

Appendix B

Runway Length Requirements Calculation

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Runway Length Requirements Calculations

Runway length requirements used in the Facility Requirements section of this Master Plan utilized the guidance provided in FAA Advisory Circular 150/5325-4B, *Runway Length Requirements for Airport Design* (AC 4B). This Appendix section will explain the rationale, procedures and calculations used to determine the runway requirements.

Methodology

Using the planning criteria defined in AC 4B Chapter 1, the runway length requirements calculations used in this analysis utilizes the procedures outlined in Chapter 4 “*Runway Lengths For Regional Jets And Those Airplanes With A Maximum Certificated Takeoff Weight Of More Than 60,000 Pounds (27,200 Kg)*” of AC 4B.

Data Input

As stated in AC 4B, the design procedure for this weight category requires the following information:

- The critical design airplanes under evaluation and their APMs
- The maximum certificated takeoff weight (MTOW) or takeoff operating weight for short-haul routes
- Maximum certificated landing weight (MLW)
- Airport elevation above mean sea level
- Effective runway gradient
- The mean daily maximum temperature of the hottest month at the airport

Appendix Table 1 shows this required information.

Appendix Table 1:
AC 4B Required Information

Required Design Element	Data Input
Critical Aircraft	Gulfstream G550
Maximum Certificated Takeoff Weight (MTOW)	91,000 lbs.
Maximum certificated landing weight (MLW)	75,300 lbs.
Airport Elevation	647' MSL
Effective Runway Gradient	4.166'
Mean Daily Maximum Temperature	83°F/28°C

Source: Critical Aircraft: FAA Approved Master Plan Forecast; MTOW and MLW: <http://www.gulfstream.com/aircraft/gulfstream-g550>; Airport Elevation: <https://enacr.faa.gov/eNACR/nacr/Current/Airport/8190>; Effective Runway Gradient: 2018 CMT Runway Survey; Mean Daily Maximum Temperature: National Centers For Environmental Information NOAA

Resources

APM: Gulfstream G550 “Airplane Flight Manual” Revision 29 FAA Approved May 27/09

Aircraft Characteristics Database – Updated Appendix 1 of AC 150/5300-13A, found on FAA website, Excel file “Aircraft Characteristics (October 2018)”

Weather – U.S. Department of Commerce, National Oceanic & Atmospheric Administration, as shown in **Appendix Exhibit 1**.

Appendix Exhibit 1:
Summary of Monthly Normals 1981-2010

U.S. Department of Commerce
National Oceanic & Atmospheric Administration
National Environmental Satellite, Data, and Information Service
Current Location: Elev: 636 ft., Lat: 42.1208° N Lon: -87.9047° W
Station: CHICAGO PALWAUKEE AIRPORT, IL US USW00004838

Summary of Monthly Normals 1981-2010

Generated on 02/04/2019

National Centers for Environmental Information
151 Patton Avenue
Asheville, North Carolina 28801

Station: CHICAGO PALWATKEE AIRPORT, IL US USW00004838

Temperature (°F)																							
Mean							Cooling Degree Days						Heating Degree Days				Mean Number of Days						
							Base (above)						Base (above)										
Month	Daily Max	Daily Min	Mean	Long Term Max Std Dev	Long Term Min Std Dev	Long Term Avg Std Dev	55	57	60	65	70	72	55	57	60	65	Max ≥ 100	Max ≥ 90	Max ≥ 50	Max ≤ 32	Min ≤ 32	Min ≤ 0	
01	30.8	16.6	23.7	4.9	5.9	5.3	0	0	0	0	0	0	0	970	1032	1125	1280	0.0	0.0	1.4	16.8	29.0	2.7
02	35.2	20.4	27.8	5.0	5.1	5.0	-7777	-7777	-7777	-7777	0	0	0	162	817	901	1041	0.0	0.0	2.3	11.1	24.7	1.1
03	46.1	28.9	37.5	3.8	3.0	3.3	9	6	3	-7777	0	0	0	551	610	700	853	0.0	0.0	10.0	2.5	20.5	0.0
04	57.9	37.6	47.8	3.6	2.8	3.0	39	27	15	4	1	-7777	256	305	382	522	0.0	0.0	22.0	0.1	7.7	0.0	
05	69.1	47.5	58.3	3.4	3.1	3.0	161	126	84	38	13	7	58	85	136	245	0.0	0.7	30.5	0.0	0.4	0.0	
06	79.0	57.8	68.4	3.5	2.7	2.9	404	347	268	154	72	48	3	5	16	52	0.0	2.7	30.0	0.0	0.0	0.0	
07	83.3	63.8	73.6	3.0	2.4	2.6	575	513	420	269	139	98	0	0	-7777	4	0.1	4.8	31.0	0.0	0.0	0.0	
08	81.5	63.1	72.3	3.1	2.3	2.6	536	474	381	232	108	72	-7777	-7777	1	6	0.0	3.0	31.0	0.0	0.0	0.0	
09	74.3	54.3	64.3	3.0	2.1	2.3	292	240	170	81	28	16	13	22	41	102	0.0	0.6	30.0	0.0	0.0	0.0	
10	61.7	42.6	52.2	3.3	2.7	2.8	72	53	31	11	3	2	160	203	274	409	0.0	0.0	27.4	0.0	3.1	0.0	
11	48.1	32.0	40.0	4.3	3.2	3.6	6	3	1	-7777	0	0	0	455	512	600	749	0.0	0.0	12.7	2.0	15.1	0.0
12	35.1	20.9	28.0	5.3	6.0	5.5	1	-7777	0	0	0	0	0	837	899	991	1147	0.0	0.0	2.6	11.2	26.4	0.9
Summary	58.5	40.5	49.5	3.8	3.4	3.5	2095	1789	1373	789	364	243	4065	4490	5167	6410	0.1	11.8	230.9	43.7	126.9	4.7	

-7777: a non-zero value that would round to zero

Empty or blank cells indicate data is missing or insufficient occurrences to compute value

Source: https://www.ncdc.noaa.gov/cdo-web/datasets/NORMAL_MLY/stations/GHCND:USW00004838/detail

Procedures

Determining the required runway length begins in the guidance provided in AC -4B in Chapter 1 paragraph 102 (b) Procedure and Rationale for Determining Recommended Runway Lengths. Below is paragraph 102 (b) from AC 4B:

***“b. Procedure and Rationale for Determining Recommended Runway Lengths.** This AC uses a five-step procedure to determine recommended runway lengths for a selected list of critical design airplanes. As previously stated, the information derived from this five-step procedure is for airport design and is not to be used for flight operations. Flight operations must be conducted per the applicable flight manual. The five steps and their rationale are as follows:*

***(1) Step #1.** Identify the list of critical design airplanes that will make regular use of the proposed runway for an established planning period of at least five years. For Federally funded projects, the definition of the term “substantial use” quantifies the term “regular use” (see paragraph 102a(8).)*

***(2) Step #2.** Identify the airplanes that will require the longest runway lengths at maximum certificated takeoff weight (MTOW). This will be used to determine the method for establishing the recommended runway length. Except for regional jets, when the MTOW of listed airplanes is 60,000 pounds (27,200 kg) or less, the recommended runway length is determined according to a family grouping of airplanes having similar performance characteristics and operating weights. Although a number of regional jets have an MTOW less than 60,000 pounds (27,200 kg), the exception acknowledges the long-range capability of the regional jets and the necessity to offer regional jet operators the flexibility to interchange regional jet models according to passenger demand without suffering operating weight restrictions. When the MTOW of listed airplanes is over 60,000 pounds (27,200 kg), the recommended runway length is determined according to individual airplanes. The recommended runway length in the latter case is a function of the most critical individual airplane’s takeoff and landing operating weights, which depend on wing flap settings, airport elevation and temperature, runway surface conditions (dry or wet), and effective runway gradient. The procedure assumes that there are no obstructions that would preclude the use of the full length of the runway.*

***(3) Step #3.** Use table 1-1 and the airplanes identified in step #2 to determine the method that will be used for establishing the recommended runway length. Table 1-1 categorizes potential design airplanes according to their MTOWs. MTOW is used because of the significant role played by airplane operating weights in determining runway lengths. As seen from table 1-1, the first column separates the various airplanes into one of three weight categories. Small airplanes, defined as airplanes with MTOW of 12,500 pounds (5,670 kg) or less, are further subdivided according to approach speeds and passenger seating as explained in chapter 2. Regional jets are assigned to the same category as airplanes with a MTOW over 60,000 pounds (27,200 kg). The second column identifies the applicable airport design approach (by airplane family group or by individual airplanes) as noted previously in step #2. The third column directs the airport designer to the appropriate chapter for design guidelines and whether to use the referenced tables contained in the AC or to obtain airplane manufacturers’ airport planning manuals (APM) for each individual airplane under evaluation. In the latter case, APMs provide the takeoff and landing runway lengths that an airport designer will in turn apply to the associated guidelines set forth by this AC to obtain*

runway lengths. The airport designer should be aware that APMs go by a variety of names. For example, Airbus, the Boeing Company, and Bombardier respectively title their APMs as “Airplane Characteristics for Airport Planning,” “Airplane Characteristics for Airport Planning,” and “Airport Planning Manuals.” For the purpose of this AC, the variously titled documents will be referred to as APM. Appendix 1 lists the websites of the various airplane manufacturers to provide individuals a starting point to retrieve an APM or a point of contact for further consultation.

(4) Step #4. Select the recommended runway length from among the various runway lengths generated by step #3 per the process identified in chapters 2, 3, or 4, as applicable.

(5) Step #5. Apply any necessary adjustment to the obtained runway length, when instructed by the applicable chapter of this AC, to the runway length generated by step #4 to obtain a final recommended runway length. For instance, an adjustment to the length may be necessary for runways with non-zero effective gradients. Chapter 5 provides the rationale for these length adjustments. “

As stated in the first sentence of paragraph 102 (b), a 5-step procedure is used to determine the recommended runway length. Below is an outline of how each step was followed to determine the recommended runway length for Chicago Executive Airport’s primary runway.

Step #1 “Identify the list of critical design airplanes that will make regular use of the proposed runway for an established planning period of at least five years. For Federally funded projects, the definition of the term “substantial use” quantifies the term “regular use” (see paragraph 102a(8).)”

In the previous section of this Master Plan report, the FAA approved Forecast identifies the Gulfstream G550 as the most demanding aircraft that utilizes the airport and meets the requirement of “substantial” use, defining it as both the critical airport, and the Airport Reference Code (ARC). The G550 is categorized as a D-III aircraft in the FAA’s Aircraft Characteristics database.

Step #2 “Identify the airplanes that will require the longest runway lengths at maximum certificated takeoff weight (MTOW). This will be used to determine the method for establishing the recommended runway length...”

Step #2 is used to identify the method that will be used for establishing the recommended runway length and is based on aircraft weight category. When the MTOW of the aircraft identified in Step #1 has a MTOW of 60,000 pounds or more, the recommended runway length is determined according to “individual airplanes.” The MTOW of the G550 is shown in **Appendix Table 2**.

**Appendix Table 2:
Aircraft MTOW**

Equipment	AAC	ADG	MTOW
Gulfstream G550	D	III	91,000

Source: FAA Aircraft Characteristics Database (October 2018)

Step #3 “Use table 1-1 and the airplanes identified in step #2 to determine the method that will be used for establishing the recommended runway length. Table 1-1 categorizes potential design airplanes according to their MTOWs.”

Using Table 1-1 from AC 4B, the guidance identifies that the design approach used to determine the recommended runway length will be based on individual large airplanes and to use Chapter 4 of AC 4B for the next step. Table 1-1 from AC 4B is shown below in **Appendix Exhibit 2**.

**Appendix Exhibit 2
Step #3 MTOW of Critical Design Airplane List**

Airplane Weight Category Maximum Certificated Takeoff Weight (MTOW)			Design Approach	Location of Design Guidelines
12,500 pounds (5,670 kg) or less	Approach Speeds less than 30 knots		Family grouping of small airplanes	Chapter 2; Paragraph 203
	Approach Speeds of at least 30 knots but less than 50 knots		Family grouping of small airplanes	Chapter 2; Paragraph 204
	Approach Speeds of 50 knots or more	With Less than 10 Passengers	Family grouping of small airplanes	Chapter 2; Paragraph 205 Figure 2-1
		With 10 or more Passengers	Family grouping of small airplanes	Chapter 2; Paragraph 205 Figure 2-2
Over 12,500 pounds (5,670 kg) but less than 60,000 pounds (27,200 kg)			Family grouping of large airplanes	Chapter 3; Figures 3-1 or 3-2 ¹ and Tables 3-1 or 3-2
60,000 pounds (27,200 kg) or more or Regional Jets ²			Individual large airplane	Chapter 4; Airplane Manufacturer Websites (Appendix 1)

Note¹: When the design airplane's APM shows a longer runway length than what is shown in figure 3-2, use the airplane manufacturer's APM. However, users of an APM are to adhere to the design guidelines found in Chapter 4.

Note²: All regional jets regardless of their MTOW are assigned to the 60,000 pounds (27,200 kg) or more weight category.

Source: CMT 2018.

AC 4B: Chapter 4

At this point in Step #3, AC 4B directs the planner to Chapter 4 of the advisory circular. Chapter 4 is used to determine runway lengths for aircraft greater than 60,000 pounds and require the usage of individual aircraft's Airport Planning Manuals (APM).

Using the G550 APM, procedures in Chapter 4 require both takeoff and landing runway lengths to be identified for the critical aircraft. Procedures for this include:

- Mean daily maximum temperature of the hottest month at the airport: 83° Fahrenheit
- Landing length chart requirements
 - Use highest flap setting chart
 - Enter weight axis equal to maximum certified landing weight
 - Use “wet runway” if APM provides a wet and dry runway option
 - Airport altitude above sea level: 647 feet
- Takeoff length chart requirements
 - Use dry runway takeoff chart
 - Apply zero wind and zero effective runway gradient conditions
 - Enter weight axis equal to maximum certified takeoff weight
 - The proposed project would remove current weight and payload constraints from users and allow them to make long-haul stage lengths; therefore, to obtain a realistic, real-world runway length, parameters assumed stage lengths equal to MTOW
 - Airport altitude above sea level: 647 feet

Using the APM, runway takeoff and landing length requirements were determined for the Gulfstream G550. It should be noted that owners of business jets that operate at CEA desire to use the full capacities of their aircraft. Although the majority of stage lengths of which aircraft regularly operate at CEA are 1,000 nautical miles or less, MTOW was used in the analysis to represent an unconstrained approach where business jets are able to utilize the full capabilities, or range, of the aircraft.

The APM charts used to determine required runway length are shown in Appendix Exhibit 3.

Appendix Exhibit 3: Gulfstream G550 Runway Length Determination

Parameters:

Mean Maximum Temperature for The Hottest Month: 83° F/28° C

Max Takeoff Weight: 91,000 lbs

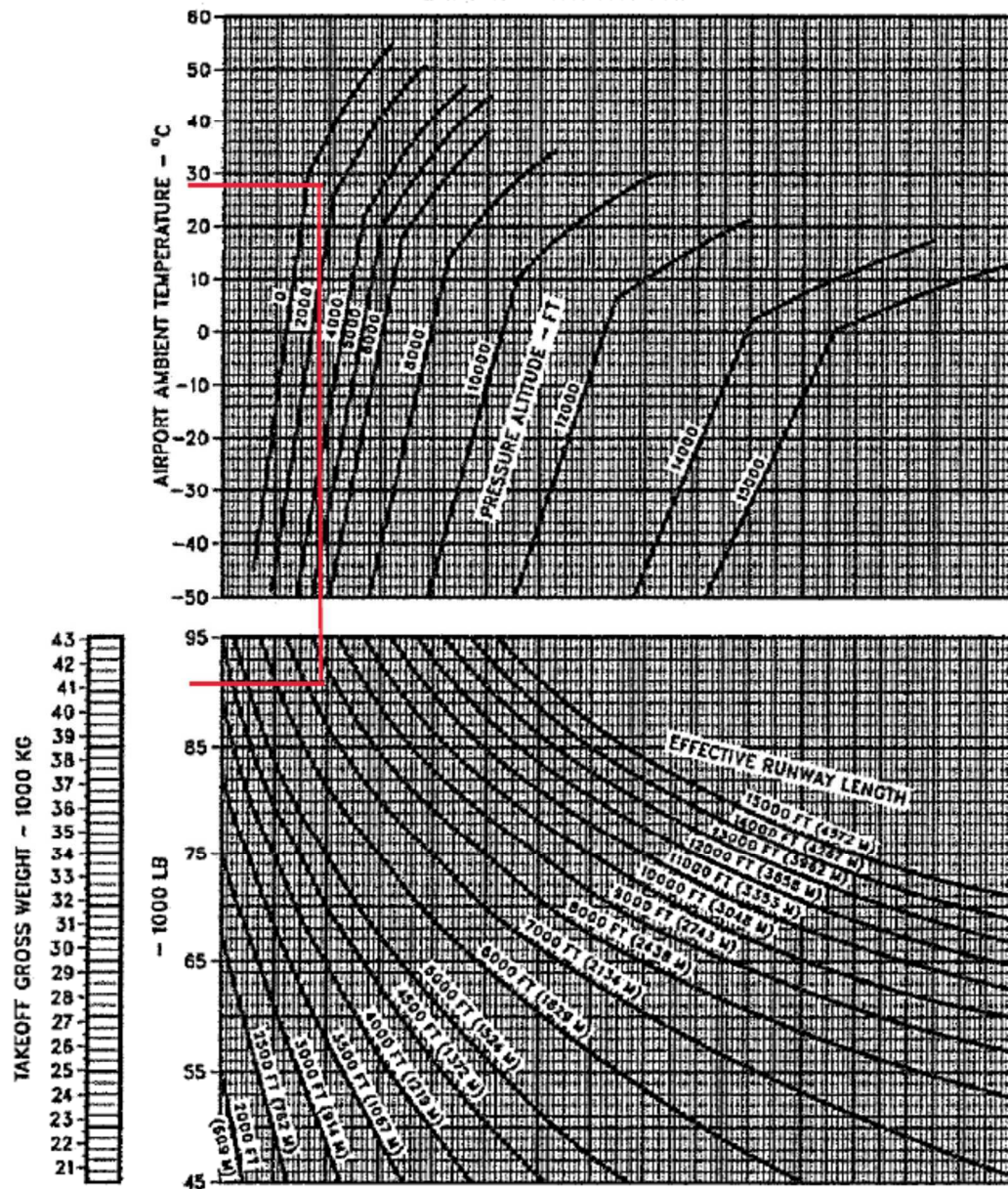
Max Landing Weight: 75,300 lbs

Elevation Above Sea Level: 647'

Takeoff Distance Required: 7,500'

GULFSTREAM G550 AIRPLANE FLIGHT MANUAL

LIMITATION EFFECTIVE RUNWAY LENGTH REQUIRED FLAPS 10° DRY RUNWAY



Landing Distance Required: 5,600'

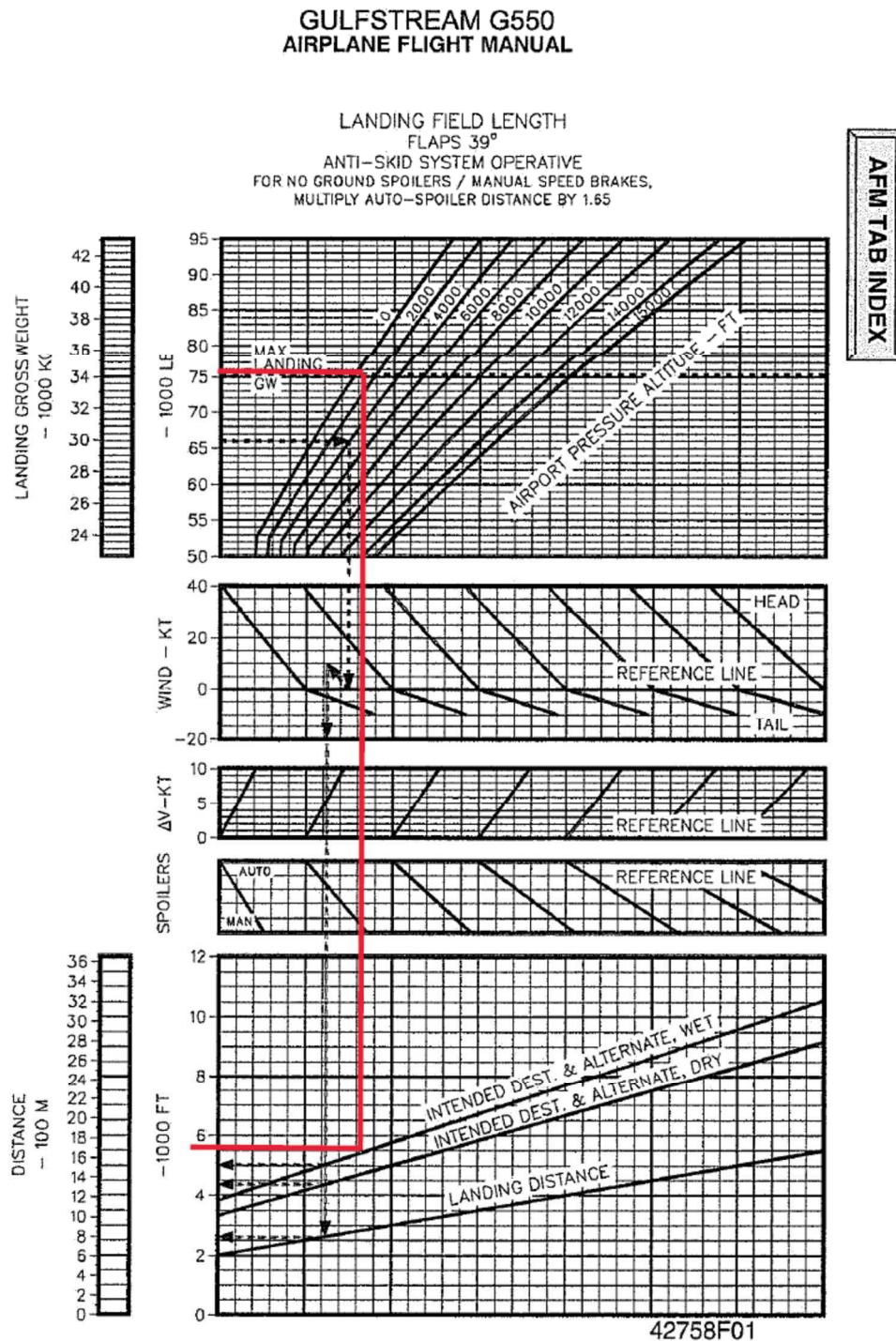


Figure 5. G550 Landing Field Length, Flaps 39°, Anti-Skid System Operative

Source: Gulfstream G550 "Airplane Flight Manual" Revision 29 FAA Approved May 27/09; CMT 2018

Step #4 “Select the recommended runway length from among the various runway lengths generated by Step #3 per the process identified in Chapters 2, 3, or 4, as applicable.”

This step summarizes the required runway lengths that are determined in Step # 3 when using more than one aircraft. In this case, the G550 was the only aircraft used to determine runway length requirements. The takeoff and landing distances determined in the previous step are shown in Appendix Table 3.

**Appendix Table 3:
Step #4 Recommended Runway Length Determinations**

Equipment	Takeoff Distance Required	Landing Distance Required
Gulfstream G550	7,500'	6,500'

Source: Gulfstream G550 “Airplane Flight Manual” Revision 29 FAA Approved May 27/09; CMT 2018

Step #5 “Apply any necessary adjustment to the obtained runway length, when instructed by the applicable chapter of this AC, to the runway length generated by step #4 to obtain a final recommended runway length.”

AC 4B allows certain adjustments to be made to the runway lengths generated in the previous step. Adjustments are applied per the guidance in Chapter 5 “Design Rationale.”

The only adjustment that can be applied to this analysis is an adjustment accounting for maximum difference of runway centerline elevation. This adjustment is obtained to approximate the operational increase required to overcome the uphill effective runway gradient. The adjustment allows for 10 feet of runway length to be added to the takeoff distance calculation for every 1 foot of centerline elevation difference between the low and high spots on the runway. Using CMT’s 2018 runway survey data, and using Runway 16/34 as a representative of the effective runway gradient, the low point of the runway is 640.282 feet above sea level and the high point is 644.448 feet above sea level – a difference of 4.166 feet. This allows for an additional 41.66 feet to be added to the takeoff distance required.

Appendix Table 4:
Final Recommended Runway Length Determinations

Element	Takeoff Length	Landing Length
G550 Step #3 Runway Length	7,500'	6,500'
Chapter 5 Gradient Adjustment	42'	-
FINAL RECOMMENDED RUNWAY LENGTH	7,542'	6,500'

Source: Gulfstream G550 "Airplane Flight Manual" Revision 29 FAA Approved May 27/09; CMT 2018; AC 150/5325-4B

Runway Length Determination Summary

AC 4B provides the criteria and guidance to determine the recommended runway length requirements at an airport. The Gulfstream G550 was identified in the Master Plan's previous chapter, Forecast, as the approved critical aircraft. Using the procedures of AC 4B's runway length analysis, both the takeoff and landing length requirements for the G550 were calculated. Using the more demanding of the G550's takeoff and landing requirements, the runway length analysis resulted in a recommended runway length for CEA to be 7,542 feet.