present within the ultimate RSA, but to a greater extent due to the increased dimensions of the C-II RSA. As previously mentioned, the current ALP includes the construction of EMAS beds to mitigate RSA deficiencies and provide for a full safety area. The alternatives in the next chapter will reexamine this recommendation and consider other options to mitigate non-standard RSA conditions to provide for an unimpeded safety area.

Runway Object Free Area

The ROFA is "a two-dimensional ground area, surrounding runways, taxiways, and taxilanes, which is clear of objects except for objects whose location is fixed by function (i.e., airfield lighting)." The ROFA does not have to be graded and level like the RSA; instead, the primary requirement for the ROFA is that no object in the ROFA penetrates the lateral elevation of the RSA. The ROFA is centered on the runway and extends out in accordance with the critical design aircraft utilizing the runway.

Existing B-II-5000 design standards establish the ROFA width at 500 feet and the length at 300 feet. Similar to the RSA, there are obstructions within the ROFA at each runway end. The declared distances currently published do not account for these obstructions, so the Runway 2-20 ROFA does not currently meet the standard, and a Modification to Standards (MOS) has not been issued by the FAA.

For ultimate C-II-5000 design standards, the FAA calls for the ROFA to be 800 feet wide and extend 1,000 feet beyond each runway end, with only 600 feet needed prior to the threshold. At these dimensions, the standard for the ultimate ROFA cannot be met without mitigative action. The alternatives in the next chapter will analyze potential projects to provide a clear ROFA in the ultimate C-II condition to comply with FAA design standards.

Runway Obstacle Free Zone

The ROFZ is an imaginary surface that precludes object penetrations, including taxiing and parked aircraft. The only allowance for ROFZ obstructions is navigational aids mounted on frangible bases that are fixed in their locations by function, such as airfield signs. The ROFZ is established to ensure the safety of aircraft operations. If the ROFZ is obstructed, the airport's approaches could be removed or approach minimums could be increased.

For all runways serving aircraft over 12,500 pounds, the ROFZ is 400 feet wide, centered on the runway, and extends 200 feet beyond the runway ends. This standard applies to the runway at GEU. In the existing and ultimate conditions, the ROFZ is obstructed by the airport's perimeter road and fencing, as well as a small portion of Glendale Avenue to the north.

Runway Protection Zone

An RPZ is a trapezoidal area centered on the extended runway centerline beginning 200 feet from the end of the runway. This safety area is established to protect the end of the runway from airspace penetrations and incompatible land uses. The RPZ dimensions are based on the established RDC and the approach visibility minimums serving the runway. While the RPZ is intended to be clear of incompatible objects or land uses, some land uses are permitted with conditions and other land uses are prohibited. According to AC 150/5300-13B, Change 1, the following land uses are permissible within the RPZ:

- Farming that meets the minimum buffer requirements
- Irrigation channels, as long as they do not attract birds
- Airport service roads, as long as they are not public roads and are directly controlled by the airport operator

- Underground facilities, as long as they meet other design criteria, such as RSA requirements, as applicable
- Unstaffed navigational aids (NAVAIDs) and facilities, such as those required for airport facilities that are fixed by function regarding the RPZ
- Aboveground fuel tanks associated with backup generators for unstaffed NAVAIDs

In September 2022, the FAA published AC 150/5190-4B, *Airport Land Use Compatibility Planning*, which states that airport owner control over RPZs is preferred. Airport owner control over RPZs may be achieved through the following methods:

- Ownership of the RPZ property in fee simple
- Possessing sufficient interest in the RPZ property through easements, deed restrictions, etc.
- Possessing sufficient land use control authority to regulate land use in the jurisdiction that contains the RPZ
- Possessing and exercising the power of eminent domain over the property
- Possessing and exercising permitting authority over proponents of development within the RPZ (e.g., where the sponsor is a state)

AC 150/5190-4B further states that "control is preferably exercised through acquisition of sufficient property interest and includes clearing RPZ areas (and keeping them clear) of objects and activities that would impact the safety of people and property on the ground." The FAA recognizes that land ownership, environmental, geographical, and other considerations can complicate land use compatibility within RPZs; regardless, airport sponsors must comply with FAA grant assurances, including (but not limited to) Grant Assurance 21, *Compatible Land Use*. Sponsors are expected to take appropriate measures to "protect against, remove, or mitigate land uses that introduce incompatible development within RPZs."

For a proposed project that would shift an RPZ into an area with existing incompatible land uses, such as a runway extension or the construction of a new runway, the sponsor is expected to have or secure sufficient control of the RPZ, ideally through fee simple ownership. Where existing incompatible land uses are present, the FAA expects sponsors to "seek all possible opportunities to eliminate, reduce, or mitigate existing incompatible land uses" through acquisition, land exchanges, right-of-first refusal to purchase, agreement with property owners on land uses, easements, or other such measures. These efforts should be revisited during master plan or ALP updates, and periodically thereafter, and should be documented to demonstrate compliance with FAA grant assurances. If a new or proposed incompatible land use impacts an RPZ, the FAA expects the airport to take the above actions to control the property within the RPZ and adopt a strong public stance opposing the incompatible land use.

For a new incompatible land use that results from a sponsor-proposed action (e.g., an airfield project like a runway extension, a change in the critical aircraft that increases the RPZ dimension, or lower minimums that increase the RPZ dimension), the airport sponsor is expected to conduct an alternatives evaluation. The intent of the alternatives evaluation is to "proactively identify a full range of alternatives and prepare a sufficient evaluation to be able to draw a conclusion about what is 'appropriate and reasonable'."

For incompatible development off-airport, the sponsor should coordinate with the FAA ADO as soon as the sponsor learns of the development, and the alternatives evaluation should be conducted within 30 days of the sponsor's first awareness of the development within the RPZ. The following items are typically necessary in an alternatives evaluation:

- Sponsor's statement of the purpose and need of the proposed action (airport project, land use change, or development)
- Identification of any other interested parties and proponents
- Identification of any federal, state, and/or local transportation agencies involved
- Analysis of sponsor control of the land within the RPZ
- Summary of all alternatives considered, including the following:
    - Alternatives that preclude introducing the incompatible land use within the RPZ (e.g., zoning action, purchase, and design alternatives, such as implementation of declared distances or displaced thresholds, runway shift or shortening, raising minimums, etc.)
    - Alternatives that minimize the impact of the land use in the RPZ (e.g., rerouting a new roadway through less of the RPZ, etc.)
    - Alternatives that mitigate risk to people and property on the ground (e.g., tunnelling, depressing, and/or protecting a roadway through the RPZ, implementing operational measures to mitigate any risks, etc.)
- Narrative discussion and exhibits or figures depicting the alternative
- Rough order of magnitude cost estimates associated with each alternative, regardless of potential funding sources
- Practicability assessment based on the feasibility of the alternative in terms of constructability, cost, operational impacts, and other factors

Once the alternatives evaluation has been submitted to the ADO, the FAA will determine whether the sponsor has made an adequate effort to pursue and consider appropriate and reasonable alternatives. The FAA will not approve or disapprove the airport sponsor's preferred alternative; rather, the FAA will evaluate whether an acceptable level of alternatives analysis has been completed before the sponsor makes the decision to allow or disallow the proposed land use within the RPZ.

In summary, the RPZ guidance published in September 2022 shifts the responsibility of protecting the RPZ to the airport sponsor. The airport sponsor is expected to take action to control the RPZ or demonstrate that appropriate actions have been taken. The decision to permit or disallow existing or new incompatible land uses within an RPZ is ultimately up to the airport sponsor, with the understanding that the sponsor still has grant assurance obligations, and the FAA retains the authority to review and approve or disapprove portions of the ALP that would adversely impact the safety of people and property within the RPZ.

RPZs have been further designated as approach and departure RPZs. The approach RPZ is a function of the AAC and approach visibility minimums associated with the approach runway end. The departure RPZ is a function of the AAC and departure procedures associated with the runway. For a particular runway end, the more stringent RPZ requirements (usually associated with the approach RPZ) will govern the property interests and clearing requirements the airport sponsor should pursue.

The locations and dimensions of each RPZ for both runways are depicted on **Exhibit 3D**. The approach RPZs for each runway end are positioned 200 feet beyond the displaced threshold at each end, while the departure RPZs are positioned 200 feet beyond each runway pavement end. In the existing condition, the Runway 1 departure RPZ extends beyond airport property for approximately 1.0 acre to the south, while portions of both the approach and departure RPZs associated with Runway 19 encompass a public road (Glendale Avenue). In the future/ultimate condition, the dimensions of the RPZs increase, resulting in additional uncontrolled RPZ land.

The alternatives analysis will consider options to mitigate RPZ incompatibilities and allow the airport to establish full control over the RPZs.

SEPARATION STANDARDS

There are several other standards related to separation distances from runways and taxiways. Each is designed to enhance the safety of the airfield.

Runway/Taxiway Separation

The design standard for the separation between runways and parallel taxiways is a function of the critical design aircraft and the instrument approach visibility minimums. In the existing B-II-5000 condition, the separation standard for the runway is 240 feet from the runway centerline to the parallel taxiway centerline. In the future/ultimate C-II-5000 condition, the separation standard increases to 300 feet. As shown on **Exhibit 3E**, parallel Taxiway A is located 252 feet west of the runway centerline and would not meet FAA design standards. The alternatives in the next chapter will consider options to meet the ultimate runway-to-taxiway separation standard.

Holding Position Separation

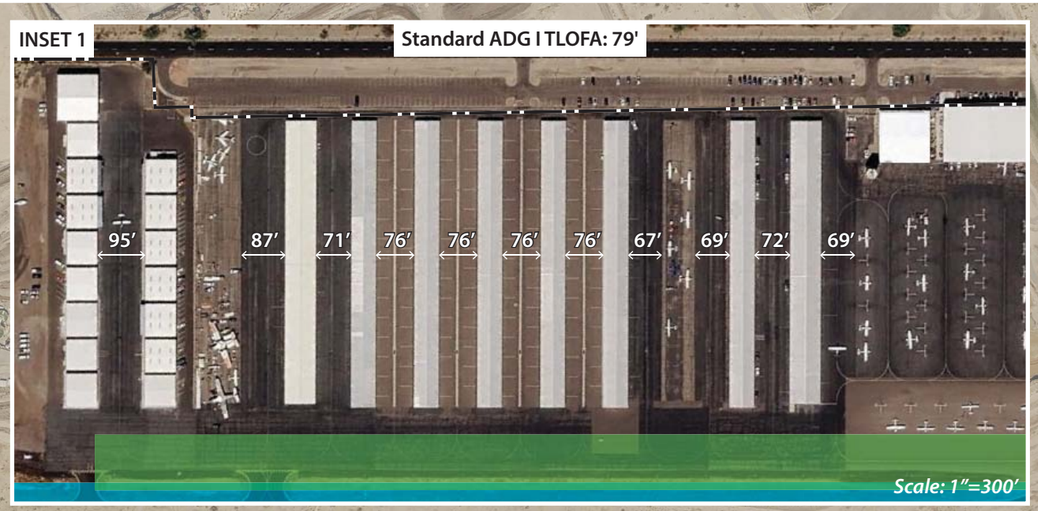
Holding position markings are placed on taxiways leading to runways. When instructed, pilots are to stop short of the holding position marking line. For existing B-II-5000 design standards, holding position markings should be situated 200 feet from the runway centerline. Under future/ultimate C-II-5000 design standards, the holding position markings should be situated 250 feet from the runway centerline. Currently, the holding position markings are located 200 feet from the runway centerline, which satisfies the standard in the existing condition. The next chapter will consider relocation of the holding position markings in conjunction with the alternatives presented to meet the future/ultimate runway-to-taxiway separation standard.

LEGEND

- Airport Property Line
- A — Taxiway Designation
- Perimeter Fence
- AWOS Critical Area
- ADG II TOFA (124')
- ADG II TLOFA (110')

KEY

ADG - Airplane Design Group
AWOS - Automated Weather Observation Station
TLOFA - Taxilane Object Free Area
TOFA - Taxiway Object Free Area





Potential TLOFA Obstruction

INSET 1

N Glen Harbor Blvd

INSET 2

W Glendale Ave

Non-standard Holding Bay

R1 R2 R3 R4 R5

A A1 A2 A3 A4 A6 A7 A8 A9

252′

Runway 2-20 (7,150 x 100′)

2

20

Perimeter Road

Direct Access

Non-standard Angled Connection

500′

Perimeter Road

New River

N

0 500

SCALE IN FEET

Aerial Source: Google Earth 06/2026

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Aircraft Parking Area Separation

According to FAA AC 150/5300-13B, Change 1, aircraft parking positions should be located to ensure aircraft components (wings, tail, and fuselage) do not:

1. Conflict with the object free areas for the adjacent runway or taxiways:

    a. Runway object free area (ROFA)
    b. Taxiway object free area (TOFA)
    c. Taxilane object free area (TLOFA)

2. Violate any of the following aeronautical surfaces and areas:

    a. Runway approach or departure surface
    b. Runway visibility zone (RVZ) – *not applicable at GEU*
    c. Runway obstacle free zone (ROFZ)
    d. Navigational aid equipment critical areas

As shown on **Exhibit 3E**, the safety areas and aeronautical surfaces listed above are generally unobstructed, with the potential exception of the row of tiedowns located on the south side of the terminal apron near the ATCT. Measuring from the edge of the adjacent T-hangar to the tiedowns, there is approximately 69 feet of separation. A standard ADG I TLOFA is 79 feet wide; however, TLOFA widths can vary based on the types of aircraft traversing the taxilane. Airport management should confirm that only aircraft with 39-foot or shorter wingspans are taxiing along this taxilane to ensure adequate wingtip clearance.

TAXIWAYS

The design standards associated with taxiways are determined by the taxiway design group (TDG) or ADG of the airport's critical aircraft. As previously determined, ADG II standards apply to Runway 2-20 in the existing and ultimate conditions. **Table 3P** presents the various taxiway design standards related to ADG I and II. The table also shows the taxiway design standards related to TDG. The TDG standards are based on the main gear width (MGW) and cockpit-to-main gear (CMG) distance of the critical aircraft expected to use those taxiways. Different taxiway and taxilane pavements can and should be planned to the most appropriate ADG and TDG design standards, based on usage. Taxiway and taxilane object free areas are depicted on **Exhibit 3E**. There are no identified obstructions to the existing taxiway object free areas.

As noted in Chapter Two, the existing and future/ultimate design standard for taxiways at GEU is ADG II and TDG 2A, which dictates a width of 35 feet. All taxiways at the airport are at least 35 feet wide, with several exceeding this width. For taxiways that exceed the current design standard, the FAA may elect not to fund regular pavement maintenance for the portions of taxiway pavement that exceed the standard. If the airport chooses to maintain the taxiways at their current widths, the costs may need to come from a local funding source, rather than federal grant money. Certain portions of the landside area that are utilized exclusively by small aircraft should adhere to TDG 1A/1B standards.

TABLE 3P: Taxiway Dimensions and Standards

STANDARDS BASED ON WINGSPAN	ADG I	ADG II
Taxiway and Taxilane Protection		
Taxiway Safety Area (TSA) Width	49'	79'
Taxiway Object Free Area (TOFA) Width	89'	124'
Taxilane Object Free Area (TLOFA) Width	79'	110'
Taxiway and Taxilane Separation		
Taxiway Centerline to Parallel Taxiway Centerline	70'	101.5'
Taxiway Centerline to Fixed or Moveable Object	44.5'	62'
Taxilane Centerline to Parallel Taxilane Centerline	64'	94.5'
Taxilane Centerline to Fixed or Moveable Object	39.5'	55'
Wingtip Clearance		
Taxiway Wingtip Clearance	20'	22.5'
Taxilane Wingtip Clearance	15'	15.5'
STANDARDS BASED ON TDG	**TDG 1A/B**	**TDG 2A/B**
Taxiway Width Standard	25'	35'
Taxiway Edge Safety Margin	5'	7.5'
Taxiway Shoulder Width	10'	15'

Source: FAA AC 150/5300-13B, Airport Design, Change 1

All dimensions are in feet.
ADG = airplane design group
TDG = taxiway design group

Taxiway Design Considerations

FAA AC 150/5300-13B, *Airport Design*, Change 1 provides guidance on recommended taxiway and taxilane layouts to enhance safety by avoiding runway incursions. A runway incursion is defined as "any occurrence at an airport involving the incorrect presence of an aircraft, vehicle, or person on the protected area of a surface designated for the landing and takeoff of aircraft."

The taxiway system at the airport generally provides for the efficient movement of aircraft; however, recently published AC 150/5300-13B Change 1 provides recommendations for taxiway design. The following is a list of the taxiway design guidelines and the basic rationale behind each recommendation:

1. *Taxiing Method*: Taxiways are designed for "cockpit over centerline" taxiing with pavement that is wide enough to allow a certain amount of wander. On turns, sufficient pavement should be provided to maintain the edge safety margin from the landing gear. When constructing new taxiways, existing intersections should be upgraded to eliminate judgmental oversteering, which is when a pilot must intentionally steer the cockpit outside the marked centerline to ensure the aircraft remains on the taxiway pavement.

2. *Curve Design*: Taxiways should be designed so the nose gear steering angle is no more than 50 degrees, which is the generally accepted value to prevent excessive tire scrubbing.

3. *Three-Path Concept*: To maintain pilot situational awareness, taxiway intersections should provide a pilot with a maximum of three choices of travel. Ideally, these are right, left, and a continuation straight ahead.

4. *Channelized Taxiing*: To support visibility of airfield signage, taxiway intersections should be designed to meet standard taxiway width and fillet geometry.

5. *Designated Hot Spots and Runway Incursion Mitigation (RIM) Locations*: A hot spot is a location on the airfield with elevated risk of collisions or runway incursions. Mitigation measures should be prioritized for areas the FAA designates as hot spots or RIM locations. **GEU does not have any FAA-designated hot spots or RIM locations.**

6. *Intersection Angles*: Turns should be designed to be 90 degrees, wherever possible. For acute-angle intersections, standard angles of 30, 45, 60, 120, 135, and 150 degrees are preferred.

7. *Runway Incursions*: Taxiways should be designed to reduce the probability of runway incursions.

    a. *Increase Pilot Situational Awareness*: Pilots who know where they are on the airport are less likely to enter a runway improperly. Complexity leads to confusion. Taxiway systems should be kept simple by using the three-path concept.

    b. *Avoid Wide Expanses of Pavement*: Wide pavements require placement of signs far from a pilot's eye. This is especially critical at runway entrance points. Where a wide expanse of pavement is necessary, direct access to a runway should be avoided.

    c. *Limit Runway Crossings*: The taxiway layout can reduce the opportunity for human error. The benefits are twofold: through a simple reduction in the number of occurrences and a reduction in air traffic controller workload.

    d. *Avoid High-Energy Intersections*: These are intersections in the middle thirds of runways. By limiting runway crossings to the first and last thirds of a runway, the portion of the runway where a pilot can least maneuver to avoid a collision is kept clear.

    e. *Increase Visibility*: Right-angle intersections between taxiways and runways provide the best visibility. Acute-angle runway exits provide greater efficiency in runway usage but should not be used as runway entrance or crossing points. A right-angle turn at the end of a parallel taxiway is a clear indication of approaching a runway.

    f. *Avoid Dual-Purpose Pavements*: 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.

    g. *Avoid Direct Access*: Taxiways should not be designed to lead directly from an apron to a runway. Such configurations can lead to confusion when a pilot typically expects to encounter a parallel taxiway.

    h. *Mitigate Hot Spots*: Confusing intersections near runways are more likely to contribute to runway incursions. These intersections must be redesigned when the associated runway is subject to reconstruction or rehabilitation. Other hot spots should be corrected as soon as practicable.

8. *Runway/Taxiway Intersections*:

    a. *Right Angle*: Right-angle intersections are the standard for all runway/taxiway intersections, except where there is a need for an acute-angled exit. Right-angle taxiways provide the best visual perspective to a pilot approaching an intersection with the runway to observe aircraft in both the left and right directions. They also provide optimal orientation of the runway holding position signs so the signage is visible to pilots.

    b. *Acute Angle*: Acute angles should not be larger than 45 degrees from the runway centerline. A 30-degree taxiway layout should be reserved for high-speed exits. The use of multiple intersecting taxiways with acute angles creates pilot confusion and improper positioning of taxiway signage. The construction of high-speed exits is typically only justified for runways that experience regular use by jet aircraft in approach categories C and above.

    c. *Large Expanses of Pavement*: A taxiway must never coincide with the intersection of two runways. Taxiway configurations with multiple taxiway and runway intersections in a single area create large expanses of pavement, which make it difficult to provide proper signage, marking, and lighting.

9. *Taxiway/Runway/Apron Incursion Prevention*: Apron locations that allow direct access to a runway should be avoided. Taxiways should be designed in a manner that increases pilot situational awareness by forcing pilots to consciously make turns. Taxiways that originate from aprons and form straight lines across runways at mid-span should be avoided.

    a. *Wide-Throat Taxiways*: Wide-throat taxiway entrances should be avoided because such large expanses of pavement may cause pilot confusion and can make lighting and marking more difficult.

    b. *Direct Access from Apron to Runway*: Taxiway connectors that cross over a parallel taxiway and directly onto a runway should be avoided. A staggered taxiway layout or no-taxi island that forces pilots to make a conscious decision to turn should be considered.

    c. *Apron to Parallel Taxiway End*: Direct connection from an apron to a parallel taxiway at the end of a runway should be avoided.

The taxiway system at GEU generally provides for the efficient movement of aircraft. As mentioned, there are no FAA-designated hot spots or RIM locations. The only non-standard taxiway conditions are direct access via Taxilane R1 and Taxiway A3 and the angled threshold connector (Taxiway A9) to Runway 19.

Taxilane Design Considerations

Taxilanes are distinguished from taxiways in that they do not provide direct access to or from the runway system. Taxilanes typically provide access to hangar areas and can be planned to varying design standards, depending on the type(s) of aircraft that utilize the taxilanes, as previously described.

HOLDING BAYS

Holding bays are designated areas for pilots to conduct pre-flight checks and allow for aircraft to bypass one another. There are three holding bays on the airfield at GEU. One is located on the north end of Taxiway A to serve aircraft departing on Runway 19 and two others are located on the south end to serve aircraft departing on Runway 1. On the south end, the holding bay located at Taxiway A2 is non-standard and lacks markings. Consideration should be given to reconfiguring this holding bay to meet standard and marking it with a centerline to provide a visual cue to pilots on where to position their aircraft to ensure there are no penetrations to the TOFA.

NAVIGATIONAL AND APPROACH AIDS

Navigational aids are devices that provide pilots with guidance and position information when utilizing the runway system. Electronic and visual guidance to arriving aircraft enhances the safety and capacity of the airfield. Such facilities are vital to the success of an airport and provide additional safety to passengers using the air transportation system. While instrument approach aids are especially helpful during poor weather, they are often used by pilots conducting flight training and operating larger aircraft when visibility is good.

Instrument Approach Aids

GEU has two published instrument approach procedures. Each end of Runway 2-20 is equipped with a global positioning system (GPS)-based localizer performance with vertical guidance (LPV) approach that provides visibility minimums down to 1-mile. While these instrument approach procedures are generally considered adequate for GEU, additional analysis has been prepared to determine the feasibility of improved procedures (i.e., lower visibility minimums and decision altitudes). The findings indicate it may be feasible to reduce the visibility minimums and decision altitudes for each runway's GPS approach to ¾-mile visibility and 250 feet, if new procedures are developed. The analysis is based on existing conditions only, so if any changes to the runway system, navigational aids, or surrounding obstacles occur, the improvements to the approaches may not be feasible.

The alternatives in the next chapter will depict GPS-based approaches to each runway end, with consideration given to maintaining the existing 1-mile visibility minimums, or a reduction to ¾-mile minimums for each runway. This is an important consideration for the airport sponsor because the RPZ associated with each runway end would increase in size if the visibility minimums were reduced below 1-mile, which could potentially introduce additional incompatible land uses. Additionally, the width of the Part 77 primary surface would increase from its current 500 feet to 1,000 feet, encompassing existing hangars. It will be necessary for the airport sponsor to coordinate with the FAA to determine if this would present a hazard to aircraft operations.

Visual Approach Aids

In most instances, the landing phase of any flight must be conducted in visual conditions. To provide pilots with visual guidance information during landings to the runway, electronic visual approach aids are commonly provided at airports. Currently, each runway end at GEU is equipped with a two-box precision

approach path indicator (PAPI-2). Consideration should be given to upgrading these systems through the planning period to a four-box PAPI (PAPI-4) system, which is recommended by the FAA for runways supporting jet operations.

Runway end identification lights (REILs) are flashing lights located at the runway threshold end that facilitate rapid identification of the runway end at night and during poor visibility conditions. REILs provide pilots with the ability to identify the runway thresholds and distinguish the runway end lighting from the other lighting on the airport and in the approach areas. REILs should be considered for all lighted runway ends not planned for more sophisticated approach lighting systems. Runway 2-20 is currently equipped with REILs on both runway ends, which should be maintained for the duration of the planning period.

Weather Reporting Aids

GEU has a lighted wind cone and segmented circle on the east side of the runway at approximately mid-field. The wind cone provides information to pilots regarding wind speed and direction. Typically, the wind cone is centralized on the airfield system and is often co-located within a segmented circle, which is the case at GEU. The segmented circle consists of a system of visual indicators designed to provide traffic pattern information to pilots.

The airport is also equipped with an automated weather observation station (AWOS), which provides weather observations 24 hours per day. The system updates weather observations every minute, continuously reporting significant weather changes as they occur in real time. This information is transmitted via a designated radio frequency at regular intervals. FAA siting criteria indicate that the AWOS should be located between 1,000 and 3,000 feet from the runway threshold and between 500 and 1,000 feet perpendicular to the runway centerline. The AWOS has a 500-foot radius critical area that must be kept free of obstructions that could interfere with its sensors. The AWOS should be maintained throughout the planning period.

Airport Traffic Control Tower

GEU has an operational ATCT, which is located directly south of the GEU Operations Facility. Currently, some portions of the apron and taxilane south of the tower are not visible to controllers. As such, the alternatives chapter will include a preliminary ATCT site selection/line-of-sight analysis that will help determine potential locations on the airfield for a new tower.

AIRFIELD LIGHTING, MARKING, AND SIGNAGE

Several lighting and pavement marking aids serve pilots using the airport. These aids assist pilots in locating an airport and runway at night or in poor visibility conditions. They also serve aircraft navigating the airport environment on the ground when transitioning to/from aircraft parking areas to the runway.

Airport Identification Lighting

GEU's rotating beacon is located on top of the ATCT. The beacon is in good working order and should be maintained for the duration of the planning period.

Runway and Taxiway Lighting

Runway 2-20 is equipped with medium intensity runway lighting (MIRL). The MIRL system on the runway utilizes light-emitting diode (LED) fixtures. Additionally, the taxiway system is equipped with medium intensity taxiway lighting (MITL). These systems are considered adequate and should be maintained.

Pavement Markings

Runway markings are typically designed to the type of instrument approach available on the runway. FAA AC 150/5340-1K, *Standards for Airport Markings*, provides guidance necessary to design airport markings. Runway 2-20 has non-precision markings on both runway ends, which are adequate for the existing and ultimate conditions.

Airfield Signs

Airfield identification signs assist pilots in identifying their locations on the airfield and directing them to their desired locations. Lighted signs are installed on the runway and taxiway systems on the airfield. The signage system includes runway and taxiway designation signage, holding position signage, routing/directional signage, and runway ends and exits. Lighted distance-remaining signs are also installed to alert pilots to the remaining runway length available after landing. All of these signs should be maintained through the planning period.

A summary of the airside facilities at GEU is presented on **Exhibit 3F**.

ADVANCED AIR MOBILITY AND EVTOL CONSIDERATIONS

Since the turn of the decade, private companies have been developing and testing advanced air mobility (AAM) technologies. AAM is a new concept of air transportation that uses electric vertical takeoff and landing (eVTOL) aircraft to move people and cargo between places that are not easily or currently served by surface or air modes. A common example is the air taxi, in which a person or small group of people could travel within or between metropolitan areas, including airports, using small eVTOL aircraft. Development of infrastructure in support of AAM is currently underway in test cities across the country, and AAM is expected to become a key component of the nation's air transportation network. Images are provided below of several different AAM/eVTOL aircraft that are currently in development.



Various eVTOL Aircraft in Development (Courtesy of VoloCopter, Joby, and Lilium)

CATEGORY	EXISTING	FUTURE/ULTIMATE
RUNWAY		
Designation	1-19	2-20
Runway Design Code	RDC B-II-5000	RDC C-II-5000
Length	7,150'	Maintain
Width	100'	Maintain
Pavement Strength	40 (S); 60 (D)	Maintain
SAFETY AREAS		
Runway Safety Area	150' wide x 300' long Meets standard due to declared distances	500' wide x 1,000' long Obstructions present; consider mitigative actions
Runway Object Free Area	500' wide x 300' long Non-standard; obstructions present; consider mitigative actions	800' wide x 1,000' long Obstructions present; consider mitigative actions
Obstacle Free Zone	400' wide x 200' long Non-standard; obstructions present; consider mitigative actions	400' wide x 200' long Non-standard; obstructions present; consider mitigative actions
Runway Protection Zone	1,000' long x 500' inner width x 700' outer width Portions uncontrolled; contains public roadway; consider mitigative actions	1,700' long x 500' inner width x 1,010' outer width Portions uncontrolled; contains public roadway; consider mitigative actions
TAXIWAYS		
Taxiway Design Group	2A	Maintain
Width	35' - Meets standard	Maintain
Parallel Taxiway Separation	252' - Meets standard	300' - Consider mitigative actions
NAVIGATIONAL AND WEATHER AIDS		
Instrument Approaches	1-mile (lowest visibility)	Evaluate lower visibility minimums
Approach Aids	PAPI-2 (1, 19), REILs (1, 19)	Consider PAPI-4; maintain REILs
Weather Aids	AWOS, Lighted Wind Cones, Rotating Beacon	Maintain
Control Tower	Yes	Evaluate potential ATCT locations to improve line-of-sight
LIGHTING, MARKING, SIGNAGE		
Runway Markings	Non-Precision	Maintain
Runway Edge Lighting	MIRL	Maintain
Taxiway Edge Lighting	MITL	Maintain
Holding Position Marking	200' - Meets standard	250' - Consider mitigative actions
Airport Identification	Rotating beacon	Maintain
Lighted Airfield Signage	Yes	Maintain

KEY

ATCT - Airport Traffic Control Tower
AWOS - Automated Weather Observation Station
MIRL - Medium intensity runway lights
MITL - Medium intensity taxiway lights
PAPI - Precision Approach Path Indicator
RDC - Runway Design Code
REIL - Runway End Identification Lighting
Pavement Strength
S - Single Wheel Load
D - Dual Wheel Load



GUIDELINES FOR VERTIPORT FACILITIES

This section reviews applicable guidelines established by the FAA regarding the design of vertiports for eVTOL aircraft. A vertiport is defined as an aviation facility with the primary purpose of supporting eVTOL aircraft. As previously stated, AAM is still a developing technology. The FAA Office of Airports and Technical Center recently solicited aircraft design information from AAM developers. Nine companies responded to the inquiry with varying levels of cooperation, including aircraft design and specifications, operational concepts, infrastructure design, and takeoff and landing profiles. As a result of the feedback, the FAA was able to finalize a document on the design of vertiports, titled Engineering Brief (EB) 105, *Vertiport Design*, which was published in December 2024.

REFERENCE AIRCRAFT

The design criteria established in EB 105 are intended for eVTOL aircraft that meet the performance criteria and design characteristics of the reference aircraft. The reference aircraft denotes an eVTOL aircraft that integrates certain performance and design features of the nine previously mentioned emerging aircraft. These aircraft models are rapidly evolving and manufacturers are approaching aircraft certification with a wide range of designs. Furthermore, new eVTOL aircraft have not yet received FAA airworthiness certification and do not have established safety records. This makes it impractical for the FAA to categorize these aircraft the way fixed-wing and helicopter aircraft have been; however, the feedback from eVTOL manufacturers revealed common characteristics, which the FAA used to produce EB 105. These preliminary design characteristics, expected performance capabilities, and assumptions regarding takeoff and landing area design for eVTOL aircraft are summarized in **Table 3Q** and on **Figure 3.1**.

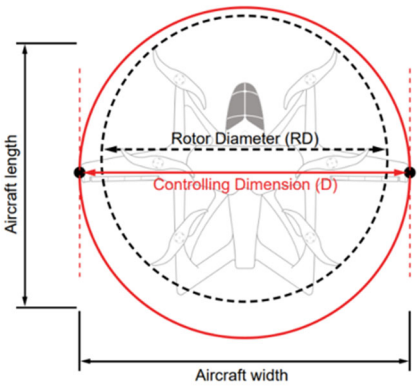


Figure 3.1 – Reference Aircraft

TABLE 3Q: Reference Aircraft

DESIGN CHARACTERISTICS	CRITERIA
Propulsion	Electric battery-driven, utilizing distributed electric propulsion
Propulsive Units	3 or more
Battery Systems	2 or more
Maximum Takeoff Weight (MTOW)	12,500 pounds (5,670 kg) or less
Controlling Dimension	50 feet (15.2 meters) or less
Flight Control	Highly augmented stability and control
Operating Conditions	
Operation Location	Land-based (ground or elevated) – no amphibian or float operations
Pilot	On board
Flight Conditions	VFR
Performance	
Hover	Hover out of ground effect (HOGE) in normal operations
Takeoff	Vertical
Landing	Vertical from a steady state hover

Source: FAA Engineering Brief 105, Vertiport Design

DESIGN STANDARDS FOR VERTIPORTS

Once the reference aircraft is determined, the design dimensions for the vertiport can be established. A vertiport may consist of several facilities, including aircraft charging and storage, a passenger terminal, and takeoff and landing areas. The landside facilities of a vertiport will be specific to and determined by the unique AAM company that chooses to establish a presence in the study area. The airside facilities are the focus of EB 105. The takeoff and landing area design and geometry contained in EB 105 include the TLOF, the FATO, and the safety area, which are defined in detail below.

- **Final approach and takeoff area (FATO):** The FATO is a defined load-bearing area over which the aircraft completes the final phase of the approach to a hover or landing, and from which the aircraft initiates takeoff. The FATO is similar to the total surface of a helipad.

- **Touchdown and liftoff area (TLOF):** The TLOF is a load-bearing, generally paved area centered in a FATO on which the aircraft performs a touchdown or liftoff. The TLOF is analogous to the center "H" of a helipad.

- **Safety area:** The safety area is a defined area surrounding the FATO that is intended to reduce the risk of damage to aircraft accidentally diverging from the FATO. The vertiport safety area is identical in purpose to a runway or taxiway safety area.

- **Downwash/outwash caution area (DCA):** Downwash is airflow created by the propulsion units on an eVTOL aircraft. It flows down and then outward when it meets the ground, which can be dangerous to people and property. A DCA that extends beyond the safety area and functions as a restricted area during eVTOL operations should be provided.

The dimensions for these areas are presented in **Table 3R** and are based on the controlling dimension (D) or rotor diameter (RD) of the design eVTOL aircraft. The RD is the largest length of all the rotors from tip to tip and must also incorporate all landing gear and surface touch points. The controlling dimension is the diameter of the smallest circle enclosing the entire eVTOL aircraft projection on a horizontal plane, including all possible configurations with rotors/propellors turning.

TABLE 3R: Takeoff and Landing Area Dimensions

Element	Length
TLOF	1 × RD
FATO	2 × RD
Safety Area	2.5 × RD

Source: FAA EB 105, Vertiport Design (Table 2-1)

FATO = final approach and takeoff area
RD = rotor diameter
TLOF = touchdown and liftoff area

Each element is centered within the subsequent element: the TLOF is located in the center of the FATO, which is centered within the safety area, as shown by **Figure 3.2**. The heliport identification marking (H) and vertiport identification marking (VTL) identify the location as a vertiport. The TLOF and FATO are both expected to be located on level terrain or a structure, be clear of penetrations and obstructions, and support the weight of the design eVTOL aircraft. The TLOF may be circular, square, or rectangular in shape. A study conducted in 2011 found that a square is the preferred visual cue by emergency medical service (EMS) helicopter pilots; the square was rated higher than a circle, triangle, or octagon. Regardless of the shape, the FATO and safety area will have the same shape.

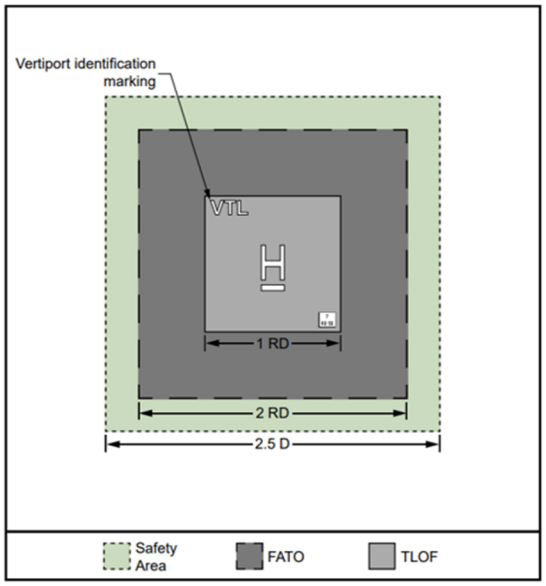


Figure 3.2 – Takeoff and Landing Area

APPROACH PROFILES

Imaginary Surfaces

The imaginary surfaces defined for heliports in Title 14 Code of Federal Regulations (CFR) Part 77, *Safe, Efficient Use and Preservation of the Navigable Airspace*, are applicable to vertiports and include the primary surface, approach, and transitional surfaces. Section 77.23 defines these surfaces for heliports, and they have been adopted for use and presented in EB 105.

- *Primary Surface*: The primary surface is the same size and shape as the FATO. This surface is a horizontal plane at the established vertiport elevation.
- *Approach Surface*: This surface begins at each end of the vertiport's primary surface, has the same width as the primary surface, and extends outward and upward for a horizontal distance of 4,000 feet, where its width is 500 feet. The slope of this surface is 8:1 and it doubles as the departure surface.
- *Transitional Surface*: The transitional surface extends outward and upward from the lateral boundaries of the primary and approach surfaces at a slope of 2:1 for 250 feet horizontally from the centerline of the primary and approach surfaces.

The primary, approach, and transitional surfaces should remain clear of penetrations whenever possible, unless an FAA analysis determines the penetrations to any Part 77 surface not to be hazardous. **Figure 3.3** is a visual representation of the imaginary surfaces as they apply to vertiports.

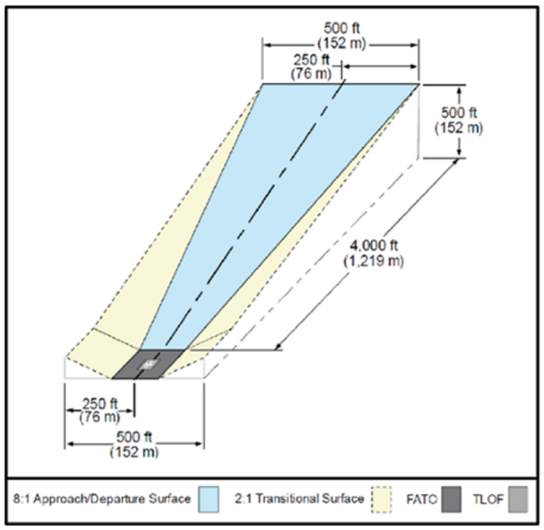


Figure 3.3 – Vertiport Imaginary Surfaces

VERTIPORT SUMMARY

eVTOLs and AAM represent an emerging, yet unproven, aviation market. Testing and initial adoption are likely to occur in large metropolitan areas and then expand to mid-sized and smaller markets. Full integration of eVTOL into the national airspace system may not occur for many years; however, it is prudent for this planning study to consider the potential for such activity at GEU. Electrical infrastructure will be needed at the vertiport to provide power and recharging capabilities for the aircraft. Initial estimates from manufacturers range between 500-kilowatt (kW) to 1.0-megawatt (MW) power supply per charger.

LANDSIDE FACILITY REQUIREMENTS

Landside facilities are those necessary for the handling of aircraft and passengers while on the ground. These facilities provide the essential interface between air and ground transportation modes. The capacity of the various components of each element was examined in relation to projected demand to identify future landside facility needs. At GEU, this includes the following components for general aviation needs:

- General aviation terminal services and auto parking
- Aircraft storage hangars
- Aircraft parking aprons
- Airport support facilities

GENERAL AVIATION TERMINAL SERVICES AND AUTO PARKING

The general aviation terminal facilities at an airport are often the first impression of a community that corporate officials and other visitors will encounter. General aviation terminal facilities at an airport provide space for passenger waiting, a pilots' lounge, flight planning, concessions, management, storage, and many other various needs. This space is not necessarily limited to a single, separate terminal building, but can include space offered by fixed base operators (FBOs) and other specialty operators for these functions and services. At GEU, general aviation terminal services are primarily provided to the public from the 22,000-square-foot (sf) terminal building; however, other on-airport businesses also offer terminal services, such as pilot lounges and flight planning rooms, to their customers.

The methodology used in estimating general aviation terminal facility needs was based on the number of airport users expected to utilize general aviation facilities during the design hour. Space requirements for terminal facilities were based on providing 125 sf per design hour itinerant passenger. A multiplier of 2.5 in the short term, increasing to 4.0 in the long term, was also applied to terminal facility needs to better determine the number of passengers associated with each itinerant aircraft operation. This increasing multiplier indicates an expected increase in larger aircraft operations through the long term. These operations typically support larger turboprop and jet aircraft, which can accommodate an increasing passenger load factor. This is the case at GEU, where an increasing number of turbine operations are anticipated.

Table 3S outlines the space requirements for general aviation terminal services at GEU through the long-term planning period. The combined amount of space currently offered by the GA terminal building is approximately 22,000 sf, which is adequate to support demand through the planning period.

TABLE 3S: General Aviation Terminal Area Facilities

	Currently Available	Short-Term Need	Intermediate-Term Need	Long-Term Need
Input Data				
General Aviation Itinerant Design Hour Operations	13	17	20	27
Passenger Multiplier	–	2.5	3.0	4.0
Design Hour Passengers	–	43	60	108
Terminal Service Space Requirements				
Space per Design Hour Passenger (sf)	–	125	125	125
Terminal Building (sf)	22,000	5,375	7,500	13,500
Terminal Vehicle Parking Requirements				
Terminal Visitor Vehicle Space	157	43	60	108
FBO/Tenant Space	470	193	208	243
Total Vehicle Parking:	**627**	**236**	**268**	**351**

Source: Coffman Associates analysis

General aviation terminal service vehicle parking demands have also been determined for GEU. Space determinations for passengers were based on an evaluation of existing airport use, as well as standards set forth to help calculate projected terminal facility needs. There are currently 157 individual spaces provided near the terminal building, with an additional 470 spaces in various parking areas supporting tenant facilities. As shown in the table, the terminal area and vehicle parking areas currently available are sufficient through the long-term planning horizon.

AIRCRAFT STORAGE HANGARS

Utilization of hangar space varies as a function of local climate, security, and owner preference. The trend in general aviation aircraft is toward more sophisticated (and, consequently, more expensive) aircraft; therefore, many aircraft owners prefer enclosed hangar space over outside tiedowns.

The demand for aircraft storage hangars is dependent on the number and type(s) of aircraft expected to be based at the airport in the future. For planning purposes, it is necessary to estimate hangar requirements based on forecasted operational activity; however, hangar development should be based on actual demand trends and financial investment conditions.

While most aircraft owners prefer enclosed aircraft storage, some will still use outdoor tiedown spaces, usually due to lack of available hangar space, high hangar rental rates, or operational needs; therefore, enclosed hangar facilities do not necessarily need to be planned for each based aircraft.

Hangar types vary greatly in size and function. Linear box hangars, T-hangars, and shade hangars are popular with aircraft owners who need to store individual private aircraft. These hangars typically provide individual spaces within a larger structure or in portable standalone buildings. There is approximately 571,700 sf of T-hangar, linear box hangar, and shade hangar space at GEU. For determining future aircraft storage needs, it is assumed that a large majority of owners of new single-engine and other smaller

aircraft (e.g., ultralights, gliders, etc.) will prefer this type of storage space. A planning standard of 1,200 sf per single-engine piston, multi-engine piston, and other aircraft is utilized for this hangar type.

Executive box (corporate) and conventional hangars are open-space facilities with no interior supporting structures. Corporate hangars can vary in size from 1,500 to nearly 10,000 sf. They are typically able to house single-engine, multi-engine, turboprop, and jet aircraft, as well as helicopters. Conventional hangars provide bulk aircraft storage and are often utilized by airport businesses, such as FBOs or aircraft maintenance operators. Conventional hangars are generally larger than executive box/corporate hangars and can range in size from 10,000 sf to more than 20,000 sf. There is approximately 137,900 sf of executive box and conventional hangar space at GEU. For future planning, standards of 3,000 sf per turboprop, 5,000 sf per jet, and 1,500 sf per helicopter are utilized for these hangar types.

Future hangar requirements for the airport are summarized in **Table 3T**.

TABLE 3T: Aircraft Hangar Requirements

	Currently Available	Short-Term Need	Intermediate-Term Need	Long-Term Need	Difference
Total Based Aircraft	355	385	415	485	+130
Hangar Area Requirements					
T-Hangar/Linear Box/Shade Hangar (sf)	571,700	591,100	608,900	644,500	-72,800
Corporate/Conventional Hangars (sf)	137,900	168,400	210,900	339,400	-201,500
Total Hangar Area (sf):	**709,600**	**759,500**	**819,800**	**983,900**	**-274,300**

Source: Coffman Associates analysis

Because most based aircraft owners prefer enclosed hangar space, it is assumed that a large percentage of based aircraft will occupy hangar spaces, as opposed to tying down on the apron. The analysis shows that future hangar requirements indicate a potential need for more than 274,000 sf of new hangar storage capacity through the long-term planning period. This includes a mixture of hangar types; the largest need is projected in the corporate/conventional hangar category. Due to the projected increase in based aircraft/annual operations and hangar storage needs, facility planning will consider additional hangars at the airport. It is expected that the aircraft storage hangar requirements will continue to be met through a combination of hangar types.

It should be noted that hangar requirements are general in nature and are based on aviation demand forecasts. The actual need for hangar space will further depend on the usage within the hangars. For example, some hangars may be utilized entirely for non-aircraft storage, such as maintenance, but they have an aircraft storage capacity from a planning standpoint; therefore, the needs of an individual user may differ from the calculated space necessary.

AIRCRAFT PARKING APRONS

The aircraft parking apron is an expanse of pavement intended for aircraft parking and circulation. Typically, a main apron is centrally located near the airside entry point, such as a terminal building or FBO facility. Ideally, the main apron is large enough to accommodate transient airport users, as well as a portion of locally based aircraft. Smaller aprons are often available adjacent to specialty aviation service operator (SASO) hangars and at other locations around the airport. The apron layout at GEU generally follows this pattern. The main terminal apron, which totals 130,000 square yards (sy), is adjacent to the terminal and FBO facilities.

To determine future apron needs, the FAA-recommended planning criterion of 805 sy was used for ADG I aircraft (single-engine and multi-engine piston aircraft), while a planning criterion of 1,360 sy was used for larger ADG II aircraft (turboprops and jets). A parking apron should also provide space for locally based aircraft that require tiedown storage. Locally based tiedowns are typically utilized by smaller single-engine aircraft; thus, a planning standard of 643 sy per position was utilized in the analysis.

The total apron parking requirements are presented in **Table 3U**. Existing apron pavement area at GEU encompasses 130,000 sy. Using the planning standards described above and factoring in assumptions regarding operational and based aircraft growth, an additional 54,000 sy of aircraft parking apron pavement is estimated to be needed over the next 20 years.

TABLE 3U: Aircraft Parking Apron Requirements

	Currently Available	Short-Term Need	Intermediate-Term Need	Long-Term Need	Difference
Aircraft Parking Area (sy)					
Based/Local Aircraft	–	150,000	146,900	148,300	+1,700
Transient GA Aircraft	–	8,900	11,300	15,300	-6,400
Transient Jet Aircraft	–	8,200	10,900	20,400	-12,200
Total Apron Area:	**130,000**	**167,100**	**169,100**	**184,000**	**-54,000**

Source: Coffman Associates analysis

SUPPORT FACILITIES

Various other landside facilities that play a supporting role in overall airport operations have also been identified. These support facilities include the following:

- Aviation fuel storage
- Perimeter fencing and gates

Aviation Fuel Storage

Glendale Aero Services is the airport's public fuel service provider and leases the fuel storage facilities located south of the corporate hangars. The fuel farm includes three 20,000-gallon aboveground fuel storage tanks; two are used for Jet A fuel and one is used for 100LL fuel. Additionally, a 3,600-gallon self-serve facility used for 100LL fuel is located on the north side of the aircraft parking apron, adjacent to the FBO facility.

Fuel flowage records for 2025 show that the airport dispensed a total of 580,197 gallons for both Jet A fuel and 100LL fuel. Through the planning period, the FBOs will be responsible for monitoring fuel storage capacity and adjusting supply levels as necessary to accommodate changes in demand.

Perimeter Fencing and Gates

Perimeter fencing is used at airports primarily to secure the aircraft operational area. The physical barrier of perimeter fencing provides the following functions:

- Gives notice of legal boundary of the outermost limits of the facility or security-sensitive area

- Assists in controlling and screening authorized entries into a secured area by deterring entry elsewhere along the boundary
- Supports surveillance, detection, assessment, and other security functions by providing a zone for installing intrusion detection equipment and closed-circuit television (CCTV)
- Deters casual intruders from penetrating the aircraft operations areas on the airport
- Creates a psychological deterrent
- Demonstrates a corporate concern for facilities
- Limits inadvertent access to the aircraft operations area by wildlife

GEU operations areas are completely enclosed by fencing, including a six-foot chain-link fence topped by three-strand barbed wire. Controlled access gates that are secured electronically or with padlocks are available for access to movement and non-movement areas. Fencing and other security features should be regularly inspected to ensure there is no damage and there are no areas where unauthorized individuals could access the airfield.

A summary of the overall general aviation landside facilities is presented in **Table 3V**.

TABLE 3V: General Aviation Landside Facility Requirements

	Current Capacity	Projected Needs		
		Short-Term	Intermediate-Term	Long-Term
General Aviation Terminal Facilities and Parking				
Terminal/FBO Service Space (sf)	22,000	5,375	7,500	13,500
Total Vehicle Parking	627	236	268	351
Aircraft Storage Hangar Requirements				
T-Hangar, Linear Box, Shade Hangar (sf)	571,700	591,100	608,900	644,500
Corporate/Conventional Hangars (sf)	137,900	168,400	210,900	339,400
Total Hangar Storage Area (sf)	709,600	759,500	819,800	983,900
Aircraft Parking Apron				
Based/Local Aircraft Parking (sy)	–	150,000	146,900	148,300
Transient Parking (sy)	–	17,100	22,200	127,700
Total Apron Area (sy)	130,000	167,100	169,100	184,000

Source: Coffman Associates analysis

POTENTIAL COMMERCIAL SERVICE FACILITIES

Chapter Two considered several scenarios in which commercial service was initiated at the airport, including a passenger membership model, hop-on jet service, regional jet service, and irregularly scheduled charter flights. The types of commercial service facilities required depend on the types of service offered (scheduled vs. unscheduled, number of seats on the aircraft). The two options below provide a high-level overview of the facilities that may be necessary to accommodate various commercial service activities.

Option 1: Non-Traditional Terminal

Chapter Two considered three commercial service scenarios that could be accommodated in a non-traditional terminal setting (i.e., no standard security checkpoint, baggage claim, or ticketing counters). This correlates to the type of service outlined in Scenarios 1 and 2 (refer to Tables 2GG and 2HH). In each of these scenarios, the service provider is able to operate at airports that are not Part 139-certified, either due to the number of seats on the aircraft (fewer than 31) or by operating under Part 135, which applies to on-demand charters. Because there is no requirement for the airport to become Part 139-certified, many of the facilities passengers are accustomed to seeing in a terminal building, such as traditional security checkpoints, are not required. Rather, these operators often use their own "private terminals" or FBO facilities where security screening and other pre- and post-flight activities are conducted. For the airport sponsor, there are several advantages to not needing to become Part 139-certified in terms of the space and cost required to support Part 139 activities. **Table 3W** outlines examples of airports offering the types of commercial service described above and the facilities they use.

TABLE 3W: Non-Traditional Terminal Example

Airport	Service Provider	Aircraft	Seats	Facility Size
Scottsdale Airport, AZ	JSX	Embraer 145	30	53,000 sf
Taos Regional Airport, NM	Contour/JSX	Embraer 135/145	30	17,000 sf
Boone County Regional Airport, AR	Southern Airways Express (Surf Air)	Cessna 208	9	6,000 sf

Source: Coffman Associates analysis

Option 2: Traditional Terminal

Scenarios 3 and 4 (refer to Tables 2JJ and 2KK) considered options in which regional jet or irregularly scheduled charter operations by aircraft with more than 30 seats are implemented. In these scenarios, it would be necessary for GEU to seek a Part 139 certification. This would include, among other requirements, an aircraft rescue and firefighting (ARFF) station and equipment, traditional security screening measures, and an FAA-approved Airport Certification Manual (ACM) that outlines how the airport complies with Part 139. Accommodating aircraft of this size and the associated passenger numbers would also necessitate the construction of a more traditional terminal facility with queuing and holding areas, baggage facilities, and other features typically found in commercial service airports. **Table 3X** presents examples of airports offering regional jet service and/or irregularly scheduled charter service and their associated facilities.

TABLE 3X: Traditional Terminal Example

Airport	Service Provider(s)	Aircraft	Seats	Facility Size	Facility Features
Dubuque Regional Airport, IA	Sun Country, Denver Air	Boeing 737-800, Embraer 145	186, 30	32,000 sf	TSA security checkpoint/screening, hold room, baggage carousel, restaurant, ticketing counters, rental car counter
Yellowstone Regional Airport, WY	United Express	Bombardier CRJ200	50	27,000 sf	TSA security checkpoint/screening, hold room, baggage carousel, restaurant, ticketing counters, rental car counter, administrative offices
Flagstaff Airport, AZ	SkyWest	Bombardier CRJ200	50	24,000 sf	TSA security checkpoint/screening, hold room, baggage carousel, restaurant, ticketing counters, rental car counter, administrative offices

Source: Coffman Associates analysis

TSA = Transportation Security Administration

In summary, the size and features of a passenger terminal building would be entirely dependent on the type of service provided. If a passenger membership model or hop-on service is implemented, as shown in Option 1, then the existing terminal building could likely support some level of this activity. Alternatively, the service provider could elect to conduct operations out of a hangar (private terminal) on the airport. If regional jet or irregularly scheduled charter service using larger aircraft is implemented, as shown in Option 2, the City of Glendale would need to pursue Part 139 certification and additional facilities beyond what exist today to support those operations. This change would likely necessitate the reconfiguration of the existing terminal building, or even construction of a new terminal building with traditional features, including a security checkpoint, ticketing, and baggage facilities, along with the required Part 139 elements, such as ARFF.

SUMMARY

This chapter outlines the safety design standards and facilities required to meet the potential aviation demand projected at GEU for the next 20 years. To provide a more flexible master plan, the yearly forecasts from Chapter Two have been converted to planning horizon levels. The short term roughly corresponds to a five-year period, the intermediate term is approximately 10 years, and the long term is 20 years. By utilizing planning horizons, airport management can focus on demand indicators for initiating projects and grant requests, rather than on specific dates in the future.

In Chapter Four, potential improvements to the airside and landside systems will be examined through a series of airport development alternatives. Most of the alternatives discussion will focus on capital improvements that would be eligible for federal and state grant funds. Ultimately, an overall airport development plan that presents a vision beyond the 20-year scope of this master plan will be developed.