APPENDIX D

RUNWAY LENGTH ANALYSIS

INTRODUCTION

Airports are an inherently dynamic environments that must adapt and evolve as conditions change. A crucial component of the airport environment is the runway surfaces. Adequate runway length must be evaluated periodically to ensure that the services provided by an airport will continue to meet existing and future aircraft demands.

RUNWAY LENGTH METHODOLOGY

The determination of runway recommendation for airport planning purposes uses the methodology found in FAA Advisory Circular (AC) 150/5325-4B, *Runway Length Requirements for Airport Design*. This AC states the design objective for primary runways is to provide a runway length for all aircraft that will regularly use the runway without causing operational weight restrictions. AC 150/5000-17*, Critical Aircraft and Regular Use Determination* defines regular use as 500 annual operations, excluding local touch-and-go operations. FAA AC 150/5325-4B describes five steps to determine recommended runway lengths. The information from these steps is to be used for airport design and not for flight operations. The five steps are to:

- Identify potential design aircraft.
- Identify the most demanding aircraft.
- Determine appropriate methodology.
- Determine the recommended runway length.
- Apply necessary adjustments as needed.

DESIGN AIRCRAFT AND MOST DEMANDING AIRCRAFT

The existing design critical aircraft for Runway 9/27 is the Bombardier CRJ-200 and the future design critical aircraft is the Embraer 175 (ERJ-175). These aircraft are determined by analyzing the most demanding aircraft that make regular use of Southwest Wyoming Regional Airport (RKS). For more detail see the Critical Aircraft Analysis Paragraph in Chapter 3 of the Airport Master Plan, *Facility Requirements*.

The existing and future critical design aircraft for Runway 3/21 is a family grouping of B-II aircraft types represented by the Cessna 208 Caravan (C208) and Swearingen Metroliner (SW4) that have approach speeds greater than 50 knots and more than 10 passenger seats excluding crew (i.e., pilot and copilot). AC 150/5325-4B categorizes all small airplanes with 10 or more passenger seats into one family grouping.

DETERMINE MOST APPROPRIATE METHODOLOGY

Following guidance provided in AC 150/5325-4B, individual Airport Planning Manuals (APMs) produced and published by aircraft manufacturers will be used for regional jets or aircraft with Maximum Takeoff Weight (MTOW) greater than 60,000 pounds. Therefore, the APMs for the CRJ-200 and ERJ-175 will be used to determine a recommended length for Runway 9/27; the family grouping of small aircraft mentioned above will be used to determine a recommended length for Runway 3/21.

The performance requirements of the design aircraft determine recommended runway length. Factors that affect aircraft performance capabilities include the airport elevation, air temperature, aircraft payload, fuel load, and wind conditions. These factors are explained below.

ELEVATION

As elevation increases the ambient air density decreases, this negatively impacts aircraft performance. The thrust produced by the aircraft on takeoff along with the aerodynamic performance of all aircraft is diminished at higher elevations compared to when operated at sea level. The elevation at RKS is 6,765 feet above mean sea level (AMSL) which is used for this analysis.

INTERNATIONAL STANDARD ATMOSPHERE

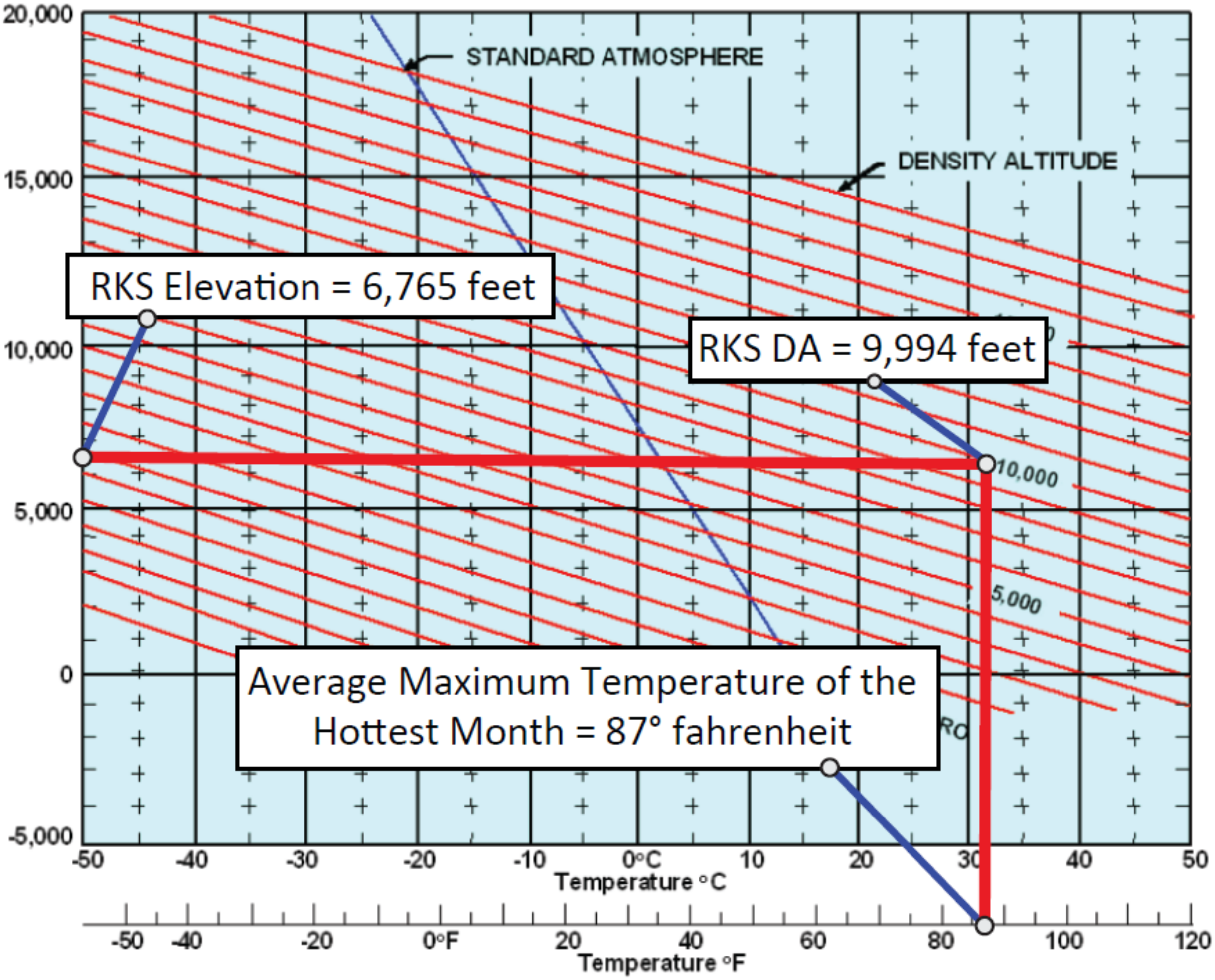
International Standard Atmosphere (ISA) is a mathematical model that describes how the earth's atmosphere, or air pressure and density, changes relative to altitude. ISA is frequently used in aircraft performance calculations because conditions that deviate from ISA will affect aircraft performance. ISA at sea level occurs when the temperature is 59 degrees Fahrenheit. According to the 1976 Standard Atmosphere Calculator, the ISA at 6,765 feet AMSL occurs when the temperature is 35 degrees Fahrenheit.

DENSITY ALTITUDE

Density Altitude (DA), which is a critical component of aircraft performance calculations, compares air density to ISA at a point in time and specific location. DA is used to describe how aircraft performance differs from the performance that would be expected when operating at ISA. DA is primarily influenced by elevation and air temperature. **Figure D.1** illustrates how DA is impacted when factoring in the average maximum temperature of the hottest month. At RKS, during the hottest month, when the ambient air temperature reaches 87 degrees Fahrenheit, the DA is observed to be 9,994 feet AMSL. This implies that the aircraft will perform as though it's operating at an altitude of 9,994 feet AMSL, even though RKS's elevation is only 6,765 feet AMSL. The DA is a crucial factor in evaluating the performance of an aircraft.

Figure D.1

DENSITY ALTITUDE AT RKS



Source: Mead & Hunt analysis using elevation data from airnav.com and weather data from weather.gov.

TAKEOFF WEIGHT AND DESTINATION

Aircraft takeoff weight is directly related to the distance of the flight and the load that the aircraft is carrying. For shorter distances, aircraft may depart with a full passenger load and less than full fuel tanks. In those instances, the aircraft will typically be departing below Maximum Take Off Weight (MTOW) and will not require as long of a runway. Aircraft require more fuel for longer trips, and the longest trips may require payload restrictions on the passengers, baggage, and cargo that can be carried. An aircraft with full passenger load and fuel will be near its MTOW which will require the longest runway necessary for that aircraft.

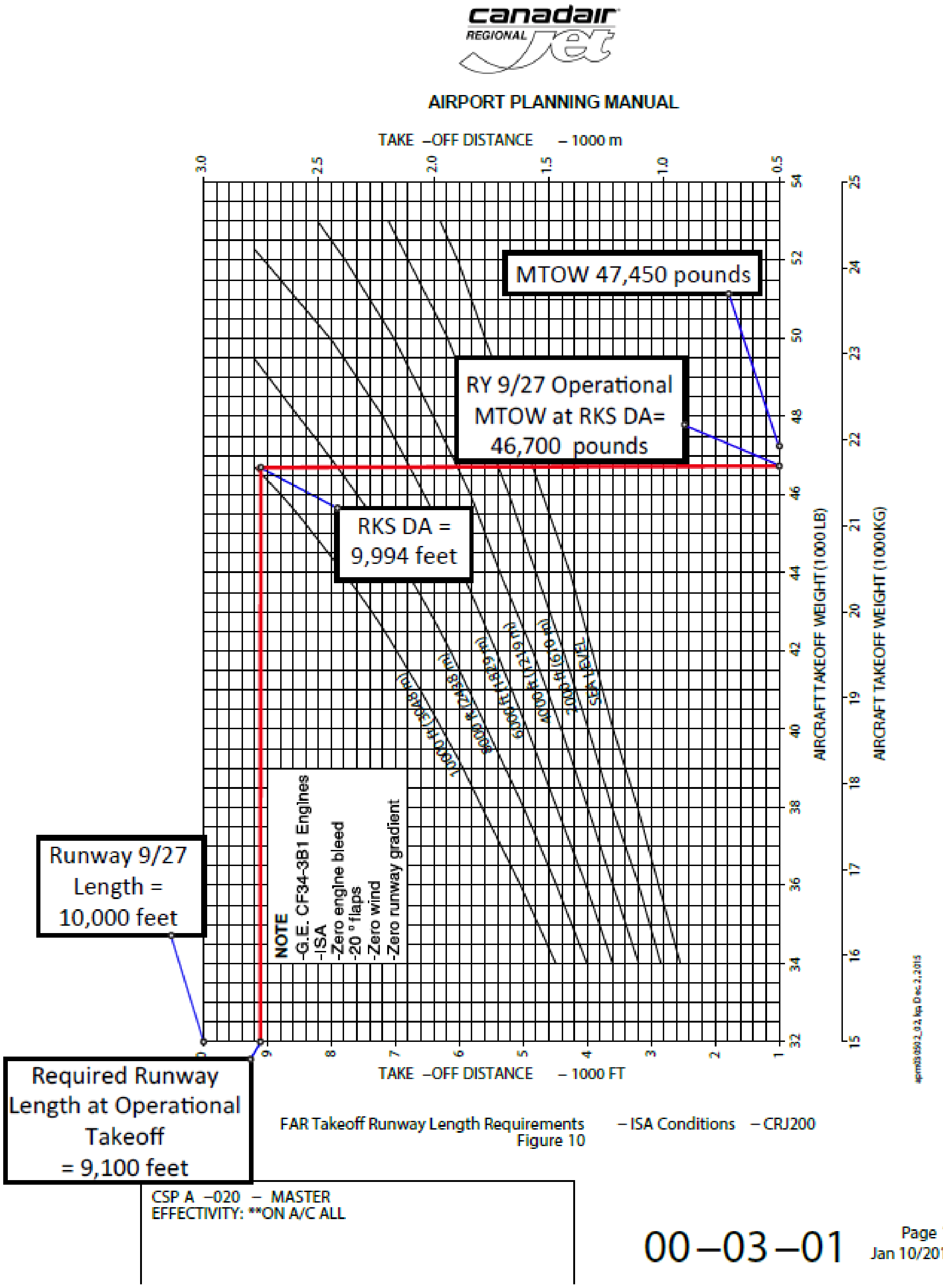
Currently, United Airlines provides non-stop service to Denver International Airport (DEN), which is approximately 230 nautical miles (NM) from RKS. Salt Lake (SLC) is an additional long-term potential destination.

RECOMMENDED RUNWAY LENGTH DETERMINATION

RUNWAY 9/27

The runway 9/27 length analysis is based on the takeoff performance and the payload and range table charts in the APMs for the existing and future design aircraft. AC 150/5325-4B allows for runway length determination to be based on MTOW. As seen in **Figure D.2**, the CRJ-200 has a MTOW of 47,450 pounds during standard conditions. Due to the performance restrictions at RKS's density altitude of 9,994 feet AMSL the operational MTOW is 46,700 pounds. The runway length for the CRJ-200 at 46,700 pounds MTOW and at RKS's DA of 9,994 feet MSL is approximately 9,100 feet. RKS's existing runway length of 10,000 feet exceeds the operational MTOW for the CRJ-200 by approximately 900 pounds. Additionally, it is understood that the CRJ 200s departing RKS currently flying to DEN, do not need full fuel capacity, and are not routinely carrying full passenger loads. Therefore, the existing 9/27 Runway length does not require improvement for the existing critical design aircraft.

Figure D.2
CRJ-200 TAKEOFF RUNWAY LENGTH REQUIREMENTS (ISA)

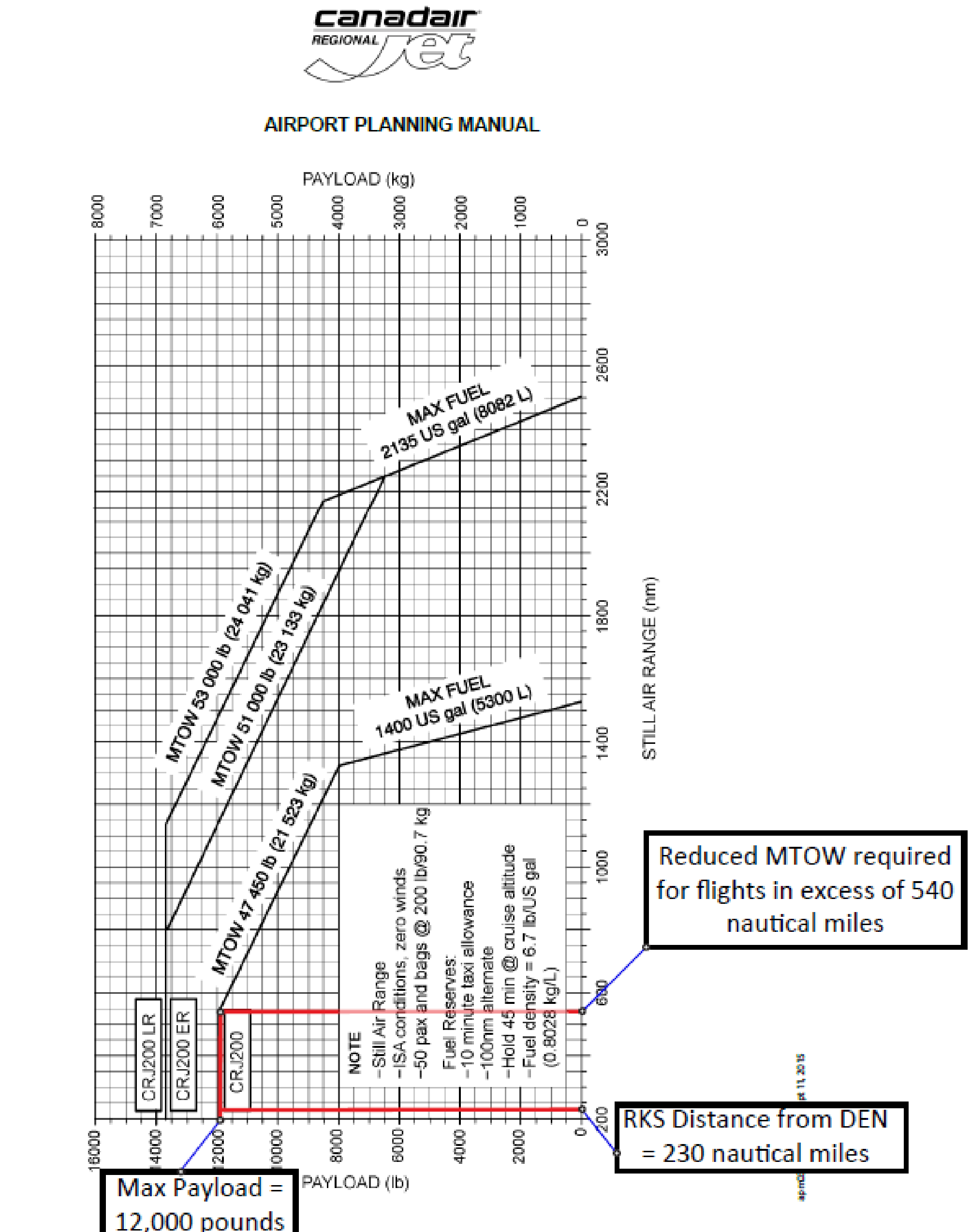


Source: Mead & Hunt analysis using CRJ-200 Airport Planning Manual.

When using the payload versus range chart, **Figure D.3** below, it is only when an approximate 540 nautical mile range is required does the CRJ-200 begin to experience maximum payload restrictions. Since payload is a measure of passengers, baggage, and cargo (i.e., not including fuel), the MTOW reductions do not affect the future destinations most likely to be served by air carriers from RKS because the reduced weight can be met with less fuel and not fewer passengers. As detailed above, the most likely future destination to be served from RKS in addition to DEN is SLC, which is well within the range of the maximum payload allowed.

Figure D.3

CRJ-200 PAYLOAD/RANGE



Payload/Range for Mach 0.80 Cruise at 37 000 ft. (11 300 m) CRJ200 US (FAA) Requirements
Figure 5

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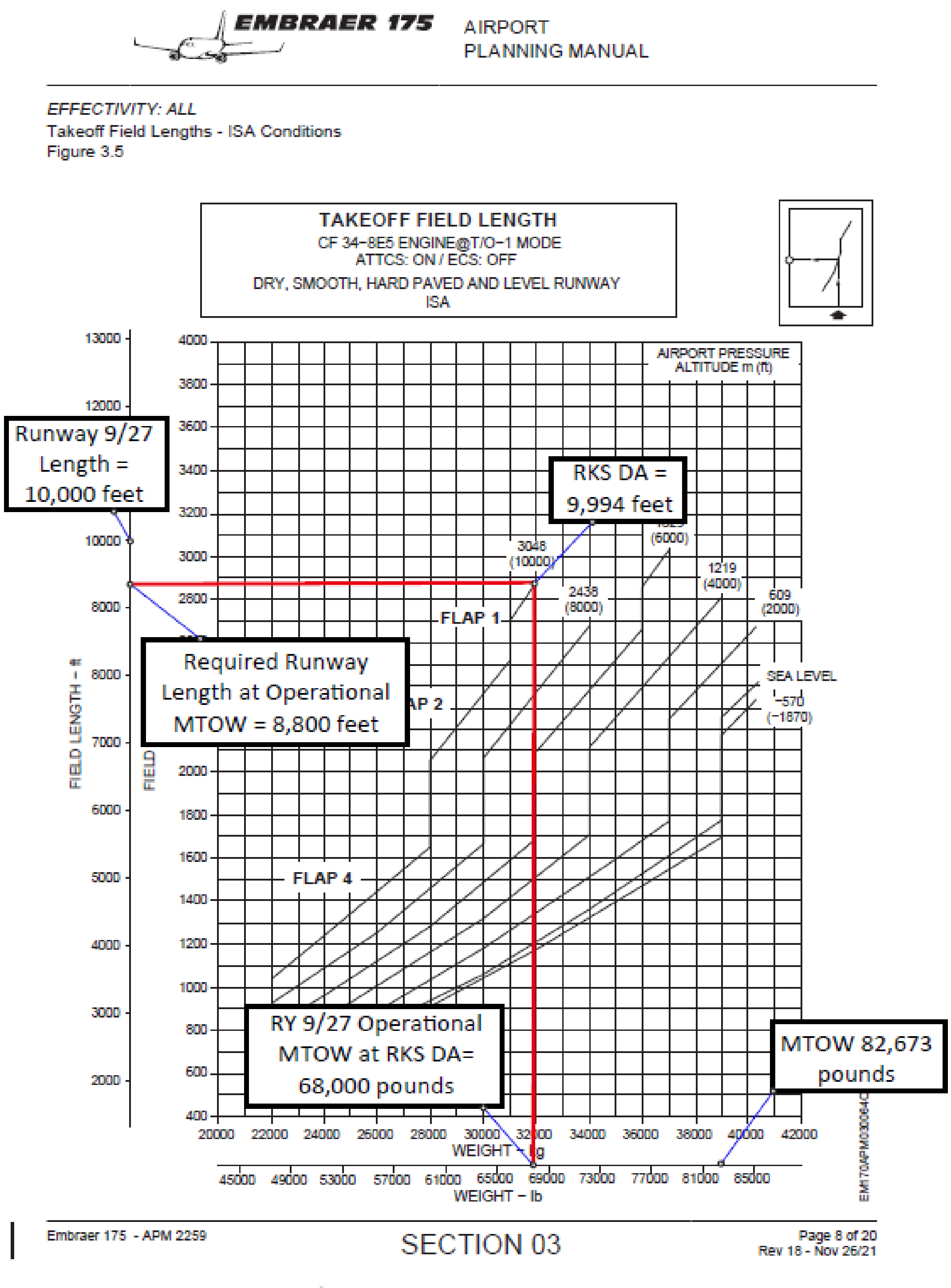
Source: Mead & Hunt analysis using CRJ-200 Airport Planning Manual.

For comparison purposes, **Figure D.4** presents the runway length requirements of the identified future commercial service air carrier aircraft (ERJ-175) for this Master Plan. At the DA of RKS the ERJ-175 has an operational MTOW of 68,000 pounds, which is reduced from the MTOW of 82,673 pounds at ISA. The runway length required at the operational MTOW of 68,000 pounds and the DA of 9,994 feet MSL is approximately 9,200 feet. The operational takeoff weight is approximately 14,650 pounds less than MTOW. However, as with the CRJ-200s, the ERJ-175 would likely be operated at weights well below the MTOW due to the relatively short stage lengths being flown. This is verified by **Figure D.5**, which indicates that not until an approximate 920 nautical mile range is required does the ERJ-175 experience maximum payload restrictions. The reduced MTOW can be attained by carrying less fuel as opposed to less passengers.

Figure D.4

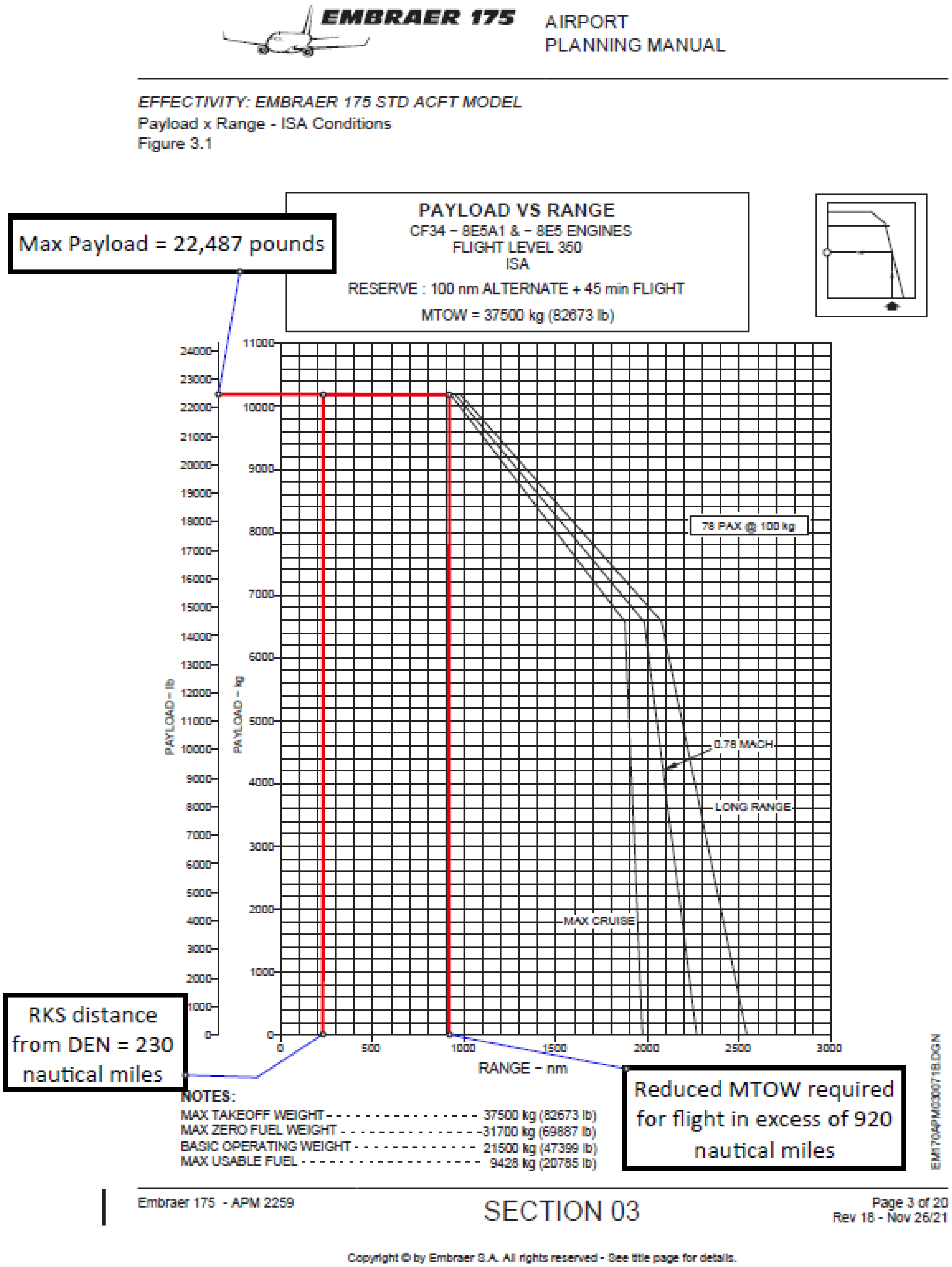
ERJ-175 TAKEOFF RUNWAY LENGTH REQUIREMENTS (ISA)



Source: Mead & Hunt analysis Embraer ERJ-175 APM.

Note: There is a typo of 8,000 feet in field length rather than 9,000 feet.

Figure D.1
ERJ-175 PAYLOAD/RANGE



Source: Mead & Hunt analysis using Embraer ERJ- 175 APM.

RUNWAY 3/21

AC 150/5325-4B notes that for airports that are at an elevation greater than 3,000 feet MSL the *100 percent of the small aircraft fleet with approach speeds greater than 50 knots and less than 10 passenger seats* chart should be used to determine required runway length. Using RKS's elevation of 6,765 feet AMSL (not the DA of 9,994 feet AMSL) and the mean maximum temperature of the hottest month (87 degrees Fahrenheit), a runway length of approximately 8,200 feet is recommended as shown in **Figure D.6**.

It is important to note that the recommended runway length isn't feasible at RKS due to geographical limitations. RKS is situated on a plateau where the elevation at either end of Runway 3/21 is approximately 200 feet higher than the elevation approximately 1000 feet off the extended centerline. Runway 3/21 is a crosswind runway, primarily utilized during instances of severe crosswind conditions on Runway 9/27, as dictated by prevailing winds.

Figure D.6
RECOMMENDED LENGTH RUNWAY 3/21

7/1/2005 AC 150/5325-4B

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

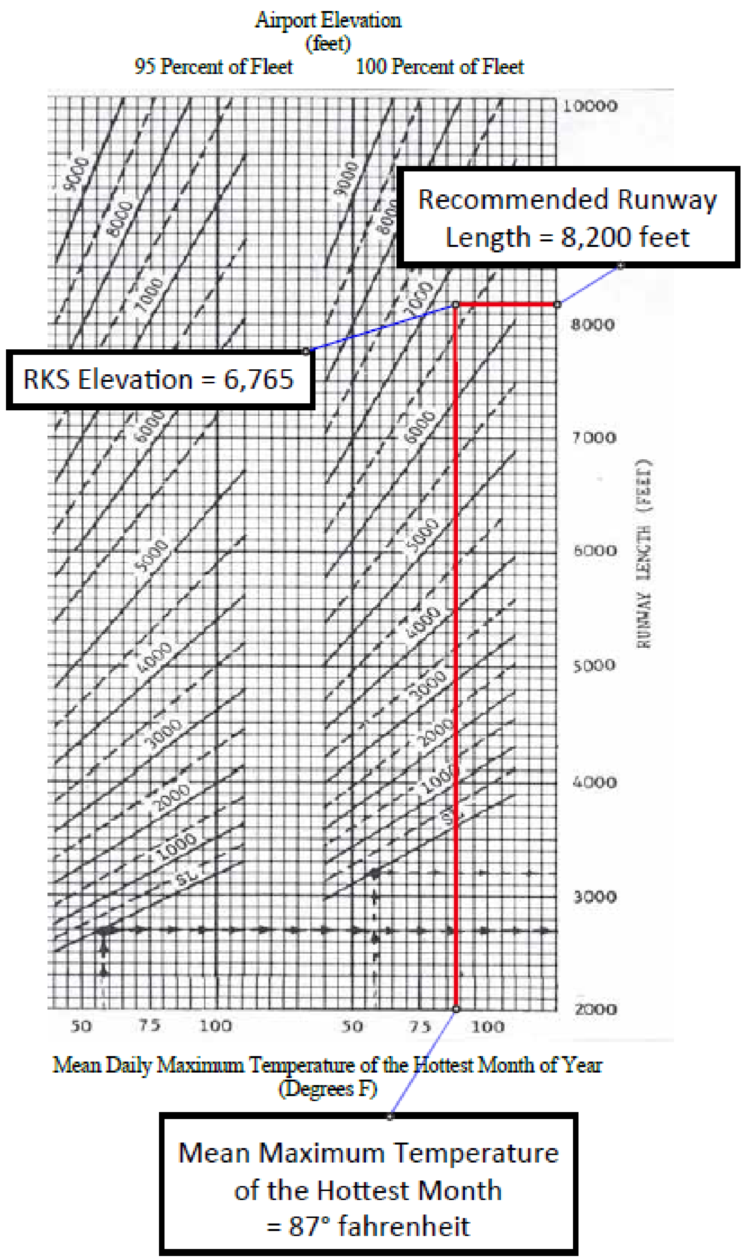
Example:

Temperature (mean day max hot month): 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)



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Source: Mead & Hunt analysis using FAA AC 150/5325-4B, Runway Length Requirements for Airport Design.

APPLY NECESSARY ADJUSTMENTS

AC 150/5325-4B allows for the adjustment of runway lengths for non-zero effective runway gradients (i.e., runways having a difference in centerline elevation that is not equal to zero). The adjustment increases the takeoff length thy 10 feet for every 1 foot of maximum elevation difference of the runway centerline. For Runway 9/27 an adjustment of 330 feet is provided since the maximum centerline elevation difference is 33 feet. For Runway 3/21 no adjustment is afforded due to the initial calculation factors in elevation differences. **Table D.1** provides the recommended runway lengths after applying the adjustments.

Table D.1

RUNWAY LENGTH RECOMMENDATIONS WITH ADJUSTMENTS

Runway	Recommended Runway Length	Maximum Centerline Elevation Difference	Adjustment	Final Recommended Runway Length
9/27 (Primary)				10,000′
Existing Design Aircraft (CRJ2)	9,100′	33′	330′	9,430′
Future Design Aircraft (E175)	8,800′	33′	330′	9,130′
3/21 (Crosswind)				5,228′
Existing and Future Design Aircraft (C208, SW4)	8,200′	NA	NA	5,228′

Source: Mead & Hunt using airport planning manuals and FAA AC 150/5325-4B methodology.
Note: 1 Existing topographic site constraints prohibit the extension of Runway 3/21.
NA: Not Applicable

RUNWAY LENGTH CONCLUSION

Due to the high elevation and maximum mean temperature in July at RKS both the existing and future design aircraft have reduced MTOW. However, the runway length analysis suggests that Runway 9/27, with an existing length of 10,000 feet, is sufficient for accommodating both the existing and future design aircraft when operating at the lower operational MTOW. The current route that is being flown to DEN, and the most likely long-term future service to SLC, are within the range of both the CRJ-200 and ERJ-175 without requiring payload restrictions, this indicates that the length of Runway 9/27 requires no additional improvements. Runway 3/21 is approximately 3,000 feet shorter than the final recommended runway length. However, due to the geographic constraints at RKS, Runway 3/21 is not practically eligible for an extension. Runway 3/21 is primarily used as a cross wind runway for light aircraft during high crosswind conditions and no additional runway length is recommended.

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