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of Transportation

**Federal Aviation
Administration**

Advisory Circular

Subject: RUNWAY LENGTH
REQUIREMENTS FOR AIRPORT DESIGN

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Change:

- 1. PURPOSE.** This Advisory Circular (AC) provides guidelines for airport designers and planners to determine recommended runway lengths.
- 2. CANCELLATION.** This advisory circular cancels Advisory Circular 150/5325-4A.
- 3. APPLICATION.** The standards and guidelines contained in this advisory circular are recommended by the Federal Aviation Administration strictly for use in the design of civil airports. The guidelines, the airplane performance data curves and tables, and the referenced airplane manufacturer manuals *are not to be used* as a substitute for flight planning calculations as required by airplane operating rules. For airport projects receiving Federal funding, the use of this advisory circular is mandatory.

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CHAPTER 1. INTRODUCTION

101. BACKGROUND. Airplanes today operate on a wide range of *available* runway lengths. Various factors in turn govern the *suitability* of those available runway lengths, most notably being the airport elevation above mean sea level, daily temperature, wind velocity, the airplane operating weights, landing flap settings, the runway surface characteristics, presences of obstructions in the vicinity of the airport, and, if any, locally imposed noise abatement restrictions or other prohibitions. Of these factors, certain ones have an operational impact on available runway lengths. That is, for a given runway the usable length made available by the airport authority may not be entirely *suitable* for all types of airplane operations. Fortunately, airport authorities, airport designers, and planners are able to mitigate various ones. For example, runways designed with longitudinal profiles equaling zero slope avoid required length adjustments. Independently, airport authorities working with their local lawmakers can establish zoning laws to prohibit the introduction of man-made structural obstructions that penetrate existing or planned runway approach and departure surfaces thereby avoiding displacements of runway thresholds or shorting takeoff lengths to permit airplanes sufficient clearance over man-made obstructions during climb outs. Airport authorities working with airport designers and planners should authenticate future runway demand by identifying the critical design airplanes. In particular, it is recommended that the evaluation process assess and verify the airport's ultimate development plan for realistic changes that could result in future operational limitations to customers. In summary, the goal is to construct an available runway length that is fully suitable for the forecasted critical design airplanes.

102. DETERMINING RECOMMENDED RUNWAY LENGTHS.

a. Procedure and Rationale for Determining Recommended Runway Lengths. The advisory circular 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 not to be used by pilots for flight operations. Pilots must consult 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 term "*substantial use*" quantifies the term "regular use" (see subsection b, Assumptions and Definitions, of this paragraph.)

(2) **Step #2.** Identify the airplanes that will require the most demanding runway lengths at maximum certificated takeoff weight (MTOW). The rationale at this stage of the procedure is to determine the applicable design concept. 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. The one exception is regional jets. Although a number of regional jets have 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 determined recommended runway length in the latter case is a direct function of the most demanding individual airplane's takeoff and landing operating weights, wing flap settings, airport elevation and temperature, runway surface conditions, and the maximum difference in runway centerline elevations. The procedure assumes no existence of obstructions that reduce the recommended runway lengths.

(3) **Step #3.** Apply table 1-1 to the airplanes from step #2. Table 1-1 categorizes *potential design airplanes* according to their MTOWs. This influential factor 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 (5,760 kg) or less, are further subdivided according to approach speeds and passenger seating as explained in chapter 2. Regional jets reside in the heaviest weight category. The second column identifies the applicable design concept 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 advisory circular or to obtain airplane manufacturers' airport planning manuals (APM) for each individual airplane under evaluation. In the later 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 advisory circular to obtain runway lengths. The airport designer should be aware that APMs go by a variety of names. For example, Airbus Industrie, the Boeing Company, Bombardier respectively title their APMs as “Maintenance Facility Planning Manuals,” “Airplane Characteristics for Airport Planning,” and “Airport Planning Manuals.” For the purpose of this advisory circular, the variously titled documents will be referred to as APM. Appendix 1 lists the websites of the various airplane manufacturers.

(4) **Step #4.** Select the recommended runway length from among the various obtained runway lengths generated by step #3.

(5) **Step #5.** Apply any necessary adjustment to the obtained runway length when instructed by the applicable chapter to the runway length generated by step #4 to obtain a single recommended runway length. For instance, a possible adjustment to the length is applying a correction multiplier for runways with non-zero longitudinal centerline profiles. Chapter 5 provides the rationale for the length adjustments.

b. Assumptions and Definitions.

(1) **Design Assumptions.** The assumptions used by this advisory circular are clear approaches and departures, zero wind, dry runway surfaces, zero effective runway gradients. Assumptions relative to airplane characteristics are described within the applicable chapter.

(2) **Critical Design Airplanes.** The selected list of airplanes (or a single airplane) that will be evaluated for their runway length demands, i.e., generates the longest runway length requirements. The listed airplanes will be evaluated either individually or as a single family grouping to obtain a recommended runway length.

(3) **Small Airplane.** An airplane of 12,500 pounds (5,760 kg) or less maximum certificated takeoff weight.

(4) **Large Airplane.** An airplane of more than 12,500 pounds (5,760 kg) maximum certificated takeoff weight.

(5) **Maximum Certificated Takeoff Weight (MTOW).** The maximum certificated weight for the airplane for takeoff, i.e., the airplane’s weight at the start of the takeoff run.

(6) **Regional Jets.** There is no unique definition for regional jets (RJ). As industry experienced, the introductory RJ models ranged from 32 to 50 passenger seats with MTOW starting at 32,000 pounds (14,545 kg). With the significant growth in RJ passenger service, larger and heavier RJs have entered service with passenger seating capacity exceeding 70 passengers. Hence, a common definition for RJ is a commercial jet airplane that carries fewer than 100 passengers.

(7) **Crosswind Runway.** An additional runway built to compensate primary runways whose runway orientation provides less than the recommended 95 percent wind coverage for the airplanes forecasted to use the airport on a regular basis.

(8) **Substantial Use.** Federally funded projects require that critical design airplanes have at least 500 or more annual itinerant operations (landings and takeoffs are considered as separate operations) for an individual airplane or a family grouping of airplanes. It is noted that under very unusual circumstances, adjustments may be made to the standard 500 total annual itinerant operations target after considering the circumstances of a particular airport. Two examples meeting this consideration are airports with demonstrated seasonal traffic variations or airports situated in isolated or remote areas that have special needs.

(9) **Itinerant Operation.** An operation involving a trip extending more than 20 miles from and/or to the airport.

(10) Effective Runway Gradient. The difference between the highest and lowest elevations of the runway centerline divided by the runway length.

Table 1-1. Airplane Weight Categorization for Design

Airplane Weight Category Maximum Certificated Takeoff Weight (MTOW)		Design Approach	Location of Design Guidelines	
12,500 pounds (5,760 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 (5,760 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 has a longer runway length than what is shown in figure 3-2, consult the airplane manufacturer’s APM. 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.

103. PRIMARY RUNWAY, ADDITIONAL PRIMARY RUNWAYS, AND DESIGN OBJECTIVES. The majority of airports provide a single primary runway. Airport authorities do, in certain cases, require two or more primary runways as a means of achieving specific airport operational objectives. The most common operational objectives are to (1) better manage the existing traffic volume that exceeds the capacity capabilities of the existing primary runway, (2) accommodate forecasted growth that will exceed the current capacity capabilities of the existing primary runway, or (3) mitigate noise impacts associated with the existing primary runway. Capacity-justified primary runways are parallel to and equal in length to the existing primary runway, unless a new runway is designed for smaller airplane, such as commuter service. Refer to AC 150/5060-5, *Airport Capacity and Delay*, for additional discussion. Another common practice is airport authorities assigning individual primary runways to separate airplane types, such as, general aviation from non-general aviation customers, as a means to increase the airport’s efficiency. The design objective for the main primary runway is to determine a recommended runway length that serves all airplanes without operational weight restrictions. The design objective for additional primary runways is shown in table 1-2. The table takes into account the separation of airplane types into distinct airplane design groups to achieve greater airport utilization. Follow the guidelines found in subparagraph 102(a) for determining recommended runway lengths for primary runways, and, for additional primary runways, apply table 1-2.

104. CROSSWIND RUNWAYS. The design objective to orient primary runways to capture 95 percent of the crosswind component perpendicular to the runway centerline is not always achievable. In those deficient cases, a crosswind runway is recommended to achieve the design standard (see AC 150/5300-13, *Airport Design*, for the standardized allowable crosswind components according to airplane design groups). Even when the 95 percentage crosswind coverage standard is achieved for the airplane design group, cases arise where certain airplanes with

lower crosswind certifications limitations as compared to airplanes with higher crosswind certification limitations are unable to utilize the primary runway. For airplanes that are crosswind limited, a crosswind runway may be built provided that there is regular usage. The design objective for the length of crosswind runways is shown in table 1-3. Procedurally, follow the guidelines found in subparagraph 102a for determining recommended runway lengths for crosswind runways, and, for additional primary runways, apply table 1-3.

Table 1-2. Runway Length for Additional Parallel Runways

Runway Service Type, User	Runway Length for Additional Primary Runway Equals
Capacity Justification, Noise mitigation Regional Jet Service	Main Primary Runway
Separating Airplane Type(s) - Commuter, Turboprop, General Aviation, Air Taxis	Recommended runway length for the airplane group

Table 1-3. Runway Length for Crosswind Runway

Runway Service	Runway Length for Crosswind Runway Equals
Scheduled ¹	100% of Primary Runway
Non-Scheduled ²	Wind Rose for the crosswind-limited airplanes lacking 95% wind coverage

Note ¹: Transport service operated over routes pursuant to published flight schedules which are openly advertised with dates or times (or both) or otherwise made readily available to the general public or pursuant to mail contracts with U.S. Postal service (Bureau of Transportation Statistics, Department of Transportation (DOT)).

Note ²: Revenue flights, such as charter flights that are not operated in regular scheduled service, and all non-revenue flights incident to such flights (Bureau of Transportation Statistics, DOT). For Federally funded programs, such as AIP, there must be at least 500 annual itinerant operations and 100% of the class.

105. RUNWAY LENGTH BASED ON DECLARED DISTANCES CONCEPT. The application of the declared distances concept to overcome safety deficiencies is not intended for new runways. New runways must meet design standards when constructed. See Advisory Circular 150/5300-13, appendix 14, for information related to declared distances.

106. COMPUTER PROGRAM. The airport design software cited in appendix 11 of Advisory Circular 150/5300-13, Airport Design for Microcomputers (AD42D.EXE), was developed for airport planners to facilitate in the planning of airport layouts. The computer program only provides estimates instead of actual length requirements. The design software is available at <http://www.faa.gov/arp/100home.cfm>

107. SELECTED RUNWAY LENGTH 14 CODE OF FEDERAL REGULATIONS. Appendix 2 provides selected 14 Code of Federal Regulations that address the operational requirements of airplanes using runways.

CHAPTER 2. RUNWAY LENGTHS FOR SMALL AIRPLANES WITH MAXIMUM CERTIFICATED TAKEOFF WEIGHT OF 12,500 POUNDS (5,760 KG) OR LESS

201. DESIGN GUIDELINES. The design procedure for small airplanes requires the following information: the critical design airplanes under evaluation, approach speed in knots (1.3 x stall speed), number of passenger seats; airport elevation above mean sea level, and the mean daily maximum temperature of the hottest month at the airport. Once obtained, apply the appropriate paragraph to obtain the recommended runway length. For this airplane weight category, no further adjustments to the obtained length from the figures 2 are necessary. For example, no operational requirement for an increase to the obtained runway length for takeoff is necessary to compensate for non-zero effective runway gradients.

202. DESIGN APPROACH. For purposes of design, this advisory circular provides a design concept for airports that serve only airplanes with a maximum certificated takeoff weight of 12,500 pounds (5,760 kg) or less. The design concept starts by grouping all small airplanes, that is, the critical design airplanes, according to approach speed. The highest approach speed group is divided on the basis of passenger seats, namely, “airplanes having fewer than 10 passenger seats” as compared to “airplanes having 10 or more passenger seats.” The less than 10 passenger seats category is further based on two percentages of fleet, namely, “95 percent of the fleet” or “100 percent of the fleet” categories, as explained in paragraph 205. For these airplanes, figures 2-1 and 2-2 show only a single curve that takes into account the most demanding operations to obtain the recommended runway length. Although both figures pertain mainly to small propeller driven airplanes, figure 2-2 does include small turbojet-powered airplanes. Airport designers can, instead of applying the small airplane design concept, determine the recommended runway length from airplane flight manuals for the airplanes to be accommodated by the airport in lieu of the runway length curves depicted in figures 2-1 or 2-2. For example, owners of multi-engine airplanes may require that their pilots use the airplane’s accelerate-stop distance in determining the length of runway available for takeoff.

203. SMALL AIRPLANES WITH APPROACH SPEEDS OF LESS THAN 30 KNOTS. Airplanes with approach speeds of less than 30 knots are considered to be short takeoff and landing or ultra light airplanes. Their recommended runway length is 300 feet (92 meters) at mean sea level. Runways located above mean sea level should be increased at the rate of 0.03 x airport elevation above mean sea level to obtain the recommended runway length at that elevation.

204. SMALL AIRPLANES WITH APPROACH SPEEDS OF 30 KNOT OR MORE BUT LESS THAN 50 KNOTS. The recommended runway length is 800 feet (244 meters) at mean sea level. Runway lengths above mean sea level should be increased at the rate of 0.08 x airport elevation above mean sea level to obtain the recommended runway length at that elevation.

205. SMALL AIRPLANES WITH APPROACH SPEEDS OF 50 KNOTS OR MORE WITH MAXIMUM CERTIFICATED TAKEOFF WEIGHT OF 12,500 POUNDS (5,760 KG) OR LESS. Figures 2-1 and 2-2 provide the recommended runway lengths based on the seating capacity and the mean daily maximum temperature of the hottest month of the year at the airport. The fleet used in the development of the figures consisted of small airplanes certificated in the United States. Figure 2-1 categorizes small airplanes with less than 10 passenger seats (excludes pilot and co-pilot) into two family groupings according to “percent of fleet,” namely, 95 and 100 percent of the fleet. Figure 2-2 categorizes all small airplanes with 10 or more passenger seats into one family grouping. Figure 2-2 further alerts the airport designer that for airport elevations above 3,000 feet (914 m), that the airport designer must use the 100 percent of fleet chart of figure 2-1 instead of using figure 2-2. As shown, both figures provide examples that start with the horizontal temperature axis then, proceed vertically to the applicable airport elevation curve, followed by proceeding horizontally to the vertical axis to read the recommended runway length.

a. Selecting Percentage of Fleet for Figure 2-1. The differences between the two percentage categories are based on the airport’s location and the amount of existing or planned aviation activities. The airport designer should make the selection based on the following criteria.

(1) 95 Percent of Fleet. This category applies to airports that are primarily intended to serve medium size population communities with a diversity of usage and a greater potential for increased aviation activities. Also included in this category are those airports that are primarily intended to serve low-activity

locations, small population communities, and remote recreational areas. Their inclusion was done because this group ultimately in many cases develops into airports with higher levels of aviation activities.

(2) **100 Percent of Fleet.** This type of airport is primarily intended to serve communities located on the fringe of a metropolitan area or a relatively large population community remote from a metropolitan area.

b. Future Airport Expansion Considerations. Airports serving small airplanes remain fairly constant in terms of the small airplane assortment and their associated operational requirements. However, the airport designer is recommended to assess and verify the airport's ultimate development plan for realistic changes that could result in future operational limitations to customers. The airport designer should at least assess the impacts of—

(1) Expansions to accommodate airplanes of more than 12,500 pound (5,760 kg). Failure to consider this change during an initial development phase may lead to the additional expenses of reconstructing or relocating facilities in the future.

(2) Requirements to operate the runway during periods of Instrument Meteorological Conditions (IMC). The requirement for this capability is highest among airplanes used for business and air taxi purposes.

206. DEVELOPMENT OF THE RUNWAY LENGTH CURVES. 14 Code of Federal Regulations Part 23, *Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes*, prescribes airworthiness standards for the issuance of small airplane type certificates. The performance information for each airplane (for example, as defined in *Section 23.51, Takeoff; Section 23.75, Landing; and Section 2.1587, Performance Information*) is contained in the individual airplane flight manual. This information is provided to assist the airplane operator in determining the runway length necessary to operate safely. Performance information from those manuals was selectively grouped and used to develop the runway length curves in figures 2-1 and 2-2. The major parameters utilized for the development of these curves were the takeoff and landing distances for figure 2-1 and the land, takeoff, and accelerate-stop distances for figure 2-2. The following conditions were used in developing the curves:

- a. Zero headwind component.
- b. Maximum certificated takeoff and landing weights.
- c. Optimum flap setting for the shortest runway length (normal operation).
- d. Airport elevation and temperature were left variable (values need to be obtained).
- e. Other factors, such as relative humidity and effective runway gradient, also have a variable effect on runway length but are not accounted for in certification. However, these other factors were accounted for in the runway length curves by increasing the takeoff or landing distance (whichever was longer) of the group's most demanding airplane by 10 percent for the various combinations of elevation and temperature.

f. 14 Code of Federal Regulations Part 135, *Operating Requirements: Commuter and On Demand Operations and Rules Governing Persons on Board such Aircraft*, imposes the operational requirements on operations conducted under this Part for those airplanes having a seating configuration of 10 passenger seats or more to include the accelerate-stop distance parameter in computing the required takeoff runway length. As previously mentioned, figure 2-2 included the accelerate-stop distance parameter.

Figure 2-1. Small Airplanes with Fewer than 10 Passenger Seats
(Excludes Pilot and Co-pilot)

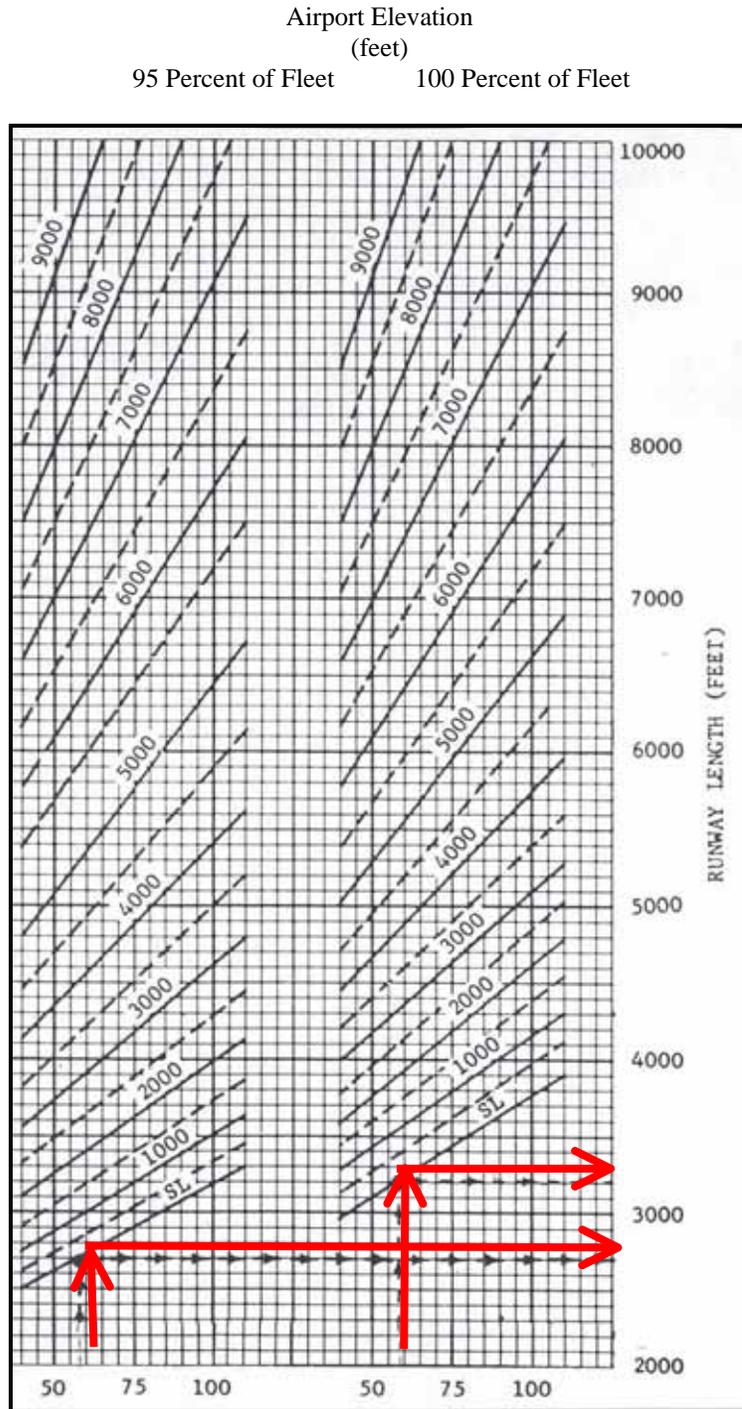
Example:

Temperature: 59° F (15° C)
Airport Elevation: Mean Sea Level

Note: Dashed lines shown in the table are mid values of adjacent solid lines.

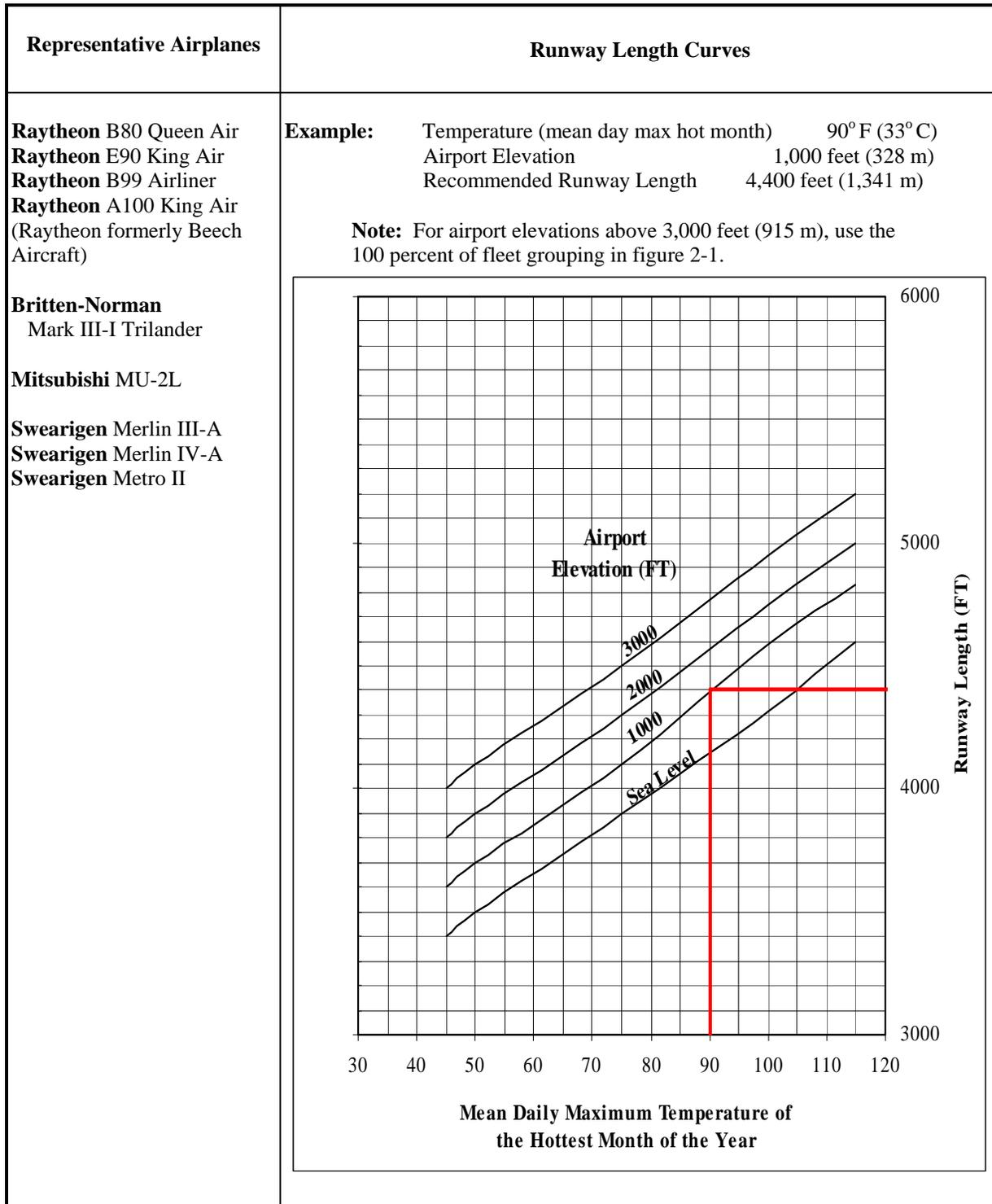
Recommended Runway Length:

For 95% = 2,700 feet (823 m)
For 100% = 3,200 feet (975 m)



Mean Daily Maximum Temperature of the Hottest Month of Year

Figure 2-2. Small Airplanes Having 10 or More Passenger Seats
(Excludes Pilot and Co-pilot)



**CHAPTER 3. RUNWAY LENGTHS FOR AIRPLANES WITH A MAXIMUM CERTIFICATED
TAKEOFF WEIGHT OF MORE THAN 12,500 POUNDS (5,760 KG), UP TO AND INCLUDING 60,000
POUNDS (27,200 KG)**

301. DESIGN GUIDELINES. The design procedure for this airplane weight category requires the following information: airport elevation above mean sea level, mean daily maximum temperature of the hottest month at the airport; the critical design airplanes under evaluation with their respective useful loads. Once obtained, apply either figure 3-1 or figure 3-2 to obtain a single runway length for the entire group under evaluation. Finally, apply any landing or takeoff length adjustments, if necessary, to the resulting runway length to obtain the recommended runway length.

302. DESIGN APPROACH. The recommended runway length obtained for this weight category of airplanes is based on performance curves (figures 3-1 and 3-2) developed from FAA-approved airplane flight manuals in accordance with the provisions of 14 Code of Federal Regulations Parts 25, *Airworthiness Standards: Transport Category Airplanes*, and 91, *General Operating and Flight Rules*. If the airport is planned for operations that will include only turbojet-powered airplanes weighing under 60,000 pounds (27,200 kg) MTOW and other small airplanes of 12,500 pounds (5,760 kg) or less, use the curves shown in either figures 3-1 or 3-2. To determine which of the two figures to apply, use tables 3-1 and 3-2 to determine which of the two “percentage of fleet” categories represents the critical design airplanes under evaluation. With that determination, then select either the “60 percent useful load” curves or the “90 percent useful load” curves on the bases of the haul lengths and service needs of the critical design airplanes. **Note:** at elevations over 5,000 feet (1,524 m) above mean sea level, the recommended runway length obtained for small airplanes from chapter 2 may be greater than those obtained by these figures. In this case, the requirements for the small airplane govern. Finally, the curves of figures 3-1 and 3-2 provide recommended runway lengths for elevations up to 8,000 feet (2,439 m) above mean sea level. For higher elevations, consult the airplane manufacturer(s) for their recommendations.

303. PERCENTAGE OF THE FLEET AND USEFUL LOAD FACTOR. The curves in figure 3-1 and 3-2 are based on a grouping of only the business jet fleet according to performance capability as contained in the FAA-approved airplane manuals under an assumed loading condition. Interpolation between the set of curves is not valid since each set assumed a specific, non-variable loading condition. Figures 3-1 and 3-2 contain a set of two curves based upon the percentage of the fleet and the percentage of useful load that can be accommodated by the runway lengths obtained from the curves. For example, the “75 percent fleet at 60 percent useful load” curve provides a runway length *sufficient to satisfy the operational requirements* of approximately 75 percent of the fleet at 60 percent useful load. This figure is to be used for those airplanes operating with at least a 60 percent useful load factor. Finally, both figures 3-1 and 3-2 provide examples that start with the horizontal temperature axis, then proceed vertically to the airport elevation curve, and finally proceed horizontally to the vertical axis to obtain the runway length. The final step is to apply any necessary length adjustments according to paragraph 304 to the obtained length to obtain the recommended runway length.

a. Percentage of Fleet.

(1) **Tables 3-1 and 3-2.** Table 3-1 provides the list of those airplanes that comprise the “75 percent of fleet” category and therefore can be accommodated by the runway lengths resulting from figure 3-1. Table 3-2, provides the remaining airplanes beyond that of table 3-1 that comprise the “100 percent of fleet” category and therefore can be accommodated by the resulting runway lengths from figure 3-2.

(2) **Selecting Figures 3-1 or 3-2.** The airport designer must determine from which list the airplanes under evaluation are found. Use figure 3-1 when the airplanes under evaluation are not listed in table 3-2. If a relatively few airplanes are listed in table 3-2, then figure 3-2 should be used to determine the runway length. If no adjustments to this length are necessary, then this length becomes the recommended runway length.

b. Useful Load Factor.

(1) The term *useful load factor* of an airplane for this advisory circular is considered to be the difference between the maximum allowable structural gross weight and the operating weight empty. A typical

operating weight empty includes the airplane's empty weight, crew, baggage, other crew supplies, removable passenger service equipment, removable emergency equipment, engine oil, and unusable fuel. In other words, the useful load then consists of passengers, cargo, and usable fuel. It is noted that although *operating empty weight* varies considerably with individual airplanes, the curves used in the figures were based on the average operating empty weights of numerous business jets.

(2) Figures 3-1 and 3-2 provide only two useful load percentages, namely "60 percent useful load" and "90 percent useful load," and not for airplanes operating at "100 percent useful load. Curves are not developed for operations at "100 percent useful load" because many of the airplanes used to develop the curves in figures 3-1 and 3-2 were operationally limited in the second segment of climb. That is, the allowable gross takeoff weight is often limited by ambient conditions of temperature and elevation to an operating weight that is less than their maximum structural gross weight. Therefore, APMs contain climb limitations when required. Because of the climb limitation, the runway length resulting from the "90 percent useful load" figures is considered by this advisory circular to approximate the limit of beneficial returns for the runway. A specific list of business jets were used to obtain an average operating empty weight, which in turn, was used to develop the curves.

c. Privately Owned Business Jets. Business jets that are privately owned are included in their respective 75 percent and 100 percent of fleet categories.

d. Air Carrier Regional Jets. As previously mentioned, the recommended runway lengths for regional jets for air carrier service are addressed in chapter 4.

304. RUNWAY LENGTH ADJUSTMENTS. The runway lengths obtained from figures 3-1 and 3-2 are based on no wind, a dry runway surface, and zero *effective runway gradient*. Effective runway gradient is defined as the difference between the highest and lowest elevations of the runway centerline divided by the runway length. Therefore, increase the obtained runway lengths from the figures to account for (1) takeoff operations when the effective runway gradient is other than zero and (2) landing operations of turbojet-powered airplanes under wet and slippery runway surface conditions. These increases are not cumulative since the first length adjustment applies to takeoffs and the latter to landings. When both adjustments are made the larger resulting runway length becomes the recommended runway length. The procedures for length adjustments are as follows:

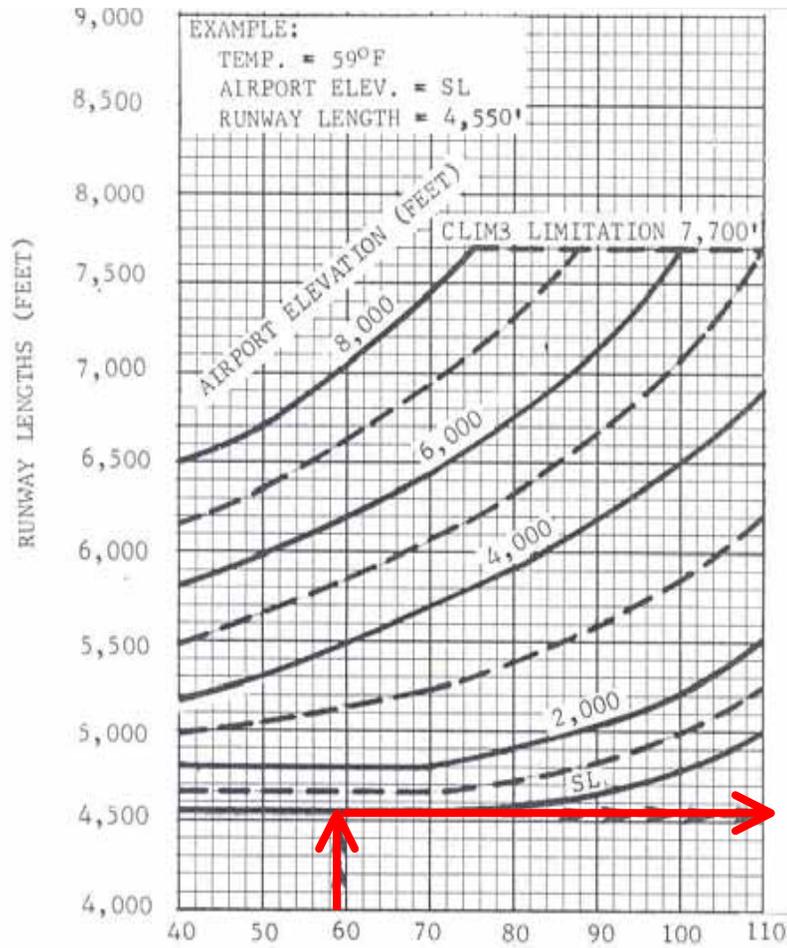
a. Non-Zero Effective Runway Gradient (Takeoff Only). The runway lengths obtained from figures 3-1 or 3-2 are increased at the rate of 10 feet (3 meters) for each foot (0.3 meters) of elevation difference between the high and low points of the runway centerline.

b. Wet and Slippery Runways (Applicable Only to Landing Operations of Turbojet-Powered Airplanes). The runway length for turbojet-powered airplanes obtained from the "60 percent useful load" curves are increased by 15 percent up or up to 5,500 feet (1,676 meters), whichever is less. The runway lengths for turbojet powered airplanes obtained from the "90 percent useful load" curves are also increased by 15 percent up or to 7,000 feet (2,133 meters), whichever is less. No adjustment is necessary by regulation for turboprop-powered airplanes.

305. PRECAUTION FOR AIRPORTS LOCATED AT HIGH ALTITUDES. At elevations above 5,000 feet (1,524 m) mean sea level, the recommended runway length for *propeller* driven airplanes of 12,500 pounds (5,760 kg) or MTOW found in chapter 2 may be *greater* than those determined in this chapter for turbojet-powered airplanes. In this case, the longer recommended runway length of the small airplane weight category must be provided.

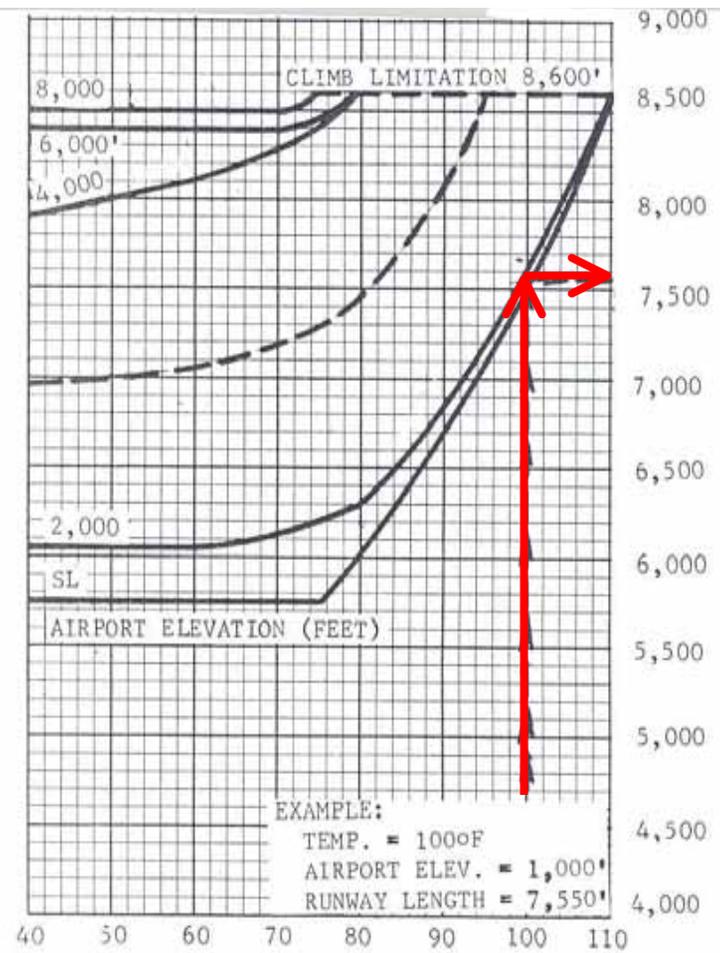
306. GENERAL AVIATION AIRPORTS. General aviation (GA) airports have witnessed an increase use of their primary runway by scheduled airline service and privately-owned business jets. Over the years business jets have proved themselves to be a tremendous assets to corporations by satisfying their executive needs for flexibility in scheduling, speed, and privacy. In response to these types of needs, GA airports that receive regular use by large airplanes over 12,500 pounds (5,760 kg) MTOW, in addition to business jets, should provide a runway length comparable to non-GA airports. That is, the extension of an existing runway can be justified at an existing GA airport that has a need to accommodate heavier airplanes on a frequent basis.

Figure 3-1. 75 Percent of Fleet at 60 and 90 Percent Useful Load



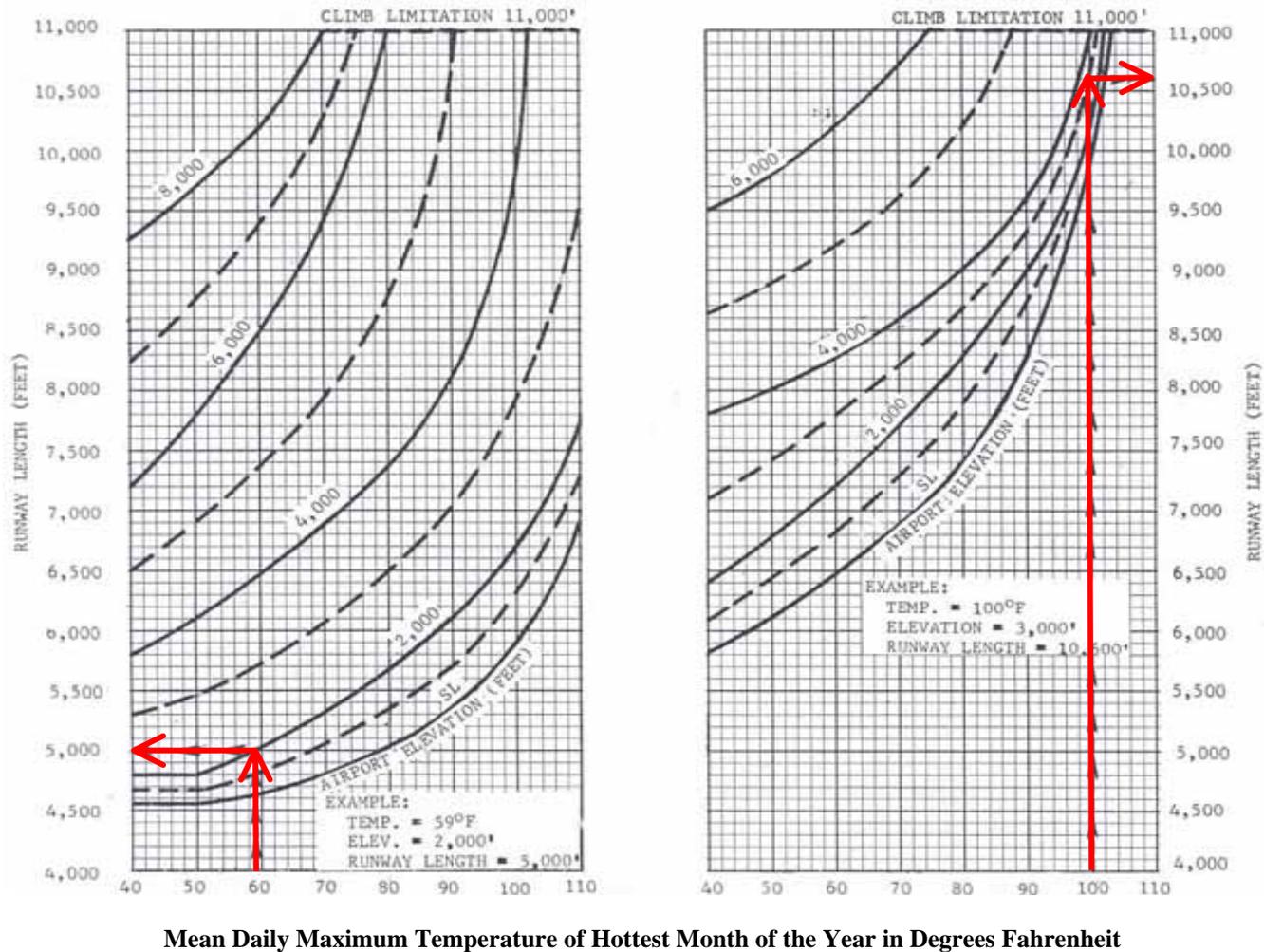
Mean Daily Maximum Temperature of Hottest Month of the Year in Degrees Fahrenheit

75 percent of feet at 60 percent useful load



75 percent of feet at 90 percent useful load

Figure 3-2. 100 Percent of Fleet at 60 and 90 Percent Useful Load



100 percent of feet at 60 percent useful load

100 percent of feet at 90 percent useful load

Table 3-1. Airplanes that Make Up 75 Percent of the Fleet

Manufacturer	Model
Aerospatiale	Sn-601 Corvette
Bae	125-700
Beech Jet	400a/T/ T-1a Jayhawk
Cessna	500 Citation
Cessna	525A Citationjet II (CJ-2)
Cessna	550 Citation Bravo
Cessna	550 Citation II
Cessna	551 Citation II/Sp
Cessna	552/T-47A
Cessna	560 Citation Encore
Cessna	560 Citation Excel
Cessna	560 Citation V Ultra
Cessna	650 Citation VII
Cessna	S550 Citation S/II
Dassault	Falcon 10
Dassault	Falcon 20

Manufacturer	Model
Dassault	Falcon 50
Hawker-Siddeley	125-400
Hawker-Siddeley	125-600
IAI	Jet Commander 1121
IAI	Westwind 1123/1124
Learjet	20 Series
Learjet	31
Learjet	35/36
Learjet	45
Mitsubishi	Mu-300 Diamond
Raytheon	390 Premier
Sabreliner	40
Sabreliner	60
Sabreliner	75a/80
Sabreliner	T-39

Table 3-2. Remaining 25 Percent of Airplanes that Make Up 100 Percent of Fleet

Manufacturer	Model
Bombardier	Cl-600 Challenger
Bombardier	Cl-601 Challenger
Bombardier	Cl-601-3a/3r Challenger
Bombardier	Cl-604 Challenger
Cessna	650 Citation III/VI
Cessna	750 Citation X
Dassault	Falcon 2000
IAI	Astra 1125
IAI	Galaxy 1126
Learjet	35/36
Learjet	55
Learjet	60
Raytheon/Hawker	125-1000 Horizon
Raytheon/Hawker	125-800
Sabreliner	65
Sabreliner	75
Dassault Falcon	900
Dassault Falcon	900 Ex

Note: Airplanes in tables 3-1 and 3-2 combine to comprise 100% of the fleet.

CHAPTER 4. RUNWAY LENGTHS FOR REGIONAL JETS AND AIRPLANES WITH A MAXIMUM CERTIFICATED TAKEOFF WEIGHT OF MORE THAN 60,000 POUNDS (27,200 KG)

401. DESIGN GUIDELINES. 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 or takeoff operating weight for short-haul routes, maximum certificated landing weight, airport elevation above mean sea level, and the mean daily maximum temperature of the hottest month at the airport. Apply the procedures in this chapter to each APM to obtain separate takeoff and landing runway requirements. Apply any takeoff and landing length adjustments, if necessary, to the resulting lengths.

402. DESIGN APPROACH. The recommended runway length obtained for this weight category of airplanes is based on using the performance charts published by airplane manufacturers, i.e., APMs, or by contacting the airplane manufacturer for the information. Regardless of the approach taken by the airport designer, the design procedure described below must be applied to the information/performance charts. Both takeoff and landing runway length requirements must be determined with applicable length-adjustments in order to determine the recommended runway length. The longest of the takeoff and landing length requirements for the critical design airplanes under evaluation becomes the recommended runway length.

a. APM. Each airplane manufacturer APM offers performance information on takeoff and landing runway length requirements for different airplane operating weights, airport elevations, flap settings, engine types, and other parameters. It is noted that all airplane manufacturers do not present the data in a standard format. However, there is sufficient consistency in the presentation of the information that allows their application after following the procedure below.

b. United States Federal Aviation Regulations (FAR) and European Joint Aviation Authority Regulations (JAR). Some APM charts provide curves for both FAR and JAR regulations. In those cases, the airport designer must use the curved labeled “FAR.” The JAR is now called the European Aviation Safety Agency (EASA).

c. Airplane Manufacturer Website. Appendix 1 provides the website addresses of the various airplane manufacturers to assist in obtaining APMs or further consultation.

403. PROCEDURES FOR DETERMINING RECOMMENDED RUNWAY LENGTH. Determine both takeoff and landing length requirements as prescribed below, select the longest resulting takeoff and landing lengths, then apply any length adjustments described in the following subparagraphs. The longest resulting runway length between the takeoff and landing lengths for the critical design airplanes under evaluation becomes the recommended runway length. *It is noted that the charts used in this procedure are provided by the airplane manufacturers for information only and not for flight operations. The pilot must use the FAA-approved flight manuals to conduct flight operations.* Appendix 3 offers several examples that employ the design guidelines and procedures.

a. APM and the Standard Day Parameter. The design procedure interrelates the value for design parameter “mean daily maximum temperature of the hottest month at the airport” with the APM parameter “standard day (SD).” This relationship permits the airport designer to use published SD charts that fall within the temperature range of $-5^{\circ}\text{ F} \leq (\text{available SD chart}) \leq +3^{\circ}\text{ F}$ [$-2^{\circ}\text{ C} \leq (\text{available SD chart}) \leq +1^{\circ}\text{ C}$]. The principle use of SD charts is for determining the takeoff length requirements of the critical design airplanes under evaluation. Table 4-1 illustrates the variation in the standard day (SD) temperatures according to airport elevation above mean sea level. Almost all APMs provide takeoff charts with various SD conditions, that is, the SD from table 4-1 and SD chart(s) with added temperatures. For example, an APM may provide the basic SD with the additional chart for SD + 27° F (+15° C). The latter chart, SD + 27° F (+15° C), could be used when an airport located at sea level has a “mean daily maximum temperature of the hottest month at the airport” equal to 86° F (32° C) or for temperature values within the range $-5^{\circ}\text{ F} \leq (\text{available SD chart}) \leq +3^{\circ}\text{ F}$ [$-2^{\circ}\text{ C} \leq (\text{available SD chart}) \leq +1^{\circ}\text{ C}$]. If no SD chart is available, consult the airplane manufacturers to obtain the takeoff length requirements under the same conditions outlined in this paragraph. Airport temperature is not used for landing length determinations.

Table 4-1. Relationship Between Airport Elevation and Standard Day Temperature

Airport Elevation		Standard Day (SD) Temperature	
Feet	Meters	° F	° C
0	0	59.0	15.00
2,000	609	51.9	11.04
4,000	1,219	44.7	7.06
6,000	1,828	37.6	3.11
8,000	2,438	30.5	-0.85

b. Landing Length Requirements. For the airplane derivative with corresponding engine type under evaluation:

(1) Locate the landing chart with the highest landing flap setting, zero wind, and zero effective runway gradient at standard day conditions. In almost all cases the charts will state “standard day condition(s).” If the chart does not indicate the “zero wind” or “zero effective runway” conditions, assume they are equal to zero.

(2) Enter the horizontal weight axis with the operating landing weight equal to the maximum certificated landing weight. Interpolation along the weights is allowed. Do not exceed any indicated limitations on the chart.

(3) Proceed vertically to the airport elevation curve. Interpolation between curves is allowed. It is noted that some charts simultaneously use both the “dry runway” and “wet runway” curves. Use the “wet runway” curve. Wet runway conditions are required only for turbojet-powered airplanes (see paragraph 508).

(4) Proceed horizontally from the wet runway curve to the length axis to read the runway length. Interpolation along the length axis is allowed.

(5) Increase the obtained landing length for “dry runway” condition by 15 percent for those cases noted in paragraph 508. No landing length adjustment is necessary by regulation for non-zero effective runway gradients for any airplane type.

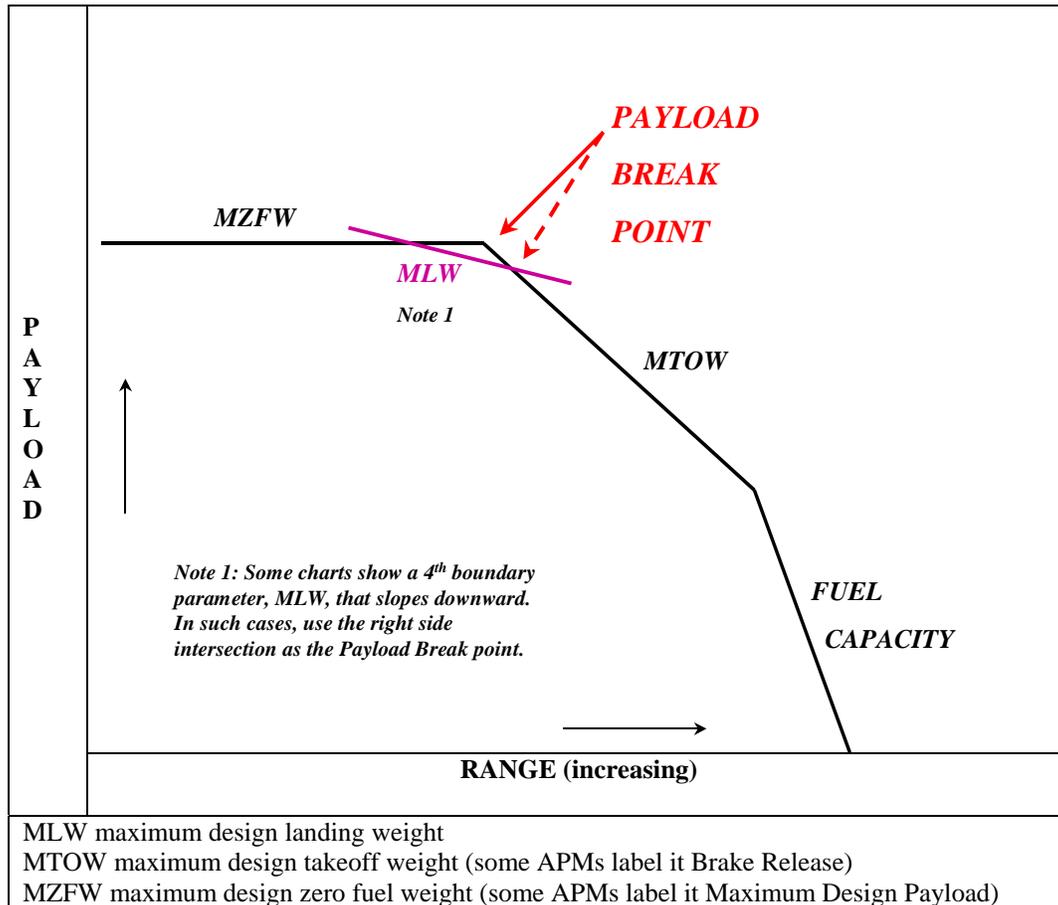
c. Takeoff Length Requirements. For the airplane derivative with corresponding engine type under evaluation, locate the takeoff chart with dry runway, zero wind, and zero effective runway gradient conditions for the appropriate standard day condition. Generally, the chart will be the chart with an *increased standard day plus a value condition*. If the chart does not indicate the “zero wind” or “zero effective runway gradient” conditions, assume they are equal to zero, but this is not a conservative assumption.

(1) Locate the chart with the appropriate standard day condition. Under this condition, if several charts are provided for more than one flap setting, select the chart with the flap setting that yields the shortest takeoff length.

(2) Enter the horizontal weight axis with the operating takeoff weight. The length of haul, or range, determines the operating takeoff weight for the design airplanes under evaluation. Long-haul routes should set the operating takeoff weight equal to the MTOW while short-haul routes should apply the actual operating takeoff weight. The Payload Break point, defined by the *Payload-Range* chart of the APM for the design

airplane(s), classifies the length of haul. Figure 4-1 illustrates a generic Payload-Range chart with Range and Payload axes, the Payload Break point, and the boundary parameters. For ranges that equal or exceed the Payload Break point, the operating takeoff weight is set equal to the MTOW. For all the other cases, the actual operating takeoff weight is used. For the latter case, *AC 120-27D, Aircraft Weight and Balance Control*, provides average weight values for passengers and baggage for payload calculations for short-haul routes.

Figure 4-1. Generic Payload-Range Chart



(3) Proceed vertically to the airport elevation curve without exceeding any indicated limitations, such as, maximum brake energy limit, tire speed limit, etc. Interpolation between the curves is allowed. It is noted that some airport elevations curves are labeled with flap settings, some with more than one indicated flap setting along the curve. In such cases, continue to use the same airport elevation curve.

(4) Proceed horizontally from the airport elevation curve to the length axis to read the takeoff length. Interpolation along the length axis is allowed.

(5) Adjust the obtained takeoff length for non-zero effective runway gradients (see paragraph 509). In those cases the airport designer must increase the obtained length by 10 feet (3 m) per foot (0.3 m) of difference in runway centerline elevations between the high and low points of the runway centerline elevations.

d. Final Recommended Runway Length. The recommended runway length is the longest resulting length after any adjustments for all the critical design airplanes that were under evaluation.

404. EXAMPLES. Appendix 3 provides example scenarios utilizing APM performance charts.

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CHAPTER 5. DESIGN RATIONALE

501. INTRODUCTION. This chapter explains the application of eight factors that affect runway lengths. Previous chapters describe how to use performance curves and tables to determine required runway length. However, the airport designer has the option to determine the recommended runway length by obtaining data provided in airplane flight manuals and then equally applying the eight variable factors discussed in this chapter and all other factors mentioned in the respective chapters in a manner to produce the shortest runway length. Table 5-1 summarizes the eight variable factors.

502. AIRPLANES. The design criterion is to catalog the current or forecasted critical design airplanes that will use the runway on a regular basis and require the longest runway length requirements.

503. LANDING FLAP SETTINGS. The design criterion is to select the landing flap setting that produces the shortest runway length. Figures in chapters 2 and 3 are based on this design criterion. Chapter 4, which relies on the use of APM, directs the airport designer to select from among the certificated landing flap settings the single setting that generates the shortest runway length.

504. AIRPLANE OPERATING WEIGHTS. The recommended runway length is based on realistic operating weights during takeoff and landing operations. These realistic weights are normally the operating weights of airplanes conducting regular operations over a specific length of haul. For existing runways the landing weight is the least of the maximum allowable landing weight under specific conditions. As shown in subparagraph 504a, three conditions affect the maximum allowable landing weight. For existing runways the takeoff weight is the least of the maximum allowable takeoff weight under specific conditions. As shown in subparagraph 504b, six conditions affect the maximum allowable takeoff weight.

a. Maximum Allowable Landing Weight. The airplane's maximum allowable landing weight is the least of the following three conditions:

- (1) Maximum structural landing weight
- (2) Climb limited landing weight
- (3) Runway length-limited landing weight (insufficient available runway length).

b. Maximum Allowable Takeoff Weight. The airplane's maximum allowable takeoff weight is the least of the following:

- (1) Maximum structural takeoff weight
- (2) Climb limited takeoff weight
- (3) Tire speed limited takeoff weight
- (4) Takeoff weight limited by maximum landing weight
- (5) Obstacle clearance limited takeoff weight
- (6) Runway length-limited takeoff weight (insufficient available runway length).

c. Operating Weights for Design. The design criterion is based on the following:

(1) **Small Airplanes 12,500 pounds (5,760 kg) or less MTOW.** Figures 2-1 and 2-2 along with the guidelines in chapter 2 provide recommended runway lengths by a single curve that incorporated both maximum allowable takeoff and landing weights.

(2) **Large Airplanes over 12,500 pound (5,760 kg) MTOW.**

i. **Chapter 3.** The curves of figures 3-1 and 3-2 provide runway lengths based on the percentage of fleet and percent of useful load. The curves used the lesser of the maximum allowable takeoff and landing weights as described above or the weight of the airplane with useful load.

ii. **Chapter 4, Using Airplane Planning Manuals (APMs).**

(a) For landing, use the maximum allowable landing weight excluding limitations of subparagraph 504a(3). In nearly all cases, the weight is set to the maximum structural landing weight.

(b) For takeoff, use the length of haul (range) and compare it to the Payload Break point of the Payload-Range chart. For ranges greater than or equal to the Payload Break point, set the operating takeoff weight equal to MOTW excluding limitations of subparagraph 504b(5) and (6), i.e., long-haul routes. For ranges less than the Payload Break point, use the calculated operating takeoff weight for the given range, i.e., short-haul routes. In many cases, the weight is set to the MTOW, resulting in a runway that permits airplanes to operate at full payload service capabilities.

505. AIRPORT ELEVATION. The design criterion is to substitute airport elevation above mean sea level for pressure altitude. This substitution is acceptable since the two are approximately equal and the probability of these conditions occurring simultaneously is relatively remote. Therefore, any difference would be slight.

506. TEMPERATURE. The design criterion is to use the mean daily maximum temperature of the hottest month at the airport. This temperature is readily available and yields a realistic operational length.

a. **Application.** Airport designers using chapters 2 and 3 are to apply the actual temperature value to the provided figures. Airport designers using an APM are to employ either the tables from the APM when the actual temperature falls within a prescribed temperature range or, when it falls outside the prescribed temperature range, to contact the airplane manufacturer directly for the applicable runway table.

b. **Availability of Temperature Data.** This information can be obtained from the publication “Monthly Station Normals of Temperature, Precipitation, and Heating and Cooling Degree-Days” (Climatology of the United States No.81). This is the official source for the mean maximum temperature for the hottest month. The latest data, averaged over a period of thirty years, may be obtained from the National Climatic Data Center, Federal Building, Asheville, North Carolina 28801. Phone: (828) 271-4800; fax: (828) 271-4876; or website: <http://www.ncdc.noaa.gov/oa/ncdc.html> (specify the state when ordering).

507. WIND. The design criterion is based on the condition of zero wind velocity for both takeoff and landing operations for all airplane weight categories. The figures in chapters 2 and 3 are based on zero wind conditions. Users of APM are instructed to select the zero wind curves.

508. RUNWAY SURFACE CONDITIONS. The design criterion is to address wet, slippery runway surface conditions for only landing operations, for only turbojet-powered airplanes. 14 Code of Federal Regulations requires an increase to the landing operations, not takeoff operations, for only turbojet-powered airplanes to allow for landing operations on wet or slippery runways. Therefore, the obtained runway lengths from this advisory circular for turbojet-powered airplanes are further increased by 15 percent. Many airplane manufacturers’ APMs for turbojet-powered airplanes provide both dry runway and wet runway landing curves. If an APM provides only the dry runway condition, then increase the obtained dry runway length by 15 percent. The landing portion of the curves in figures 3-1 and 3-2 are based on dry runway conditions. Thus, as instructed by chapter 3, increase the landing dry lengths for turbojet-powered airplanes by 15 percent to increase the landing, but not more than 5,500 feet (1,676 meters), whichever is less. The adjustment is for design purposes and not for flight operations.

509. MAXIMUM DIFFERENCE OF RUNWAY CENTERLINE ELEVATION. The design criterion is to address uphill longitudinal runway profiles for takeoff operations of large airplanes. A runway whose centerline elevation varies between runway ends produces uphill and downhill conditions, which in turn, cause certain airplane

weight categories to require longer operational lengths. This advisory circular addresses the uphill condition, termed “*effective runway gradient*,” for *takeoff* operations by using the maximum difference of runway centerline elevation. For airplanes over 12,500 pounds (5,760 kg) maximum certified takeoff weight, the recommended runway length for takeoff derived from the curves of figures 3-1 and 3-2 or from the APMs must be increased by 10 feet per foot of difference in centerline elevations between the high and low points of the runway centerline elevations. Airport designers using APMs also apply the same adjustment because APMs apply zero effective runway gradients to their takeoff curves. This adjustment to the obtained runway length approximates the operational increase required to overcome the uphill effective runway gradient. For airplanes of 12,500 pounds (5,760 kg) or less MTOW, no operational requirement for an increase to the obtained runway length for takeoff is necessary to compensate for non-zero effective runway gradients. In the case for landing operations, no operational requirement for an increase to the obtained runway length for landing is necessary to compensate for non-zero effective runway gradients.

Table 5-1. Rational Behind Recommendations for Calculating Recommended Runway Lengths

Variable Factors and Paragraph References		Family Groupings Consult Advisory Circular			Airplane Performance Characteristics Non-Turbojet/Turbojet (Consult Airplane Manufacturer's Airport Planning Manuals (APM) Chapter 4)
		Figures			
		2-1 and 2-2	3-1	3-2	
Airplane Type (Paragraph 502)		Based on number of seats	Based on percent of fleet		Specific manual for each airplane
Flap Setting (Paragraph 503)		Shortest runway length			Shortest runway length
Operating Weights (Paragraph 504)	Takeoff	Maximum takeoff weight	Based on percent of useful load		Located in airplane general characteristics
	Landing	Maximum landing weight	Based on percent of useful load		Located in airplane general characteristics
Airport Elevation (Paragraph 505)		Indicated on AC curves			Indicated on APM curves
Temperature (Paragraph 506)	Takeoff	Indicated on AC curves			Indicated on APM curve
	Landing	Indicated on AC curves	Independent of results		Independent of results
Wind (Paragraph 507)	Takeoff	Zero wind			Zero wind
	Landing	Zero wind			Zero wind
Runway Surface Conditions (Paragraph 508)	Takeoff	Independent of results			Independent of results
	Landing	Independent of results	Dry		Wet
Difference in Centerline Elevation (Paragraph 509)	Takeoff	Independent of results	Zero		Zero
	Landing	Independent of results			Independent of results
Runway Length for Takeoff		Airplane takeoff distance	Larger of airplane takeoff distance or accelerated stop distance		Larger of airplane takeoff distance or accelerated stop distance
Runway Length for Landing		Airplane takeoff distance	Airplane dry landing distance divided by 0.6		If available, airplane wet landing distance divided by 0.6. Otherwise, airplane dry landing distance divided by 0.6 then multiplied by 1.15

APPENDIX 1. WEBSITES FOR AIRPLANES OVER 60,000 POUNDS (27,200 KG)

Airplane Manufacturers	Website
Aerospatiale Matra	www.aeromatra.com
Airbus Industrie	www.airbus.com
Antonov	www.antonovaircargo.com
BAE Systems	www.baesystems.com
Boeing	www.boeing.com
Bombardier	www.bombardier.com
Bristol	www.baesystems.com
Canadair	www.canadair.com
Dassault Aviation	www.dassault-avation.com
de Havilland	www.dhsupport.com
Embraer	www.embraer.com
Fairchild Dornier	www.fairchilddornier.com
Fokker	www.fokker.com
General Dynamics	www.generaldynamics.com
Grumman	www.northgrum.com
Gulfstream	www.gulfstream.com
Hawker Siddeley	www.bombardier.com
Ilyushin	No existing web page Mailing address: 45g Leningradsky Prospekt 125190 Moscow Phone: 7 (095) 157-3312
Kawasaki	www.khi.co.jp
Lockheed Martin	www.lmco.com
MAI	www.merlinaircraft.com
Marshall	http://www.marshall-group.co.uk/
McDonnell Douglas	www.boeing.com

Airplane Manufacturers	Website
Short Brothers	www.bombardier.com
Tupolev	www.tupolev.ru
Vickers	www.vickers-aircraft.com

APPENDIX 2. SELECTED FEDERAL AVIATION REGULATIONS CONCERNING RUNWAYS

Part	Section
Part 23: Airworthiness standards: Normal, utility, acrobatic, and commuter category airplanes	Section 45: General
Part 25: Airworthiness standards: Transport category airplanes	Section 105: Takeoff
Part 25: Airworthiness standards: Transport category airplanes	Section 109: Accelerate-stop distance
Part 25: Airworthiness standards: Transport category airplanes	Section 113: Takeoff distance and takeoff run
Part 91: General operating and flight rules	Section 605: Transport category civil airplane weight limitations
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 173: General
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 177: Airplanes: Reciprocating engine-powered: Takeoff limitations
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 189: Airplanes: Turbine engine powered: Takeoff limitations
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 195: Airplanes: Turbine engine powered: Landing limitations: Destination airports
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 197: Airplanes: Turbine engine powered: Landing limitations: Alternate airports
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 199: Non-transport category airplanes: Takeoff limitations
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 203: Non-transport category airplanes: Landing limitations: Destination airport
Part 121: Operating requirements: Domestic, flag, and supplemental operations	Section 205: Non-transport category airplanes: Landing limitations: Alternate airport
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 367: Large transport category airplanes: Reciprocating engine powered: Takeoff limitations
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 375: Large transport category airplanes: Reciprocating engine powered: Landing limitations: Destination airports
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 377: Large transport category airplanes: Reciprocating engine powered: Landing limitations: Alternate airports
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 379: Large transport category airplanes: Turbine engine powered and Takeoff limitations
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 385: Large transport category airplanes: Turbine engine powered: Landing limitations: Destination airports
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 387: Large transport category airplanes: Turbine engine powered: Landing limitations: Alternate airports
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 393: Large non-transport category airplanes: Landing limitations: Destination airports
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 395: Large non-transport category airplanes: Landing limitations: Alternate airports
Part 135: Operating requirements: Commuter and on demand operations and rules governing persons on board such aircraft	Section 398: Commuter category airplanes performance operating limitations

APPENDIX 3. EXAMPLES USING AIRPLANE PLANNING MANUALS

SAMPLE SCENARIO #1. BOEING 737-900

1-1. INFORMATION. This example scenario, involving a Boeing 737-900, allows the airport designer to use published information in the airplane manufacturer’s airport planning manual (APM). The temperature value for the design parameter “mean daily maximum temperature for the hottest month of 84° F” falls within the allowable temperature range ($-5^{\circ}\text{F} \leq (\text{available SD chart}) \leq +3^{\circ}\text{F}$) for a published standard day (SD) takeoff length chart. Thus, the airport designer will determine the separate length requirements for takeoff and landing, make necessary adjustments to those lengths, and then select the longest length as the recommended runway length.

1-2. DATA. The calculation will use the following design conditions:

a.	Airplane	Boeing 737-900 (CFM56-7B27 Engines)
b.	Mean daily maximum temperature	84° Fahrenheit
c.	Airport elevation	1,000 feet
d.	Maximum design landing weight (see table A3-1-1)	146,300 pounds
e.	Maximum design takeoff weight (see table A3-1-1)	174,200 pounds
f.	Maximum difference in runway center elevations	20 feet

1-3. CALCULATIONS. The steps used in the calculations are those provided in paragraph 403, noting applicable conditions. Figures A3-1-1 and A3-1-2 are used for the calculations. It is noted that the charts are only for informational design purposes and not for flight operations.

a. Landing Length Requirement (see figure A3-1-1).

- (1) Step 1 – the Boeing 737-900 APM provides three landing charts for flap settings of 40-degrees, 30-degrees, and 15-degrees. The 40-degree flap setting landing chart, figure A3-1-1, is chosen since it results in the shorter landing length requirement.
- (2) Steps 2 and 3 – Enter the horizontal weight axis at 146,300 pounds and proceed vertically and interpolate between the airport elevation curves of sea level and 2,000 feet for the 1,000-foot value. Select the dash-curve labeled “Wet Runway” and not the solid-curve labeled “Dry Runway” (see subparagraph 402b). Interpolation is allowed for both design parameters.
- (3) Step 4 – Proceed horizontally to the length axis to read 6,600 feet. Interpolation is allowed for this design parameter.
- (4) Step 5 – Do not adjust the obtained length since the “Wet Runway” curve was used (see paragraph 508).
- (5) The length requirement is 6,600 feet. **Note:** Round lengths of 30 feet and over to the next 100-foot interval. Thus, the landing length for design is 6,600 feet.

b. Takeoff Length Requirement (see figure A3-1-2).

- (1) Step 1 – the Boeing 737-900 APM provides a takeoff chart at the SD + 27°F (15° C) for various flap settings. Select this chart, see figure A3-1-2.
- (2) Steps 2 and 3 – Enter the horizontal weight axis at 174,200 pounds and proceed vertically and interpolate between the airport elevation curves of sea level and 2,00 feet for the 1,000-foot value. Select the dash-curve labeled “FAR” and not the solid-curve labeled “JAR” (see subparagraph 402b). Interpolation is allowed for both design parameters.

- (3) Step 4 – Proceed horizontally to the length axis, the result is 8,800 feet. Interpolation is allowed for this design parameter.
- (4) Step 5 – Adjust for non-zero effective runway gradient (see paragraph 509).

$$8,800 + (20 \times 10) = 8,800 + 200 = 9,000 \text{ feet}$$

- (5) The takeoff length requirement is 9,000 feet. **Note:** Round lengths of 30 feet and over to the next 100-foot interval. Thus, the takeoff length for design is 9,000 feet.

1-4. ANSWER.

Max. Landing Design Weight	146,300 pounds
Max. Takeoff Design Weight	174,200 pounds
Landing Length	6,600 feet
Takeoff Length	9,000 feet

Select the longest length for airport design. In this case, the takeoff length of 9,000 feet is the recommended runway length.

Table A3-1-1. Boeing General Airplane Characteristics for 737-900
(Reference document number: D6-58325-3)

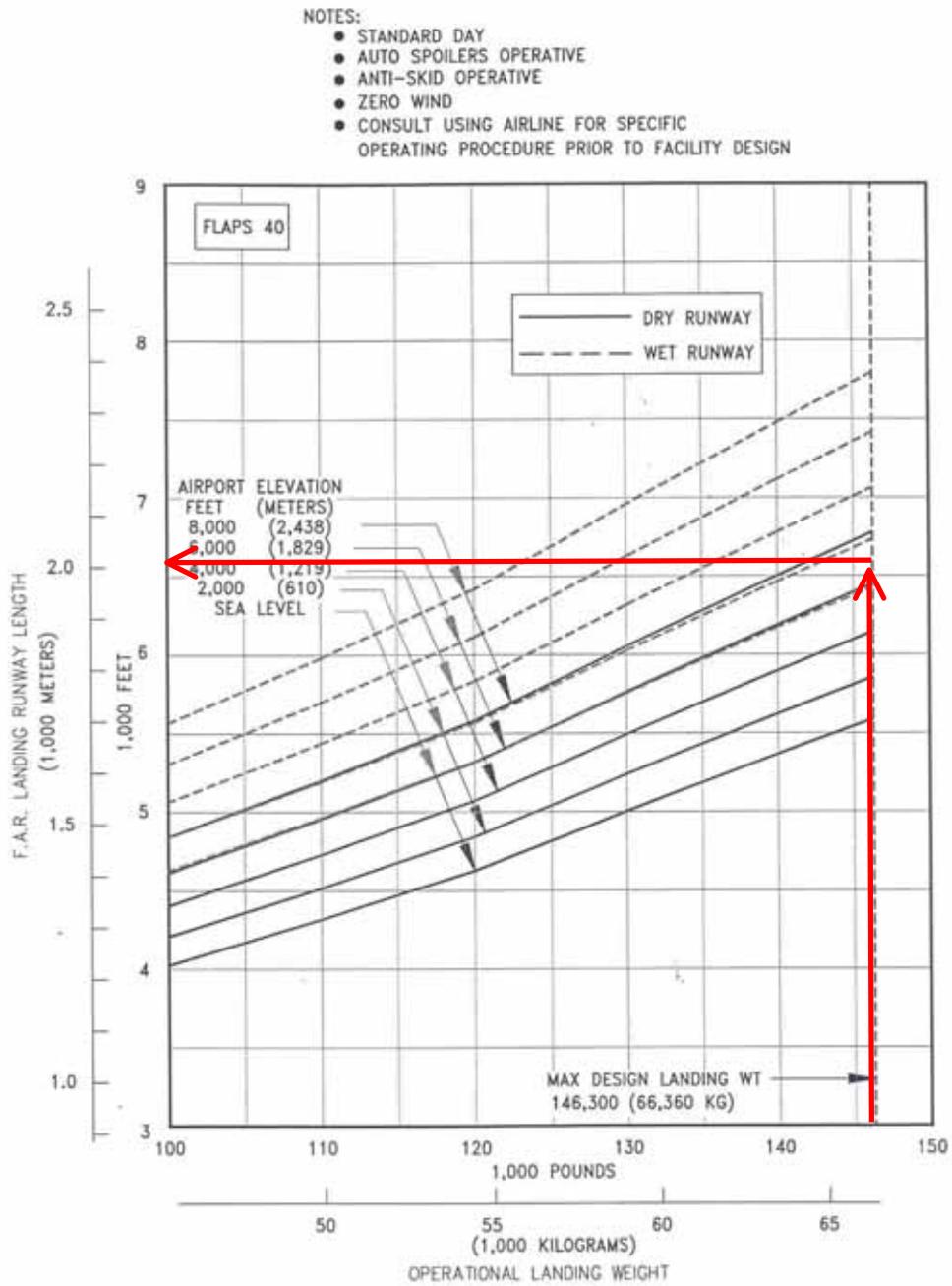
CHARACTERISTICS	UNITS	737-900	
MAX DESIGN TAXI WEIGHT	POUNDS	164,500	174,700
	KILOGRAMS	74,616	79,243
MAX DESIGN TAKEOFF WEIGHT	POUNDS	164,000	174,200
	KILOGRAMS	Takeoff Weight	79,016
MAX DESIGN LANDING WEIGHT	POUNDS		Landing Weight
	KILOGRAMS	66,361	
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	138,300	140,300
	KILOGRAMS	Landing Weight	63,639
OPERATING EMPTY WEIGHT (1)	POUNDS		Landing Weight
	KILOGRAMS	42,901	
MAX STRUCTURAL PAYLOAD	POUNDS	43,720	45,720
	KILOGRAMS	19,831	20,738
SEATING CAPACITY (1)	TWO-CLASS	177	177
	ALL-ECONOMY	189	189
MAX CARGO - LOWER DECK	CUBIC FEET	1,835	1,835
	CUBIC METERS	52.0	52.0
USABLE FUEL	US GALLONS	6875	6875
	LITERS	26,022	26,022
	POUNDS	46,063	46,063
	KILOGRAMS	20,894	20,894

NOTE: (1) OPERATING EMPTY WEIGHT FOR BASELINE MIXED CLASS CONFIGURATION. CONSULT WITH AIRLINE FOR SPECIFIC WEIGHTS AND CONFIGURATIONS.

2.1.4 GENERAL CHARACTERISTICS
MODEL 737-900

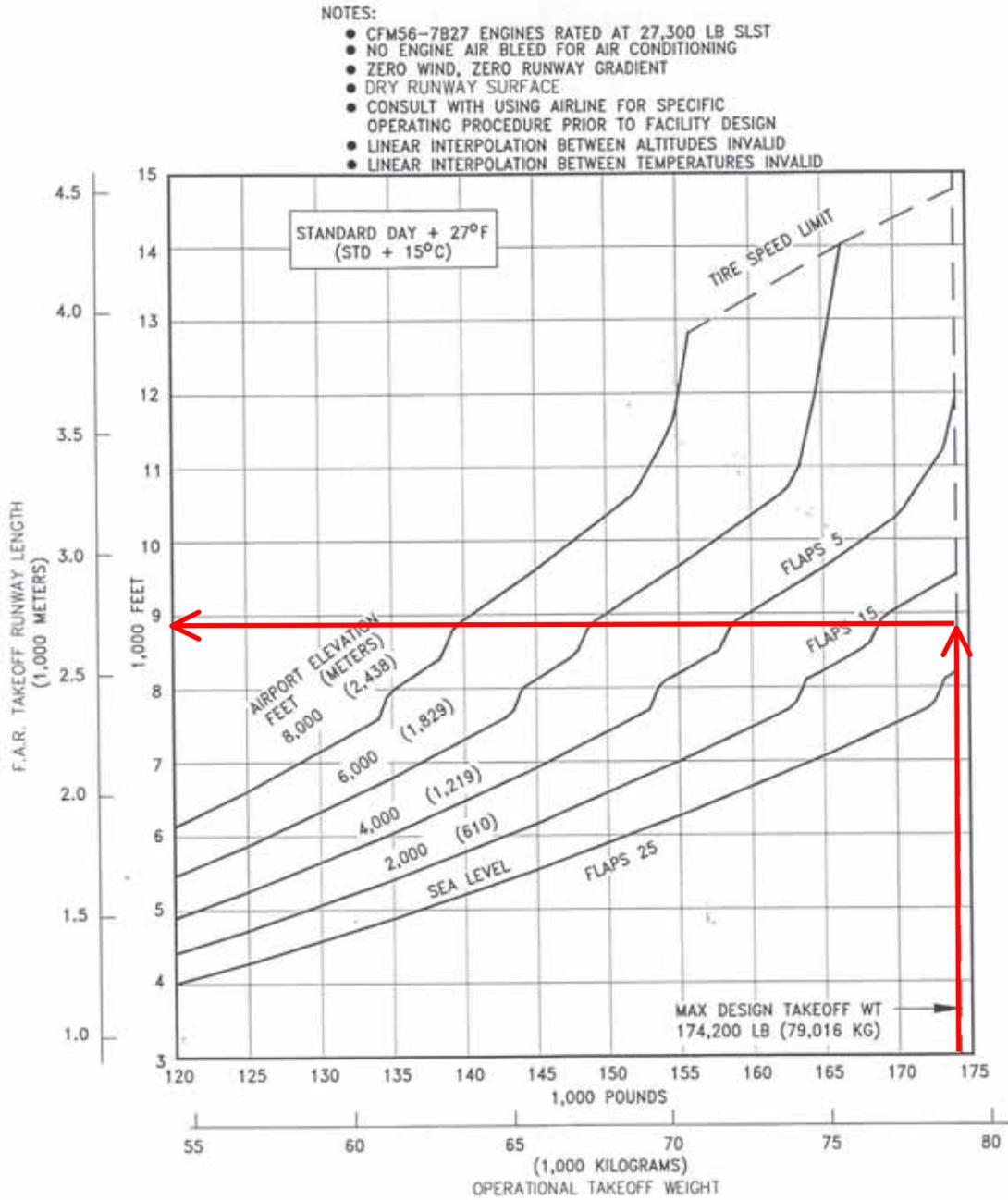
D6-58325-3

Figure A3-1-1. Landing Runway Length for Boeing 737-900 (CFM56-7B27 Engine)
(Not for Flight Operations)
(Reference document number: D6-58325-3)



3.4.10 F.A.R. LANDING RUNWAY LENGTH REQUIREMENTS - FLAPS 40
MODEL 737-900

**Figure A3-1-2. Takeoff Runway Length for Boeing 737-900 (CFM56-7B27 Engine)
(Not for Flight Operations)
(Reference document number: D6-58325-3)**



3.3.46 F.A.R. TAKEOFF RUNWAY LENGTH REQUIREMENTS
STANDARD DAY +27°F (STD + 15°C), DRY RUNWAY
MODEL 737-900 (CFM56-7B27 ENGINES AT 27,300 LB SLST)

SAMPLE SCENARIO #2. SAAB FAIRCHILD 340B

2-1. INFORMATION. This example scenario, involving a SAAB Fairchild 340B, allows the airport designer to use published information in the airplane manufacturer’s airport planning manual (APM) in addition to the figures of chapter 3 of this advisory circular. The temperature value for the design parameter “mean daily maximum temperature for the hottest month of 74° F” falls within the allowable temperature range ($-5^{\circ}\text{ F} \leq (\text{available SD chart}) \leq +3^{\circ}\text{ F}$) for a published standard day (SD) takeoff length chart. Thus, the airport designer will determine the separate length requirements for takeoff and landing, make necessary adjustments to those lengths, and then select the longest length as the recommended runway length.

2-2. DATA. The calculation will use the following design conditions:

a.	Airplane	
b.	Saab 340B (CT7-9B Engines)	
c.	Mean daily maximum temperature	74° Fahrenheit
d.	Airport elevation	Sea level
e.	Maximum design landing weight (see table A3-2-1)	28,000 pounds
f.	Maximum design takeoff weight (see table A3-2-1)	28,500 pounds
g.	Percentage of useful load	90%
h.	Percent of Fleet	75%
i.	Maximum difference in runway center elevations	20 feet

2-3. CALCULATIONS. The steps used in the calculations are those provided in paragraph 403, noting applicable conditions. Figures A3-2-1 and A3-2-2 are used for the calculations. It is noted that the charts are only for informational design purposes and not for flight operations.

a. Landing Length Requirement (see figure A3-2-1).

- (1) Step 1 – the SAAB 340 APM provides two landing charts for flap settings of 25-degrees and 35-degrees. The 35-degree flap setting landing chart, figure A3-2-1, is chosen since it results in the shorter landing length requirement.
- (2) Steps 2 and 3 – Enter the horizontal weight axis at 28,000 pounds and proceed vertically to the airport elevation curve for sea level. Select the dash-curve labeled “FAR” and not the solid-curve labeled “JAR” (see subparagraph 402b).
- (3) Step 4 – Proceed horizontally to the length axis to read 3,450 feet.
- (4) Step 5 – Do not adjust the obtained length for wet landing operations for the SAAB 340B since it is a turboprop-powered airplane. The 15-percent adjustment applies only to turbojet-powered airplanes (see paragraph 508).
- (5) The length requirement is 3,450 feet. **Note:** Round lengths of 30 feet and over to the next 100-foot interval. Thus, the landing length for design is 3,500 feet.

b. Takeoff Length Requirement (see figure A3-2-2).

- (1) Step 1 – the SAAB 340 APM provides a takeoff chart at the SD + 18°F (10° C) for flap setting of 15-degrees. The 15-degree flap setting takeoff chart, figure A3-2-2, is chosen.
- (2) Steps 2 and 3 – Enter the horizontal weight axis at 28,500 pounds and proceed vertically to the airport elevation curve for sea level. Select the dash-curve labeled “FAR” and not the solid-curve labeled “JAR” (see subparagraph 402b). Interpolation is allowed for both design parameters.
- (3) Step 4 – Proceed horizontally to the length axis, the result is 4,375 feet.

- (4) Step 5 – Adjust for non-zero effective runway gradient (see paragraph 509).

$$4,375 + (20 \times 10) = 4,375 + 200 = 4,575 \text{ feet}$$

- (5) The takeoff length requirement is 4,575 feet. **Note:** Round lengths of 30 feet and over to the next 100-foot interval. Thus, the takeoff length for design is 4,600 feet.

2-4. ANSWER.

Max. Landing Design Weight	28,000 pounds
Max. Takeoff Design Weight	28,500 pounds
Landing Length	3,500 feet
Takeoff Length	4,600 feet

Select the longest length for airport design. In this case, the takeoff length of 4,600 feet is the recommended runway length.

Table A3-2-1. SAAB 340 Airplane Characteristics
(Reference number SAAB 340 ACAP 000)

SAAB 340
Airplane Characteristics



Weights

AIRLINER TYPICAL SPEC. WEIGHTS	340A		340B	
	lb	Kg	lb	Kg
MAX DESIGN TAXI WEIGHT (MTW)	28300	12835	28800	13065
MAX DESIGN TAKE-OFF WEIGHT (MTOV)	28000	12700	28500	12930
MAX DESIGN LANDING WEIGHT (MLW)	27200	12340	28000	12700
MAX DESIGN ZERO FUEL WEIGHT (MZFW)	25700	11660	26000	11795
OPERATIONAL EMPTY WEIGHT (OEW)	17615	7990	7715	8035
PAYLOAD (P/L)	8085	3670	8285	3760

Takeoff Weight

Landing Weight

Figure A3-2-1. Landing Runway Length for SAAB 340B (CT7-9B Engine)
(Not for Flight Operations)
(Reference number SAAB 340 ACAP 000)

SAAB 340

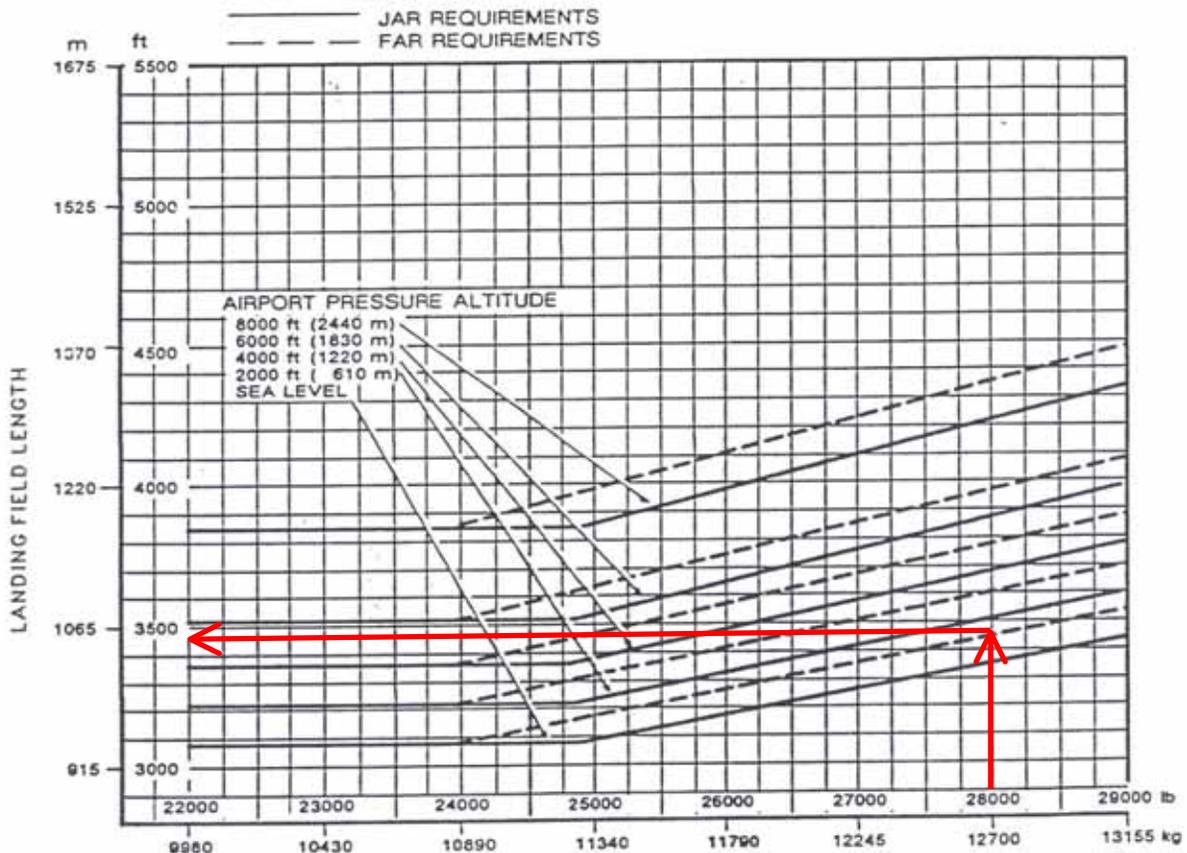
Airplane Characteristics



Landing Runway Length Requirements (ISA day)

340B (CT7-9B engines)

NOTE: ISA standard day with zero wind.
Dry paved runway with zero slope.
Flaps 35°.
Coordinate with using airline for specific requirements prior to facility design.



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AIRPLANE LANDING WEIGHT

340B (CT7-9B engines)

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**Figure A3-2-2. Takeoff Runway Length for SAAB 340B (CT7-9B Engine)
(Not for Flight Operations)
(Reference number SAAB 340 ACAP 000)**

SAAB 340

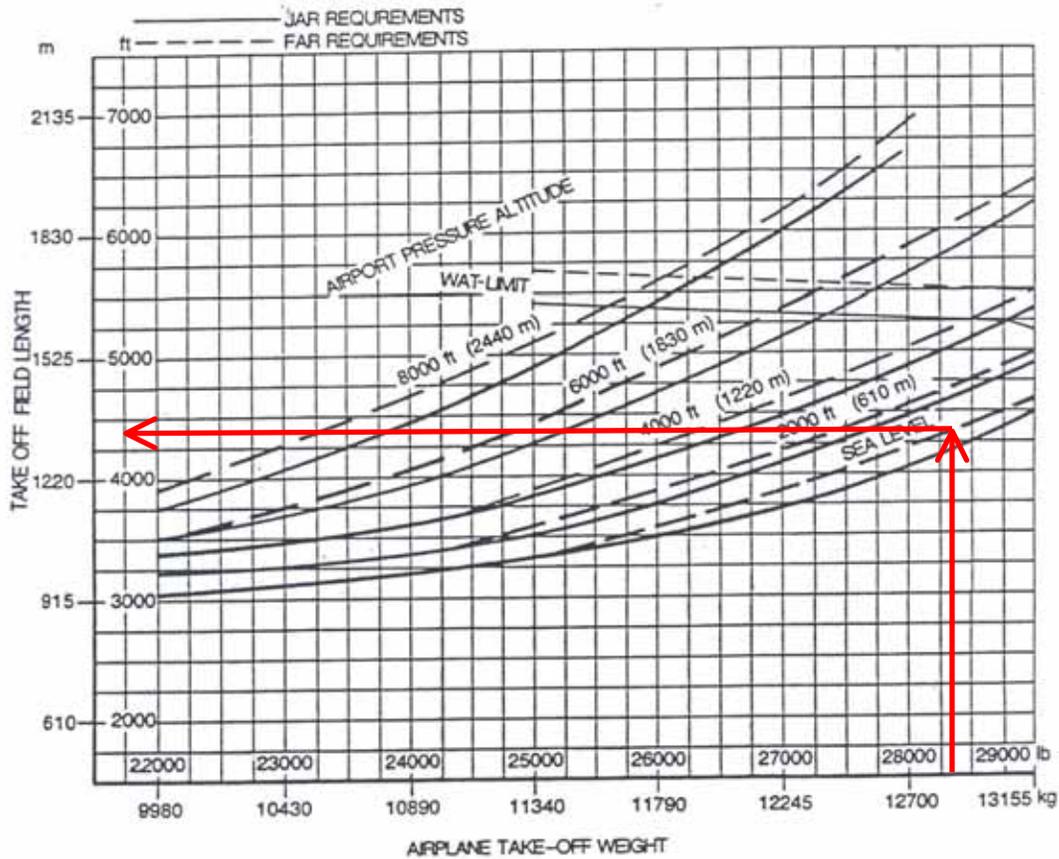
Airplane Characteristics



Take-Off Runway Length Requirements (ISA day +10°C)

340B (CT7-9B engines)

NOTE: ISA standard day +10°C with zero wind.
Max. take-off power.
Dry paved runway with zero slope.
Flaps 15°
Environmental control system off.
De-icing system off.
Coordinate with using airline for specific requirements prior to facility design.



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340B (CT7-9B engines)

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