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2013 | INNSBRUCK | AUSTRIA
15.-18. SEPTEMBER 2013
NOISE CONTROL FOR QUALITY OF LIFE

# Implementing performance based navigation procedures at US airports: improving community noise exposure

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## ABSTRACT

The Federal Aviation Administration (FAA) is implementing an ambitious program to modernize the US air traffic control system. NextGen technology – specifically Performance Based Navigation (PBN) – provides opportunities to address aircraft noise in a more precise and targeted way than ever before. This paper presents an overview of the process currently being used to develop and model the noise impacts of PBN. A critical success factor is the use of a collaborative team that includes procedure developers, air traffic control subject matter experts, airline representatives, performance specialists, and noise analysts, to analyze potential noise impacts of proposed procedural changes. Noise analyses are prepared using FAA tools. Communication of results is complex, and best accomplished through graphical displays. PBN and NextGen technologies provide a unique opportunity to improve the noise environment around airports. However, procedures need to be carefully designed and evaluated by a collaborative multidisciplinary team in order to achieve maximum benefit.

## 1. INTRODUCTION

Over the next two decades the Federal Aviation Administration (FAA) will face major challenges meeting future operational demand while improving safety, reducing delays, and protecting the environment. The Next Generation Air Transportation System (NextGen) represents the FAA's chief means of transforming the National Airspace System (NAS) from a ground-based system to a space-based system using Global Positioning Satellites (GPS). Advancements in aircraft sensing and communications technologies accommodate these challenges. Figure 1 summarizes the major technology improvements anticipated throughout the phases of flight.

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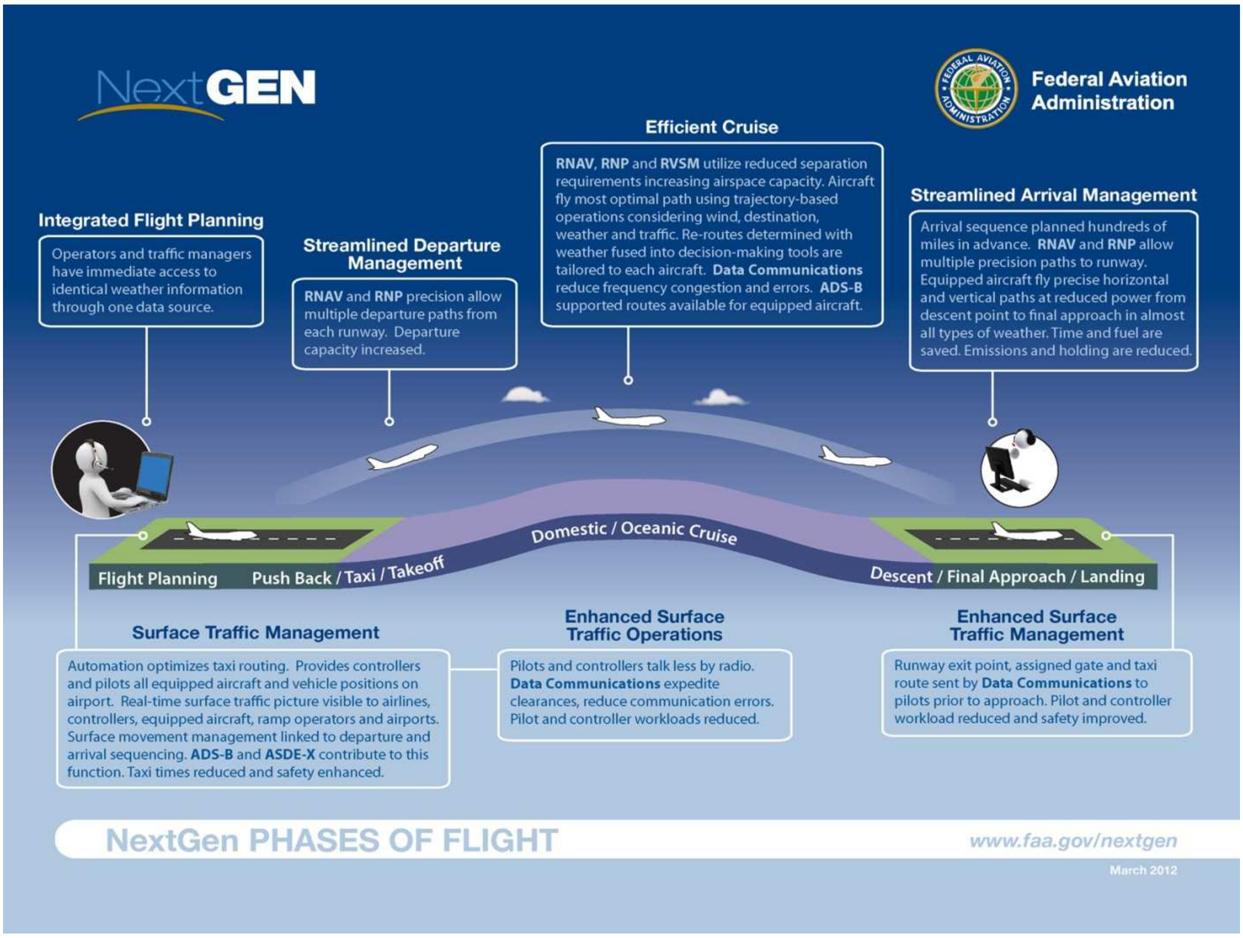


Figure 1 – NextGen Technologies Applicable to Various Phases of Flight

In September 2009, the FAA received an industry task force report [1] containing recommendations to expedite implementation of NextGen's top initiatives. A key component of the recommendations was the formation of study teams to leverage FAA and industry expertise to facilitate the design and implementation of optimized airspace and procedures. The new arrival and departure procedures that are required to implement the optimized airspace designs are referred to generally as Performance Based Navigation (PBN).

The National Environmental Policy Act of 1969 (NEPA) requires federal agencies to disclose to decision makers and the interested public a clear, accurate description of potential environmental impacts of proposed federal actions [2]. Through NEPA, Congress directed federal agencies to integrate environmental factors in their planning and decision making processes and to encourage and facilitate public involvement in decisions that affect the quality of the human environment. The FAA has established a process to ensure compliance with the provisions of NEPA through FAA Order 1050.1E, Environmental Impacts: Policies and Procedures [3].

## 1.1 Performance Based Navigation

Performance Based Navigation (PBN) encompasses a variety of specific procedure types including Area Navigation (RNAV) procedures, Optimized Profile Descents (OPDs) and Required Navigation Performance (RNP) procedures. All rely on GPS guidance rather than radar and air traffic control interaction for point-to-point navigation; additionally, on-board instrumentation permits aircraft to fly curved flight paths between two points. The characteristics of each procedure type are described briefly below.

### 1.1.1 Area Navigation (RNAV)

RNAV Procedures: A suitably-equipped aircraft flying an RNAV procedure is able to fly on any desired flight path within tighter tolerances than previously able, as long as the aircraft is within the coverage of ground- or space-based navigation aids, or within the limits of its own self-contained system, or a combination of both. As such, RNAV aircraft have better access and flexibility for efficient point-to-point operations in all phases of flight, including departure, en route, arrival, and approach to land.

### 1.1.2 RNP Procedures

RNP is RNAV with the addition of an on-board performance monitoring and alerting capability. A suitably-equipped aircraft on an RNP procedure is able to monitor its own navigational performance and alert its crew if the procedure is not being flown within its design tolerance. The increased situational awareness means that the aircraft are usually on an even narrower course than those associated with standard RNAV procedures.

### 1.1.3 Optimized Profile Descent

FAA has authorized development of arrival procedures with vertical profiles optimized to facilitate a continuous descent from the start of descent to touchdown. Optimized Profile Descent (OPD) procedures are designed to reduce fuel consumption, air emissions, and noise during descent by allowing pilots to set aircraft engines near idle power while they descend, instead of flying the more typical "step-down" approaches that require intervening level flight segments, resulting in increased throttle settings, and therefore added fuel burn.

## 2. DEVELOPMENT OF PBN PROCEDURES USING COLLABORATIVE TEAMS

One of the keys to successful development of PBN procedures that achieve real environmental benefits is collaboration with industry stakeholders, including air traffic controllers, and other key subject matter experts in its initiatives, such as operators and airport environmental specialists. A recent report from the General Accounting Office suggests that FAA's focus on collaboration has been instrumental in advancing and accelerating implementation of PBN procedures [4]. The following are among the anticipated benefits of this collaborative approach:

• Enhances PBN usage: New procedures are much more likely to be used if air traffic controllers are involved in the design. New procedures developed without controller input may not be feasible from an operational or safety perspective, and controllers may not see that the new routes are advantageous. In addition, the inclusion of airline stakeholders in the design process also helps keep industry informed and involved and helps assure that the proposed procedures can be flown by participating airlines.

• Addresses community concerns: The inclusion of airports in PBN procedure development and other projects can help address potentially adverse environmental—often noise-related—community impacts, since these entities often have primary responsibility for addressing community concerns and are likely more familiar than FAA with the airport's environmental impacts and the surrounding communities. Trust and respect are the keys to a long-term relationship between stakeholders—in this case between FAA and airport representatives, who are responsible for addressing community concerns about airport-related noise.

A collaborative approach for NextGen that involves key stakeholders better positions FAA to fully leverage those stakeholders' expertise, help identify possible solutions, and facilitate implementation of NextGen improvements.

## 3. METHODOLOGY

### 3.1 NEPA Impact Criteria

FAA Order 1050.1E, Policy and Procedures for Considering Environmental Impacts, specifies a number of requirements for noise analyses, including use of the yearly Day/Night Average Sound Level (DNL) as the noise metric of record. The DNL is a measure of cumulative noise exposure that takes into account all of the aircraft operations that occur during an "average" 24-hour day, However, events occurring after 10:00 p.m. at night and before 7:00 a.m. in the morning are penalized as if they were louder than they actually are to account for the increased disturbance due to nighttime operations. The penalty, or weighting, on each nighttime operation is 10 decibels (dB), equivalent in terms of its effect on DNL, to adding 10 daytime operations of the same aircraft.

FAA Order 1050.1E states that the noise analysis should not include noise contours or a focus on population and demographic effects but instead focus on changes in noise levels, using the following criteria:

- For DNL values from 60 to 65 dB, identify changes of ±3 dB or more.

- For DNL values from 45 to 60 dB, identify changes of ±5 dB or more.

FAA Order1050.1E states: a “significant noise impact” would occur if the noise analysis shows that the Proposed Action will cause areas to experience an increase in DNL of 1.5 dB or more at or above DNL 65 dB noise exposure when compared to No Action for the same timeframe. Order 1050.1E further elaborates on the meaning of significant impact, indicating that special consideration needs to be given to the evaluation of sensitive areas such as national parks, national wildlife refuges, and other uses such as traditional cultural properties. In summary, Table 1 below lists the criteria used in the noise analyses to evaluate both the existing DNL exposure levels as well as the changes in future exposure levels resulting from the proposed new flight procedures. The table also includes characterizations of the magnitude of those changes.

Table 1 – Basis for Characterization of Changes in Noise

| DNL Exposure Interval | Change in DNL | Characterization of Change |
|---|---|---|
| Greater than or equal to 65dB | 1.5 dB or more | Significant impact |
| 60 to less than 65dB | 3 dB or more | Can receive consideration for mitigation, if there is a significant noise impact, i.e., 1.5 dB or more increase in DNL greater than or equal to 65 dB |
| 45 to less than 60dB | 5 dB or more | Requires disclosure |

Source: FAA Order 1050.1E

### 3.2 Aircraft Noise Modeling

FAA Order 1015.1E specifies that one of the following three noise models should be used for NEPA studies: FAA’s Integrated Noise Model (INM), the Heliport Noise Model (HNM), or the Noise Integrated Routing System (NIRS). More specifically, it directs FAA that for air traffic airspace actions over large study areas or at altitudes above 3,000 feet above ground level (AGL), noise modeling “will be conducted using NIRS.” In 2012, FAA released the Aviation Environmental Design Tool (AEDT), and directed that it should be used to conduct noise, fuel burn, and emissions modeling for FAA air traffic airspace and procedure actions under NEPA [5].

AEDT requires inputs in a number of categories, including: routes and events for each scenario, airport and runway locations, annualization weights for each traffic component of each scenario, population locations for calculation of DNL, additional grids for calculation of DNL and other metrics, geographic areas, and terrain files.

Results of AEDT analyses for air traffic actions focus on change analysis, comparing the DNL between two scenarios, e.g., baseline and alternative at specified locations. Results are not typically depicted by noise contours.

## 4. CASE STUDY: GREENER SKIES OVER SEATTLE

### 4.1 Project Overview

The “Greener Skies Over Seattle” Project [6] was designed to increase air traffic control efficiencies through the use of new Area Navigation (RNAV) and Optimized Profile Descent (OPD) procedures into Seattle-Tacoma International Airport (SEA). The project addressed a number of air traffic actions, including two new Standard Arrivals (STARS) and 24 new Required Navigational Performance (RNP) procedures, all with Optimized Profile Descents, as shown in Figure 2.

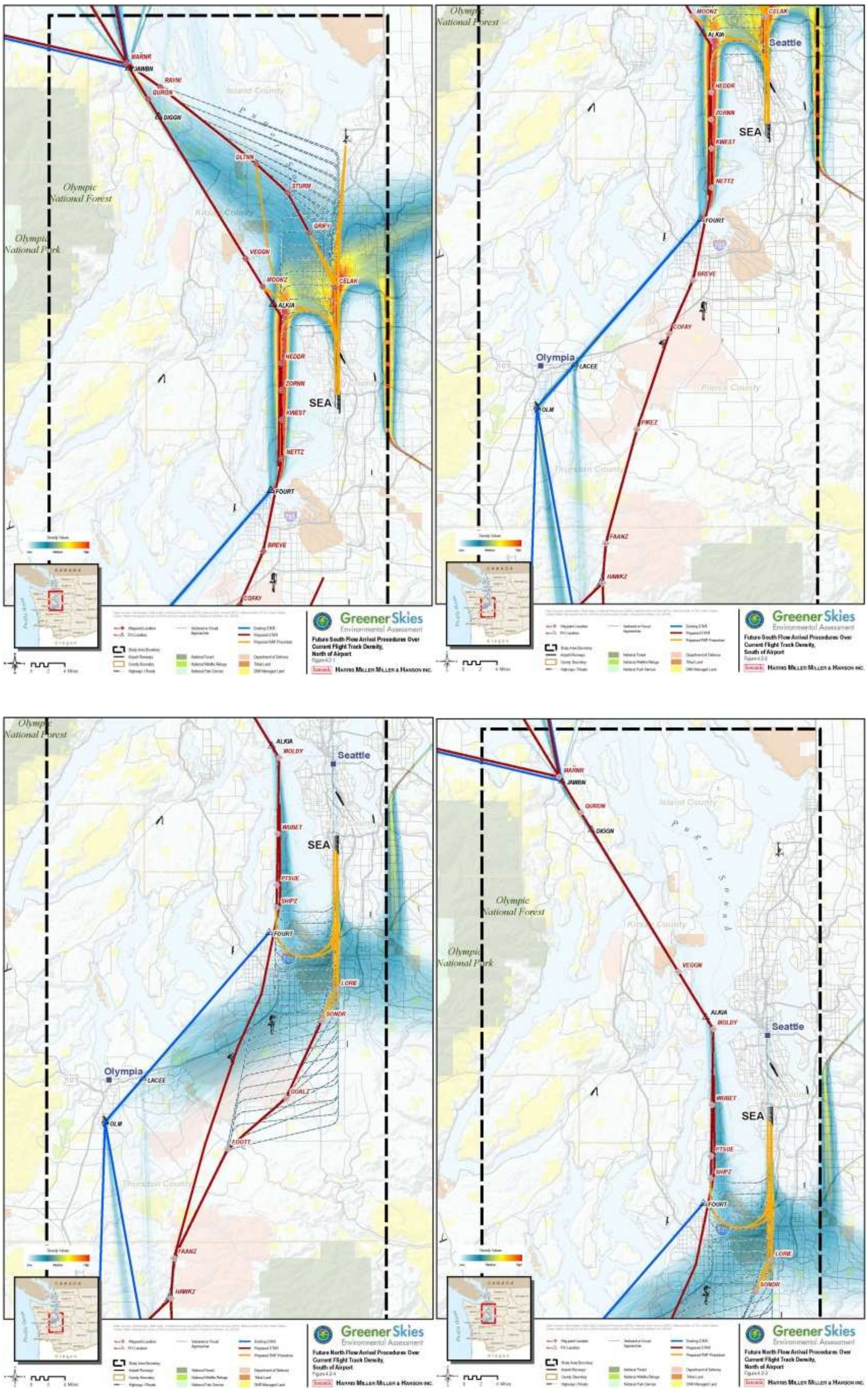


Figure 2 – Greener Skies Proposed Arrival Procedures

## 4.2 Noise Analysis

Noise was examined for three study years (2014, 2018 and 2023) using NIRS. Computations of noise exposure were made at 40,788 population centroids and nearly 15,000 additional points disassociated with population but useful for representing noise levels in more remote areas such as parks or wildlife refuges. Several hundred additional points were selected to represent schools, specific historic sites and several locations directly under proposed flight paths or in areas of variable terrain representative of additional potentially sensitive locations. All modeled points were adjusted for terrain elevation so that aircraft altitudes over the ground would be more accurately represented in the noise calculations. Elevation data were downloaded from the United States Geographic Survey (USGS). Terrain files imported into NIRS for noise computations must be in the USGS 1:250,000 scale DEM format – 1 degree square with 3 by 3 arc-second data spacing. These points are shown in Figure 3.

Specific noise and performance data must be entered into the NIRS for each aircraft type operating at the airport. Noise data are included in the form of sound exposure levels (SELs) at a range of distances from a particular aircraft with engines at a specific thrust level. Performance data include thrust, speed and altitude profiles for takeoff and landing operations. The NIRS database contains standard noise and performance data for over one hundred different fixed wing aircraft types, most of which are civilian aircraft. The NIRS automatically accesses the noise and performance data for takeoff and landing operations by those aircraft.

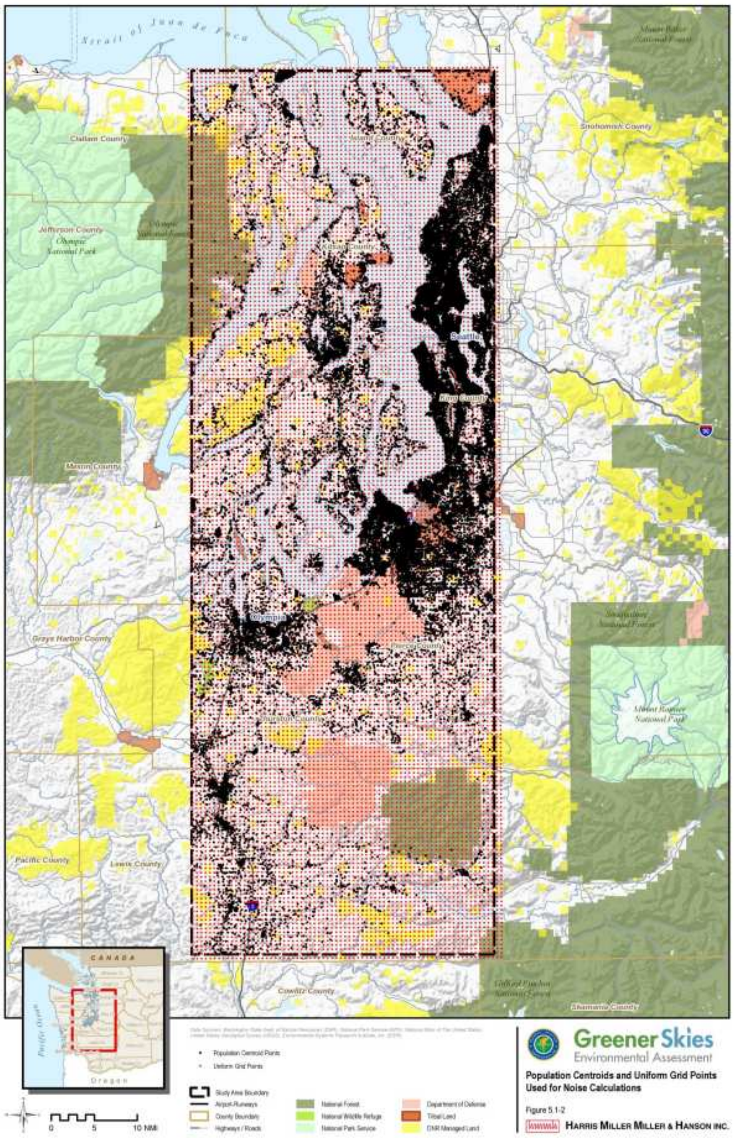


Figure 3 – Population Centroids and Uniform Grid Points Used for Noise Calculations in Study Area

### 4.3 Results

Using the inputs described above, NIRS was exercised to compute existing DNL noise exposure levels at the nearly 56,000 population centroids, uniform grid points, and specific sensitive locations.

The resulting DNL values are shown in Figure 4, color-coded in 5-decibel (dB) increments from 45 dB to 65 dB DNL and above. NIRS does not compute or generate noise contours from these calculations, but the density of the centroids and the color-coding of the results illustrate quite clearly a pattern of exposure that mimics typical DNL contours. Changes in predicted DNL are presented in Figure 5. Table 2 summarizes results.

Conclusions from the noise analysis are that:

- Of the 3,171,686 residents represented by the 40,788 population centroids in the study area, no one would be exposed to an increase in noise exposure that exceeds FAA's criterion for significant impact (a 1.5 dB or greater increase to a DNL of 65 dB or greater) as a result of the Greener Skies Proposed Action for any of the study years examined.
- No one would be exposed to increases in noise exposure from the Proposed Action that exceed any of FAA's other criteria for reportable changes – either a 3 dB or greater change in DNL from 60 to 65 dB, or a 5 dB or greater change in DNL from 45 to 60 dB – for any of the study years examined.
- In each of the three study years, there are residents exposed to noise greater than DNL 45 who will experience slight increases in exposure due to the Proposed Action, and others who will experience slight decreases, none of them greater than approximately ± 1 dB. Those experiencing decreases outnumber those experiencing increases by more than 2 to 1.
- For each study year, there are population centroids that are newly exposed to DNL values greater than 65 dB as a result of the Proposed Action. However, the maximum increase in DNL attributable to the Proposed Action along these final approach paths is only 0.1 dB in 2014 and 2018 and only 0.2 dB in 2023. Such changes are extremely small and not likely even to be noticed.

Table 2 – Summary Results for Greener Skies Proposed Action

| Study Year | Greatest Change in DNL Relative to No Action | | Population Experiencing Change | | Population Exceeding FAA Order 1050.1E Criteria | | | Population Newly Exposed to DNL 65 or above |
|---|---|---|---|---|---|---|---|---|
| | Increase | Decrease | Increase | Decrease | >1.5dB, DNL 65 or above | >3dB from DNL 60 - 65 | >5dB from DNL 45 - 60 | |
| 2014 | 0.9dB | -0.8dB | 120,386 | 277,754 | 0 | 0 | 0 | 396 |
| 2018 | 0.9dB | -0.8dB | 123,081 | 290,391 | 0 | 0 | 0 | 43 |
| 2023 | 1.1dB | -0.7dB | 132,484 | 311,122 | 0 | 0 | 0 | 214 |

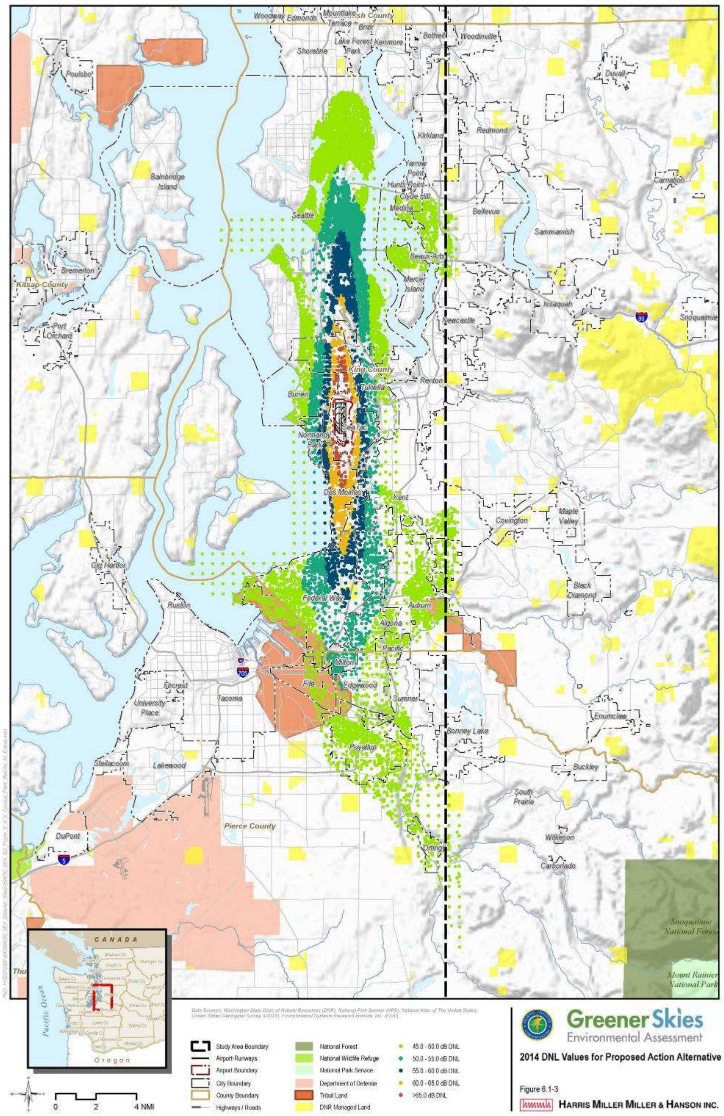


Figure 4 – 2014 DNL Values for the Proposed Action

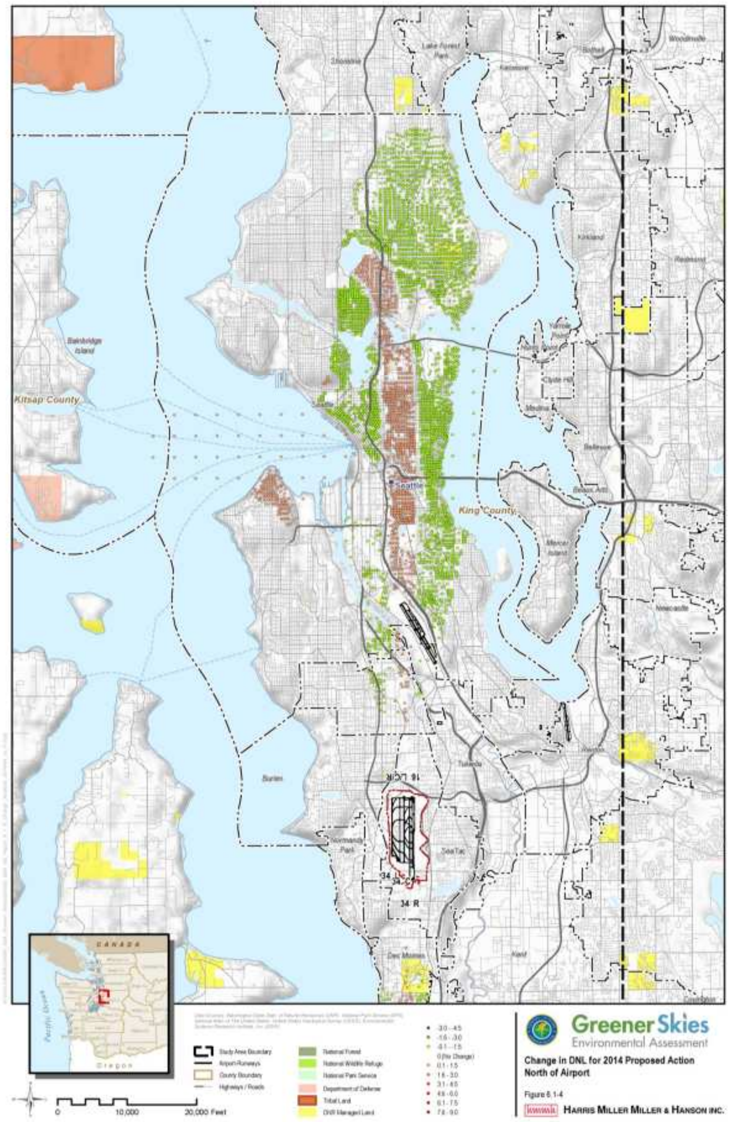


Figure 5 – Change in DNL for 2014 Proposed Action, North of SEA

## 5. CONCLUSIONS

Successful implementation of PBN procedures requires a collaborative team to develop procedures that take into consideration perspectives from multiple stakeholders, including air traffic controllers, operators, and airport and community representatives. Detailed and sophisticated noise modeling, using state-of-the-art models provides transparency that allows for a robust discussion of tradeoffs and challenges of implementation that ultimately results in a better outcome. NEPA review is not only required, but helpful to provide a framework for considering environmental impacts of these procedures.


## ACKNOWLEDGEMENTS

Harris Miller Miller & Hanson Inc. (HMMH) conducted the Greener Skies Over Seattle Environmental Assessment under contract to the Federal Aviation Administration.


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