APPENDIX J

REQUIRED NAVIGATION PERFORMANCE IMPACTS EVALUATION REPORT

JUNEAU INTERNATIONAL AIRPORT (JNU) RNP RNAV EIS ANALYSIS

February 01, 2007

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1. EXECUTIVE SUMMARY

Required Navigation Performance (commonly referred to as RNP RNAV) is an aerial navigation operating concept that, when combined with the advanced technology navigation systems that are available on current production commercial aircraft, brings increased benefit to aircraft operations in terms of access, reliability, efficiency and safety when compared to traditional operating concepts and systems. RNP is widely recognized as a key enabler to the future global aviation transportation system. At present, over 300 RNP based procedures are in use worldwide, with the number expected to increase in the next 10 years. Beginning in 1994, Alaska Airlines pioneered the use of RNP based operations and technology in Juneau, with the current RNP instrument flight procedures being the first ever deployed in the world. Juneau has proven to be an ideal candidate for RNP based procedures due to the terrain surrounding the airport, the prevailing inclement weather conditions and the limited availability of traditional aerial navigation systems. Prior to the deployment of these procedures, the existing instrument procedures provided limited utility as the aircraft were not guided directly towards the runway, and pilots had to acquire the airport visually 3.2 miles from the end of the runway at an altitude of 2000 feet above the ground in order to land. This represented a high operational burden for Alaska Airlines as weather conditions are often below these values, forcing crews to conduct “missed” approaches and enter holding patterns to delay the arrival, or divert to other locations with suitable weather. In addition, these procedures required specialized training for crews to become familiar with the unique characteristics of the navigation systems and visual flight procedures required to arrive and depart from the airport.

The RNP procedures at Juneau were the first in a series of RNP procedures that Alaska Airlines deployed throughout South East Alaska in the mid 1990’s. These procedures fundamentally changed the economics of Alaska Airline’s South East Alaska operations and the communities that they serve. These procedures provide for increased access, increased operational reliability, reduced fuel consumption and reduced green house gas emissions when compared to the traditional procedures in place. The RNP procedures into Juneau allow flight crews to fly down to a ceiling of 318’ (for runway 26) and 687’ (for runway 08) before needing to visually acquire the runway to land. These altitudes are known as “Decision Heights (DA (H))” as it is the altitude at which the pilot makes the decision to land based on visual acquisition of the runway or runway environment.

This report summarizes the potential changes to Alaska Airlines RNP RNAV approach procedures that would result from displacing the landing threshold locations as specified in the Draft Environmental Impact Statement (EIS; April 2005) for Juneau International Airport. The Draft EIS describes a number of runway displacement configurations for consideration within runway safety area improvement alternatives. Naverus has evaluated the approach procedures against each of three runway configurations and determined that the only potential changes to these procedures involve changes of less than 10 feet to the currently published decision heights (DA(H)’s) based on the conditions set forth in this report and described in the sections that follow.

Although a number of mitigations to reduce this change are described in the report, Naverus does not consider the changes in DA(H) to be of operational significance. However, it must be understood that a relocation of the runway ends would require an entire redesign and submittal of the procedures. The procedures currently in place (and those that would need to be designed to replace them) use specialized design rule sets that recognize the unique capabilities of the Alaska Airlines 737 -400 and 737 – NG fleet. Redesign and approval of the Juneau RNP procedures could represent a substantial risk to Alaska Airlines and to the community of Juneau from a direct cost standpoint related to designing and implementing a new procedure and an unknown time to benefit, based on the current approval process within the FAA. For this reason, Naverus recommends that Alaska Airlines be consulted directly to determine cost and risks associated with the redesign and approval.

The changes are summarized as follows:

Affect on Decision Altitudes

Configuration 1: Runway 08 - Displace the threshold 446 ft. east of existing location (representing modified alternative RSA-5C in the Final EIS):

- Runway 08 RNP RNAV "X", "Y" and "Z" Approaches:

Decision Altitudes *increase* six feet for RNP 0.15, RNP 0.20 and RNP 0.30.

Configuration 2: Runway 26 - Displace both the threshold and departure ends of runway 520 ft. east of existing locations (representing a new alternative RSA-5E in the Final EIS):

- Runway 26 RNP RNAV Approach:

Decision Altitudes *decrease* six to seven feet for RNP 0.15, RNP 0.20 and RNP 0.30.

Configuration 3: Runway 26 - Displace both the threshold and departure ends of runway 188 ft. west of existing locations:

- Runway 26 RNP RNAV Approach

Decision altitudes *increase* two feet for RNP 0.15, RNP 0.20 and RNP 0.30.

As stated above, these changes are not considered to be operationally significant. An increase of seven feet represents an increase of less than 2%.

Potential Mitigations Considered:

1. Change the threshold crossing height.
2. Adjust the glide path angle.
3. Remove controlling obstacle to improve DA(H).

2. BACKGROUND AND SCOPE

The analysis documented in this report summarizes the potential consequences to Alaska Airlines special approach procedures associated with alternatives proposed in the Juneau International Airport (JNU) Draft Environmental Impact Statement (EIS) and pending Final EIS. The analysis is intended to provide guidance to the FAA and JNU in choosing the optimum RSA alternative.

The following alternatives were analyzed (runway length is maintained for all alternatives):

- Displace RW08 threshold 446' east.
- Displace RW26 threshold 520' east.
- Displace RW26 threshold 188' west.

The analysis summarizes the consequences in terms of the affect on decision heights (DA(H)'s) . Decision height refers to the minimum altitude (DA) or height (H) above touchdown in the approach at which a missed approach must be initiated if the required visual reference to continue the approach has not been established. Required visual reference indicates that the runway threshold or approach lights or markings identifiable with the landing runway are clearly visible to the pilot. The decision altitudes are arrived at through the engineering analysis, application and optimization of various procedure design elements as described in this report.

The analysis includes a baseline assessment of the existing runway configuration, and of the scoped EIS alternative configurations. Naverus RNP RNAV Approach Procedure Design Criteria and processes were used to analyze both the existing (baseline) configuration and scoped EIS alternative configurations. It should be noted that a limited number of elements of the criteria and processes used by Alaska Airlines to design the currently approved procedures differ from the Naverus criteria and processes applied in this analysis. This report does not contain a quantitative analysis of the differences between the criteria sets, but describes the results in terms of the relative differences between the Naverus baseline and alternative configurations. It is the judgment of Naverus that in the instances described in this report, the differences between the Naverus and Alaska Airlines criteria are not relevant in terms of the relative consequences quantified, and that the application of the Alaska Airlines criteria would yield similar results.

No obstacle flight inspection has been conducted to validate reported obstacle heights, and no test simulations have been conducted in generating this analysis.

3. CONDITIONS

The results of this analysis are based on the following data:

3.1. Terrain, Obstacles and Charts

- Electronic surface model from LIDAR data with a vertical accuracy of two meters or less and a horizontal accuracy of five meters
- FAR-77 Obstacle Data, released by the National Geodetic Survey, verified on 03 September 2001,
- 25k & 63.3k topographical charts

3.2. Runway Threshold Coordinates

Existing Baseline Configuration:
Alaska Airlines Coordinate for RW08: Latitude: N 58-21-28.55 Longitude: W 134-35-51.21
Alaska Airlines Coordinate for RW26: Latitude: N 58-21-07.19 Longitude: W 134-33-18.00

Threshold Displaced 446' East:
Derived Coordinate for RW08 Displaced Threshold: Latitude: N 58-21-27.44 Long: W 134-35-43.12

Threshold Displaced 520' East:
Derived Coordinate for RW26 Displaced Threshold: Latitude: N 58-21-05.87 Long: W 134-33-08.58

Threshold Displaced 188' West:
Derived Coordinate for RW26 Displaced Threshold: Latitude: N 58-21-07.67 Long: W 134-33-21.41

3.3. Runway Threshold Elevation and Touchdown Zone Elevation

From Alaska Airlines: RW08: 21' & 19'
From Alaska Airlines: RW26: 20' & 18'

The touchdown zone elevation is the highest point in the first 3,000 feet of the landing runway. Analysis of alternative configurations assumed no change in threshold or touchdown zone elevations.

3.4. Runway Threshold Crossing Height (TCH)

RW08: 50'
RW26: 50'

The threshold crossing height is the designated crossing height of the glide slope above the landing threshold point. Analysis of alternative configurations assumed no change in threshold crossing height.

3.5. Regulatory Documents

An important consideration in the design of RNP procedures is the rule set, or criteria, applied to accomplish the design. Currently, there are two different published criteria sets that have been produced by the FAA and are widely accepted: AC 120 – 29A and Order 8260.52.

AC120 – 29A describes an "open" rule set that allows designers to optimize RNP procedures by applying specific characteristics of individual aircraft capabilities. These capabilities include, but are not limited to, navigation sensors such as GPS, specialized cockpit displays and the performance of the aircraft's engines. Procedure designers using AC 120 – 29A must tailor the criteria to these specific capabilities for each aircraft type. The Alaska criteria is based on AC120-29A and contains a number of proprietary elements that allows Alaska Airlines to take full advantage of the capabilities of the specialized equipment installed in their 737 aircraft. Naverus procedure design criteria are also based on AC120-29A and contain a number of proprietary elements.

In order not to breach proprietary design information, a baseline and subsequent analysis was conducted for each runway end and each threshold location per the Naverus design criteria. Despite subtle differences between the Alaska and Naverus criteria sets, this analysis assumes each will yield a similar order of magnitude change from the pre-existing to the final condition.

Order 8260.52 is more formulaic in nature and applies specific "generic" rule sets that capture a broad range of aircraft capabilities. This rule set is necessarily restrictive in order to provide utility to a broad range of aircraft types. It does not fully exploit the capabilities of the Alaska Airlines 737 fleet. This criteria set provides substantial benefit for the majority of locations around the world, however, in a location such as Juneau, the application of this criteria set would potentially result in procedures that provide little or no benefit over the traditional procedures in place.

The FAA is beginning to produce publicly available instrument approach procedures based on 8260.52. The FAA has recognized that operators may still want to design their own procedures based on the capabilities of their specific aircraft, and allows the production and implementation of these procedures via a specialized review and approval process. Currently, this approval process can extend beyond three years.

The proposed changes to the runway ends at Juneau would require Alaska Airlines to design and submit for approval, all new procedures based on their proprietary criteria. This process represents a substantial potential risk to Alaska Airlines for the Juneau procedures. Naverus recommends that Alaska Airlines be consulted directly to determine cost and risks associated with the redesign and approval.

3.6. Aircraft Performance

For this analysis, Naverus developed a generalized aircraft performance model that is representative of most current production twin engine narrow body aircraft. In the judgment of Naverus, the differences between this generalized performance model and the actual performance characteristics of aircraft currently flying the existing approaches are inconsequential to the outcome of this analysis.

3.7. Engine Failure Contingencies

All procedure paths include engine failure contingencies.

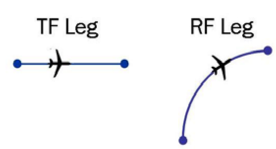
3.8. Temperature Adjustment Analysis

As a general rule, all altitudes depicted are corrected for temperature deviations from ISA, so temperature compensation by the flight crew is not necessary to maintain obstacle clearance during cold temperatures.

4. RUNWAY 08 DISCUSSION

4.1. General Layout and design assumptions

RNP procedures are constructed by connecting segment legs together with waypoints. A segment is identified by the method used to define the lateral path and how the segment terminates. There are several leg types available for RNP operations. Track-to-Fix (TF) and Radius-to-fix (RF) legs are the primary leg types normally used. A TF leg connects two waypoints by a line. An RF leg connects two waypoints with a curved path that is tangent to adjoining segments.



The collection of segments that make up a procedure provide guidance for the aircraft from the enroute or feeder airways to the runway. A procedure is subdivided into initial, intermediate and final approach segments. Initial Segment provides a smooth transition from the enroute environment to the Intermediate Segment and generally has a maximum length of 50 nautical miles (NM). The Intermediate Segment provides a smooth transition to the Final Approach Segment (FAS) and begins at a waypoint referred to as the initial fix (IF). The intermediate segment is limited to 15 NM in length. The FAS begins at the final approach fix (FAF) with an optimum length of five to seven nautical miles. The FAS is the only segment of the approach where vertical obstacle clearance is based on the guidance capability of the aircraft systems.

The Runway 08 RNP approach and missed approach procedures were designed to follow the approved Alaska Airlines special procedures with a series of Track-to-Fix (TF) and Radius-to-Fix (RF) legs. Approaches “X”, “Y” and “Z” were analyzed. Naverus criteria allows for the inclusion of RF legs, whereas the Alaska Airlines special procedures at Juneau only consider TF legs. The RF legs that were inserted took the most conservative route available and closely match the current operation of a TF to TF transition.

The baseline and each alternative match the existing published approach glide path angle of 3.5 degrees.

It was assumed there would be no change to threshold elevations, threshold crossing heights or touchdown zone elevations between the configurations analyzed. To provide a true comparison for the before and after condition, it was assumed that no existing procedural waypoints (other than the runway waypoint) would change location between the configurations analyzed.

4.2 Runway 08 Initial Approach Analysis

All procedural elements of the initial approach segments will remain unchanged from the existing configuration regardless of the alternative configurations applied.

4.3 Runway 08 Intermediate (IF to FAF) Analysis

All procedural elements of the intermediate approach segments will remain unchanged from the existing configuration regardless of the alternative configurations applied.

4.4 Runway 08 Final and Missed Approach Analysis

Using the existing horizontal track location, design software was used to perform an analysis of the existing baseline configuration for the RW 08 approach and missed approach tracks. The track was sampled across a digital terrain model and cross sections were developed that showed the track with the 3.5 degree glide path overlaying the existing surface model. This analysis determined controlling obstacles and decision altitude (DA(H)) for RNP 0.15, RNP 0.20 and RNP 0.30 containment levels. The RNP containment level refers to the lateral RNP segment width for which obstacle protection is provided. The lateral segment width is two times the specified RNP level on either side of the procedure centerline. The RNP level is defined in nautical miles. Because smaller RNP values yield narrower obstacle clearance surfaces, they generally lead to lower decision altitudes.

In addition to analyzing terrain model data, FAR-77 survey obstacles were also considered in the analysis. The FAR-77 surveyed obstacles include vegetation and man-made obstacles. The FAR-77 survey provides more specific obstacle elevations than the terrain model data.

All controlling obstacles were in the approach segment of the track. There were no controlling obstacles in the missed approach segment of the track.

A second analysis was conducted to determine the consequence of displacing the threshold 446 feet to the east. The track was re-sampled across the existing terrain, cross sections were again developed and a controlling obstacle was determined. Due to the relatively small angle of inclination of the obstacle clearance surfaces, the same obstacle controls both the baseline and displaced threshold configurations. The 446 foot displacement results in a six foot increase in decision altitude.

Though no coding or simulation was done, it appears that coded altitudes at the waypoints with coded angles would require minor adjustment at most. These altitudes relate only to the flyability of the procedures and would not affect the DA(H)'s in any way.

Baseline Condition (See Table 4-1 below): Existing condition based on Alaska Airlines existing procedure and analyzed using Naverus design criteria with a glidepath angle of 3.5 degrees.

Threshold Displaced 446' East (See Table 4-1 below): Landing threshold point is displaced 446' east of its existing location. The remainder of the approach and missed approach remain unchanged from the baseline condition, including a 3.5 degree glidepath. Additionally, the threshold and touchdown zone elevations are assumed to remain the same as in the baseline condition.

Summary Baseline to Displaced 446' East (See Table 4-1 below): RNP 0.15, 0.20 and 0.30 all result in an increase in decision altitude of five to six feet.

Table 4-1

JNU RW 08 DA(H) Summary
Baseline to Threshold 446' East

RNP	DA	(H)
0.15	+5	+5
0.20	+6	+6
0.30	+5	+5

5. RUNWAY 26 DISCUSSION

5.1 General Layout and design assumptions

The Runway 26 RNP approach and missed approach procedures were designed to follow the approved Alaska Airlines special procedures with a series of Track-to-Fix (TF) and Radius-to-Fix (RF) legs. Naverus criteria allows for the inclusion of RF legs, whereas the Alaska Airlines special procedures at Juneau only consider TF legs. The RF legs that were inserted took the most conservative route available and closely match the current operation of a TF to TF transition.

The baseline and each alternative match the existing published approach glide path angle of 3.5 degrees.

It was assumed there would be no change to threshold elevations, threshold crossing heights or touchdown zone elevations between the configurations analyzed. It was assumed that no procedural waypoints (other than the runway waypoint) would change location between the configurations analyzed.

5.2 RW 26 Initial Approach Analysis

All procedural elements of the initial approach segments will remain unchanged from the existing configuration regardless of the alternative configurations applied.

5.3 RW 26 Intermediate (IF to FAF) Analysis

All procedural elements of the intermediate approach segments will remain unchanged from the existing configuration regardless of the alternative configurations applied.

5.4 RW 26 Final Approach Analysis

Using the existing horizontal track location and similar to runway 08, design software was used to perform an analysis of the existing baseline configuration for the RW 26 approach and missed approach tracks. This analysis determined controlling obstacles and DA(H) for RNP 0.15, RNP 0.20 and RNP 0.30 containment levels. The track was sampled across a digital terrain model and cross sections were developed that showed the track with the 3.5 degree glide path overlaying the existing surface model, and the controlling obstacle was determined. FAR-77 survey obstacles were also considered in the analysis. All controlling obstacles are in the intermediate or final approach segments. There are no controlling obstacles in the missed approach.

Additional analyses were conducted to determine the consequence of displacing the threshold 520 feet to the east and 188 feet to the west. The track was re-sampled across the existing terrain, cross sections were again developed and a controlling obstacle was determined for each scenario. As with runway 08, due to the relatively small angle of inclination of the obstacle clearance surfaces, the same obstacle controls both the baseline and displaced threshold analysis. Displacing the RW 26 threshold 520 feet to the east will provide a minimal benefit in the form of a six to seven foot reduction in decision altitude. This amounts to a less than 2% change in altitude. The 188 foot displacement results in a two foot increase in DA(H) (less than 0.6% difference).

Though no coding or simulation was done, it appears that coded altitudes at the waypoints with coded angles would require minor adjustment at most. These altitudes relate only to the flyability of the procedures and would not affect the DA(H)'s in any way.

Baseline Condition (See Table 5-1 below): Existing condition based on Alaska Airlines existing procedure and analyzed using Naverus design criteria with a glidepath angle of 3.5 degrees.

Threshold Displaced 520' East (See Table 5-1 below): Landing threshold point is displaced 520' east of its existing location. The remainder of the approach and missed approach remain unchanged from the baseline condition, including a 3.5 degree glidepath. Additionally, the threshold and touchdown zone elevations are assumed to remain the same as in the baseline condition.

Summary Baseline to Displaced 520' East (See Table 5-1 below): RNP 0.15, 0.20 and 0.30 all show a decrease in decision altitude of six to seven feet.

Table 5-1

JNU RW 26 DA(H) Summary

Baseline to Threshold 520' East

RNP	DA	(H)
0.15	-6	-6
0.20	-7	-7
0.30	-6	-6

Threshold Displaced 188' West (See Table 5-2 below): Landing threshold point is displaced 188' west of its existing location. The remainder of the approach and missed approach remain unchanged from the baseline condition, including a 3.5 degree glidepath. Additionally, the threshold and touchdown zone elevations are assumed to remain the same as in the baseline condition.

Summary Baseline to Displaced 188' West (See Table 5-2 below): RNP 0.15, 0.20 and 0.30 all show an increase in decision altitude of two feet.

Table 5-2

JNU RW 26 DA(H) Summary

Baseline to Threshold 188' West

RNP	DA	(H)
0.15	+2	+2
0.20	+2	+2
0.30	+2	+2

6. Potential Mitigations

Options for mitigating the negative consequence related to the increase in DA(H) resulting from the displacement of the landing threshold follow.

6.1 Adjust Threshold Crossing Height

One method of mitigation evaluated, was to hold the procedures exactly as they are and adjust the threshold crossing height (TCH) to absorb the horizontal shift in the landing threshold location (see Table 5-6 below). A 520 foot shift to the threshold would require a more extreme shift in threshold crossing height than, for example, a 188' shift to the west. It is the judgment of Naverus that this is not a viable mitigation as the revised threshold crossing heights reported in Table 5 – 6 (in particular the 23' and 39' TCH's) are not compliant with the Naverus design criteria and likely would be rejected by the FAA and or Alaska Airlines when balanced against the potential benefit.

Table 6-1
Potential Revised Threshold Crossing Heights

Runway	Threshold	TCH
08	446' East	23'
26	520' East	82'
26	188' West	39'

6.2 Remove Existing Controlling Obstacle

Another method of mitigating the negative consequence of an increase in DA(H) would be to remove the existing controlling obstacle and determine the resulting controlling obstacle. Without benefit of a survey it is difficult to predict the number of obstacles that would need to be removed or what reduction in DA(H) could be achieved.

6.3 Adjust Glide Path Angle

Due to steep terrain and local conditions, Juneau was designed with a nominal 3.5 degree glide path to provide the lowest possible decision altitudes. Another variable that could be adjusted to absorb the change in landing threshold location would be to make a slight adjustment to glide path angle (GPA). Holding the FAF to its current altitude and holding a threshold crossing height of 50', would flatten or make the GPA steeper depending on the direction of the shift. Applying these adjusted angles has minimal benefit to alleviate the higher decision altitudes that result from the proposed conditions; approximately one foot in each case. The glide path angles that would be required to realize the full mitigation were not directly analyzed as these would require angles that in some instances would potentially fall outside of acceptable glide path angles to the runway, or altitudes at the FAF's, from a flyability standpoint. When balanced against the potential benefit, Naverus considers any changes to glide path angles to be of limited or no operational relevance.

Table 6-2
Potential Revised Glide Path Angles

Runway	Threshold	GPA
08	446' East	3.47°
26	520' East	3. 60°
26	188' West	3.48°