APPENDIX 2

Runway Length Analysis
Prescott Municipal Airport

May 11, 2009
Version 2 (draft)

Table of Contents

INTRODUCTION

In addition to examining airside facility requirements as part of the Facility Requirement section of the current Master Plan Update, Berger has developed this technical White Paper to address the Purpose and Need for the Prescott Municipal Airport (PRC) proposed Runway 3R-21L extension. The following Runway Length Analysis was prepared to determine the runway length requirement for the regional air carrier passenger service, United States Forest Service Firefighting aircraft operations and general aviation for Runway 3R-21L at PRC.

The proposed Runway 3R-21L extension was initially planned in the 1997 Airport Master Plan. In addition to the current airfield characteristics, design standards, current and future operational and safety requirements, Berger has examined all the information gathered from the previous Master Plan, the Draft Environmental Assessment (EA) for the proposed runway extension, and the Prescott Municipal Airport *Runway Safety Area Standards Evaluation (2005)*.

PRC is a Class I, Federal Aviation Regulation (FAR) Part 139 certified airport assisted by federal airport improvement grants. Under FAA Order 5190.6A, *Airport Compliance Requirements* it is required that the airport is safely and properly maintained and operated in a manner which protects the public interests and as stated in Order 5190.6A paragraph 4-17j "any facility developed with grants funds must be constructed to the then current applicable FAA design standards". Therefore all applicable requirements and directives reported in the following documents have been applied on the Runway 3R-21L length analysis:

- ✈ FAA Advisory Circular 150/5325-4B - Runway Length Requirements for Airport Design;
- ✈ FAA AC 150/5300-13
- ✈ FAA Order 5090.3C - Field Formulation of the National Plan of Integrated Airport Systems (NPIAS); and
- ✈ Aircraft manufacturer's characteristics manuals and charts.

SECTION 1 – PURPOSE & NEED

Runway 3R-21L is PRC's primary runway. The runway is surfaced with asphalt, and is 7,616 feet long and 150 feet wide. The primary purpose of the Runway 3R-21L improvements identified in this Runway Length Analysis is to provide a safe operating environment for the range of aircraft that regularly utilize PRC, and to those that are expected to use the airport in the future.

The Forecast in the current Master Plan Update (2009) indicates that the PRC Airport Service Area (ASA) can support the demand for additional air service to new markets. The PRC Passenger Leakage Study and the new Arizona State Airports System Plan (SASP) have anticipated a robust potential demand of air service to other markets mostly due to the rapid population growth in the airport ASA. Various populations' forecast suggests that this growth will continue over the next 20 years.

Historically, PRC has not been served by regional jets due to its runway length limitations. In turn, this has effectively stunted the airport's marketing and air service development efforts. As the more modern regional jets (RJs) enter the market to replace older equipment, PRC will need to provide additional runway length to provide adequate air service to its community. Additionally, the runway extension is needed because PRC, a Commercial Service Airport in the NPIAS, is only able to accommodate less than 75 percent of the large aircraft fleet (more than 60,000 lbs) at 60 percent useful load, while a reliever airport for other commercial service airports should be able to accommodate 75% of large aircraft at 90% useful load.

Furthermore, safety concerns have been voiced with regards to the operations of the U.S. Forest Service (USFS). During the fire season, which spans through the hottest months in Arizona, the USFS utilizes the Lockheed P-3 Orion and Lockheed C-130. A longer runway will provide for the additional pavement necessary in case of an aborted take-off.

SECTION 2 – DESIGN STANDARDS

Guidelines for airport design standards are set forth in the FAA's Advisory Circular (AC) 150/5300-13, *Airport Design*. Each airport can be classified based upon the aircraft which it is designed to serve using the Airport Reference Code (ARC). The ARC is established by two separate factors: Approach Category (which group aircraft based on approach speed) and Design Group (which group aircraft based on wingspan).

Aircraft approach categories are defined as follows:

- Category A: Speed less than 91 knots;
- Category B: Speed 91 knots or more, but less than 121 knots;
- Category C: Speed 121 knots or more, but less than 141 knots;
- Category D: Speed 141 knots or more, but less than 166 knots; and
- Category E: Speed 166 knots or more.

Airplane design groups are defined as follows:

- Group I: Up to but not including 49 feet (with a subcategory for small aircraft);
- Group II: 49 feet or more, but less than 79 feet;
- Group III: 79 feet or more, but less than 118 feet;
- Group IV: 118 feet or more, but less than 171 feet;
- Group V: 171 feet or more, but less than 214 feet; and
- Group VI: 214 feet or more, but less than 262 feet.

PRC'S Runway 3R-21L is currently designated as C-III.

SECTION 3 - METHODOLOGY & ASSUMPTIONS

To determine the required runway length for PRC's primary runway the procedure detailed in FAA AC 150/5325-4B, *Runway Length Requirements for Airport Design*, provides guidelines for airport designers and planners to determine recommended runway lengths for new runways or extensions to existing runways. This AC makes the following recommendations: "*When the Max Take-Off Weight (MTOW) of listed aircraft is over 60,000 pounds, the recommended runway length is determined according to individual aircraft. The design objective for the main primary runway is to determine a recommended runway length that serves all aircraft without operational weight restrictions. The design objective for the length of crosswind runways for scheduled transport service is to equal 100% of the primary runway.*"

With regards to airport dimensional standards, FAA Order 5090.3C, *Field Formulation of the National Plan of Integrated Airport Systems (NPIAS)*, states that "*Airport dimensional standards (such as runway length and width, separation standards, surface gradients, etc.) should be selected which are appropriate for the critical aircraft that will make substantial use of the airport in the planning period. Substantial use means either 500 or more annual itinerant operations, or scheduled commercial service. The critical aircraft may be a single aircraft or a composite of the most demanding characteristics of several aircraft.*"

The other factors to be considered include critical aircraft approach speed, maximum certificated takeoff weight, useful load and length of haul, the airport's field elevation above mean sea level (MSL), density altitude, the mean daily maximum temperature at the airfield, and typical runway surface conditions, such as wet and slippery.

The required departure runway length can be defined as the longest of the following three distances:

- ✈ Accelerate-Takeoff Distance—The total distance needed for the aircraft to accelerate to the critical takeoff speed (V1), takeoff, and climb to an altitude of 35 feet above the ground, with one engine failing when the aircraft reaches V1;

- ✈ Accelerate-Stop Distance - The distance needed for the aircraft to accelerate to V1 and then brake to a full stop; and
- ✈ All-Engine Takeoff Distance - 115 percent of the distance needed for the aircraft to accelerate to V1, takeoff, and climb to an altitude of 35 feet above the ground with all engines operating normally.

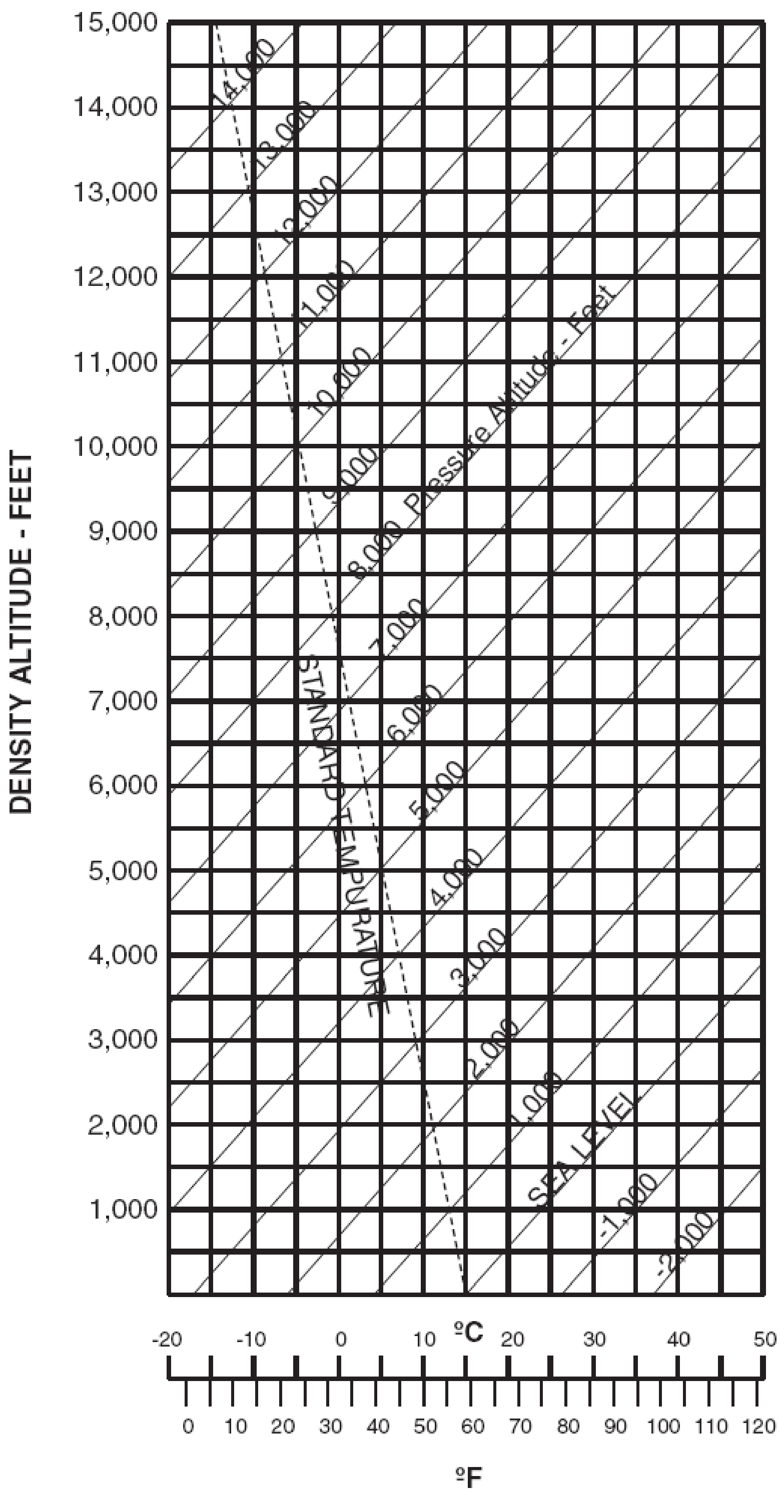
Based on these definitions, it can be noted that as the critical takeoff speed is increased, the accelerate-takeoff distance decreases while the accelerate-stop distance increases. The methodology described in FAA AC 150/5325-4A provides for the “balanced field length” runway design, or the runway length at which the tradeoff between the reduced accelerate-takeoff distances approximately equals the increased accelerate-stop distance.

PCR primary Runway 3R-21L is at 5,045’ MSL. Therefore, density altitude was factored in the determination of the runway length. Density altitude is pressure altitude corrected for nonstandard temperature and at which the density of the International Standard Atmosphere (ISA) is the same as the density of the air being evaluated. The temperature at ISA is 15°C (or 59°F). Typically increased density altitude, during period of high temperature, decreases operational performances of both propeller and jet engine aircrafts. Such loss in performance requires longer takeoff distances and faster ground speeds during landings, in turn resulting in longer runway length requirements.

At PRC, the average maximum daily temperature in the hottest month of July is 90°F. As shown in Figure 1 the density altitude for PRC at 90°F is approximately 8,000 feet. Wind speed was assumed to be zero. The flap setting configuration was assumed to be optimal. The runway gradient was assumed to be the same of the existing runway condition at 0.96%. The procedure assumes that there are no obstructions that would preclude the use of the full length of the runway.

Figure 1:

Density Altitude Chart



Altimeter Setting ("Hg)	Pressure Altitude Conversion Factor
28.0	1,824
28.1	1,727
28.2	1,630
28.3	1,533
28.4	1,436
28.5	1,340
28.6	1,244
28.7	1,148
28.8	1,053
28.9	957
29.0	863
29.1	768
29.2	673
29.3	579
29.4	485
29.5	392
29.6	298
29.7	205
29.8	112
29.9	20
29.92	0
30.0	-73
30.1	-165
30.2	-257
30.3	-348
30.4	-440
30.5	-531
30.6	-622
30.7	-712
30.8	-803
30.9	-893
31.0	-983

SECTION 4 – PRC RUNWAY LENGTH DETERMINATION

Following FAA guidelines in AC150/5325-4B, a five step procedure was used to determine the recommended length for the critical design airplane.

Step #1: Identify the Critical Design Aircraft or Category

The 2007 operations data shows that the majority of the fleet operating at PRC fell within Category A and B, with forecasts showing that this will be maintained in the future. Aircraft in these categories varies from Group I to Group III. Additionally more than 1% of the total operation was attributed to aircraft in the C category, from Group I to Group III. At present, the Q-400 (a C-III aircraft) has been introduced to the PRC fleet mix, and is expected to conduct more than 1,400 operations per year. While the B-1900, a B-III aircraft, continues to conduct thousands of operations at PRC. Additionally, at PRC the USFS Prescott Fire Center and Henry Y. H. Kim Aviation Facility continue to operate large aircraft tankers during the fire season, such as the P-3 Orin and C-130. Although, the number of operations conducted by the USFS fleet is not sufficient to be considered the critical aircraft (i.e., 500 annual operations or more), their presence supports the need to continue to plan and maintain PRC as ARC C-III.

The 1997 Master Plan had identified the Boeing 737, a C-III aircraft, as the Design Aircraft for PRC. As part the planning process, this aircraft was re-evaluated to determine if possibly another aircraft more accurately depicts the design standard requirement at the airport. While it is clear that PRC should continue to be an ARC C-III facility, it is important to identify the critical aircraft that reflects the true aviation planning need of PRC.

The commercial forecast for the PRC market identified that the RJ utilization will be introduced and continue to grow in relation to the high growth of the population in the Prescott Metropolitan Service Area (MSA). Additionally, seating capacity and range of the commercial flight service offered at PRC will increase.

Based upon the expectation that the B-1900 is soon expected to be replaced by more reliable and efficient aircraft in addition to current increasing trends in the regional carrier market, it is anticipated that RJ will play a bigger role in PRC's future (specifically in the 40-70 seat capacity segment). In the Western Region, the RJs predominantly used in this category are the CRJ-200 and CRJ-700, which are currently operated by Mesa Airlines, SkyWest, Delta Connections, Northwest Airlines, Midwest Connect, ASA, Horizon Air and others. Table 1 illustrates a few examples of the type of aircraft that are expected to operate at PRC in the future.

Table 1 - Sample of Future PRC Design Aircraft

Example	Aircraft Type	ARC
	Q-400 Wingspan:92.25 ft MTOW: 64,500 lbs Approach Speed: 125 knot	B-III
	CRJ-200 Wingspan:76.3 ft MTOW: 47,450 lbs Approach Speed: 130 knot	C-II
	CRJ-700 Wingspan:85.04 ft MTOW: 71,750 lbs Approach Speed: 140 knot	C-III
	ERJ-145 Wingspan: 65.9 ft MTOW: 48,400 lbs Approach Speed: 110 knot	C-II

Step #2: Identify the Aircraft That Will Require the Longest Runway Lengths at Maximum Certificated Takeoff Weight.

Typically, the standard FAA process is to break down the potential range of aircraft design identified in Step #1 into relevant weight groups or categories:

1) MTOW of 12,500 pounds or less;
2) MTOW Over 12,500 pounds, but less than 60,000 pounds;
3) MTOW of 60,000 pounds or Regional Jets.

Regional Jets, regardless of their MTOW, are assigned to the 60,000 pound or more weight category. Although a number of RJs have a MTOW less than 60,000 pounds (27,200 kg), the exception acknowledges the long range capability of the RJs and the necessity to offer these operators the flexibility to interchange RJ models according to passenger demand without suffering operating weight restrictions. When the MTOW of listed aircraft is over 60,000 pounds (27,200 kg), the recommended runway length is determined according to the individual aircraft. Therefore, given that the majority of the aircraft indentified in Step #1 are RJs, the recommended runway length for PRC will be determined according to individual aircraft.

Step #3: Determine the Method That Will be Used for Establishing the Recommended Runway Length

Based upon the information contained in Step #2, the standard FAA design approach for RJs and those aircraft with a MTOW of more than 60,000 pounds (27,200 kg) was used. Therefore, PRC Runway 3R-21L calculations are based upon:

1. The performance charts published by airplane manufacturers (i.e., Airport Planning Manuals); or
2. By contacting the airplane manufacturer; and/or
3. By contacting the air carriers for the information.

Both takeoff and landing runway length requirements were determined with applicable length-adjustments in order to determine the recommended runway length. The longest of the takeoff and landing runway length requirements for the critical design aircraft under evaluation then becomes the recommended runway length.

The first two options and the FAA Airport Design Computer Program 4.2D were used to calculate the Runway 3R-21L length requirement for planning purposes. The program includes an aircraft fleet profile designed to be representative of the small and large aircraft that comprise the general aviation aircraft fleet in the United States. The results are summarized in Table 2 and Table 3.

Table 2 presents the required runway lengths for PRC based upon the FAA Airport Design Computer Program 4.2D.

Table 2 - PRC Runway Length Analysis

Airport Input Data	
Airport Elevation (MSL)	5,045'
Mean daily temperature of the hottest month	90°
Maximum difference in runway centerline elevation	62'
Runway Length Recommended for Airport Design	
Small airplanes with approach speeds of less than 30 knots	450'
Small airplanes with approach speeds of less than 50 knots	1,200'
Small airplanes with less than 10 passenger seats:	
75 percent of these small airplanes...	4,640'
95 percent of these small airplanes...	6,240'
100 percent of these small airplanes...	6,410'
Small airplanes with 10 or more passenger seats	6,410'
Large airplanes of 60,000 pounds or less:	
75 percent of these large airplanes at 60 percent useful load	7,300'
75 percent of these large airplanes at 90 percent useful load	9,220'
100 percent of these large airplanes at 60 percent useful load	11,400'
100 percent of these large airplanes at 90 percent useful load	11,620'
Source: FAA Airport Design Computer Program 4.2D and FAA AC 150/5300-1.	

In addition to the FAA Program, the Airport Planning Manual for the CRJ-200, CRJ-700 and ERJ-145 was obtained. Additionally, the manufacturer Bombardier Inc. was contacted to validate the initial calculation and to use their simulation programs to run performance scenarios based on PRC environmental conditions. The results are summarized in Table 3.

Table 3 - Operational Characteristics

Aircraft Type and Engine	MTOW	Runway Length	Max Range at Max Payload
CRJ 200	47,450 lbs	8,700 feet	550 nm
CRJ 700 (CF34-8C1)	71,750 lbs	9,950 feet	1,434 nm
ERJ 145 (A1/1)	48,400 lbs	8,200 feet	900 nm

Step #4: Select the Recommended Runway Length

The recommended runway length is selected by reviewing the operational characteristics identified in Step #3. FAA AC150/5325-4B established that the longest runway length required at MTOW should become the recommended runway length. As shown in Table 3, at MTOW, the CRJ-700 requires a runway length of 9,950 feet at hot and dry conditions.

Step #5: Apply Any Necessary Adjustment to the Obtained Runway Length

The final step provides for adjustment to the obtained runway length based upon local circumstances. This includes any adjustments due to centerline elevation differences. FAA AC 150/5325-4B recommends increasing the runway length an additional 10 feet for each foot of centerline elevation difference. By maintaining the current runway gradient of 0.96%, the runway will have a difference of 62 feet in centerline elevation. Therefore, an additional 620 feet should be added to the length identified in Step #4 totaling a runway length of 10,570 feet.

SECTION 5 – SUMMARY & CONCLUSIONS

Based on the five step runway length analysis, the operationally preferred runway length for Runway 3R-21L is 10,570 feet. This result will be incorporated in the Facility & Standards Analysis and in the Alternative Analysis with regards to airfield improvement and land acquisitions.

It should be noted that the EA for the proposed runway extension will determine if such an extension will result in adverse impact to the natural and social resources surrounding the airport. The EA will determine whether it will be necessary to adjust the proposed length with respect to the Purpose and Need of the proposed improvement.