2020

Review and Assessment - Dulles International Airport Aircraft Noise Contour Map Update

JOHNSON AVIATION CONSULTING

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March 15, 2020

Ms. Rachel Flynn
Deputy County Executive
Fairfax County Virginia
12000 Government Center Parkway, Suite 552
Fairfax, Virginia 22035

Subject: Review and Assessment of Dulles International Airport Aircraft Noise Contour Map Update

Dear Ms. Flynn:

Thank you for the opportunity to provide Fairfax County with this review and assessment of the Dulles International Airport (IAD, Dulles International or Airport), *Aircraft Noise Contour Map Update* prepared by Ricondo & Associates, with Harris, Miller, Miller, & Hanson (Report or Ricondo Report), for the Planning Department of Metropolitan Washington Airport Authority (MWAA). This process is an important part of continuously working toward informed, balanced and effective compatible land use planning for local communities and residents of Fairfax County affected by IAD aircraft operations.

Dulles International is a critically important economic asset for the County and the Washington D.C. Metropolitan Area. Protecting and preserving the utility of the Airport for the long term is the highest and best use of this economic resource. Likewise, responsible land use and development around and near the Airport enhances and leverages the value of the Airport and its users for the long-term economic vitality of the County. Fairfax County and MWAA together have made Dulles International a rare example in the U.S. of well-planned, airport-compatible land use success.

Our tasks for Fairfax County regarding the review and assessment of the Ricondo Report and the MWAA noise contour update process included the following:

- Determine if it follows standard industry practices for determining airport noise contour maps;
- Advise the County on potential amendments to its Comprehensive Plan and Zoning Ordinance;
- Provide guidance as to how these noise contours and the approach used by Ricondo compare to a standard FAA Part 150 study or update; and
- Provide an understanding of airports like Dulles International and their approaches to developing noise contours and the information/recommendations they provide to affected localities.

The attached report provides our findings, analysis and recommendations to the County as a result. Our perspective on these issues are based on our experience and expertise as airport planning professionals working with both airports and local communities to find informed, balanced, airport-compatible land use plans. We respect the work of Ricondo, and their team of experts who prepared the Report, and the foresight of MWAA to engage in this process with the County. Our assessment for the County is intended to inform, advise and guide decision makers as they consider the information provided by MWAA and how to best apply it to future land use planning in the County.

The following is a brief summary of our findings from the review and assessment of the Ricondo Report.

Summary of Findings

- The approach, methodology and assumptions used in developing the inputs for the Aviation Environmental Design Tool (AEDT) noise model and the generation of the Annual Service Volume (ASV) contours for Dulles International Airport appear to be well-documented and consistent with FAA regulatory guidance.
- The current development of Ultimate ASV noise contours is intended to be generally consistent with the original methodology used to set the land use planning boundaries for Dulles International while accounting for changes in key noise factors including aircraft fleet mix and GPS navigation procedures.
- The development and use of ASV contours, based on the ultimate operational capacity of an airport's master-planned runways, is an exception in the U.S. that is followed by only two Large Hub airports built on green field sites, like Dulles International.
- Most Large Hub airports use the FAA's Part 150 Noise Study process, which is a much shorter planning horizon and based on operational demand for an airport's runways, to identify affected communities and land uses for the application of aircraft noise mitigation measures.
- We know of five large hub airports, including IAD, that actively pursue land use planning and/or residential notifications to the 60 DNL noise contour level. These airports include Dulles International Airport, Denver International Airport, Minneapolis-St. Paul International Airport, Orlando International Airport, and Portland International Airport. It is important to note that Denver is the only other known large hub airport that uses an ASV contour for land use planning. The Denver and Minneapolis airports are discussed in detail within our report.
- The ultimate operational capacity of the existing four runways at Dulles International is well beyond the reasonably foreseeable projected demand for aircraft operations for the next 60 to 75 years.
- The ultimate operational capacity of the planned addition of a fifth runway at Dulles International is well beyond the reasonably foreseeable projected demand for aircraft operations over the next 80 to 90 years.
- GPS navigation accuracy and air traffic control procedures used for aircraft arrivals and departures have the potential to reduce flight path dispersion over Fairfax County and could increase perceived impacts by some people and reduce perceived impacts by other people. This may be of particular interest to communities south and east of the Airport where it is anticipated that arrival flight path dispersion will decrease with the increased use of GPS.

The County established reasonable airport compatible land use controls through the adoption of its Airport Noise Policy and Airport Noise Impact Overlay District (ANIOD) using the long-range noise contours developed in 1993 that assumed 740,000 annual operations or approximately 2,027 average annual day (AAD) operations. This level of operations is over 2.5 times the 806 AAD operations in 2017 and is adequate to accommodate Dulles International projected demand for the next 60 years.

There have been changes from the original assumptions used in the 1993 Part 150 noise analysis and contours. The location of the newest Runway 1L/19R is further west than originally planned to allow for triple simultaneous approaches during Instrument Flight Rules (IFR) conditions when needed. Air traffic control procedures have changed and are expected to continue to evolve as noted in the Ricondo report.

In addition, the aircraft fleet mix will continue to evolve and change over time based on the travel patterns and destinations of the passengers served. Continuous research is also taking place by airplane and engine manufacturers to further reduce noise from the aircraft they build. Airlines are investing in these quieter and more efficient aircraft while working with the FAA and local communities that they serve to fly them in a manner that reduces noise impacts on those local communities. With these ever-changing conditions, it is important to know the ASV contours are meant to be a guide of where potential noise impacts may exist in the future; they are not meant to be a definitive location of future noise impacts or potential noise complaints.

Based on the findings of this review and assessment and our experience with airport compatible land use planning, we recommend that the County focus on the reasonably foreseeable potential noise and overflight impacts of Dulles International aircraft operations. We offer the following recommendations to help guide the County's airport compatible land use planning.

Recommendations:

Recommendation 1 – Using the ultimate ASV contours as a guide for land use planning, concentrate on the Ultimate 65 DNL contour and apply the County's existing Noise Level Reduction (NLR) criteria for new residential construction to that area. While the ASV contours are based on an operational capacity projection far into the future and would not likely be achieved in the typical 20-30 year planning time frame, the ultimate 65 DNL contour could be used as guidance since it accounts for any potential increase in the actual 65 DNL noise contour up to and beyond a 30-year timeframe in projected aircraft operations growth at Dulles International.

Recommendation 2 – Undertake a GIS-based analysis using the Ultimate ASV area between the 60 DNL and 65 DNL contours to assess the amount of potential residential land uses that would be newly impacted and those areas which may no longer be located within the 60-65 DNL impact areas and consider changes to land use policies that permit residential uses in those areas, balancing potential noise impacts with other county goals such as economic development and placemaking.

Recommendation 3 – Consider establishing noise notification guidelines for concentrated overflight areas within the Ultimate 60 to 65 DNL noise contours to ensure the County has adequately provided notice to future residents that they are moving into an area located in close proximity to a major international airport and may be impacted by aircraft noise and overflights. The guidance provided for residential development in Land Unit J is consistent with guidelines adopted by other jurisdictions and can be used as a model as it has largely addressed the issue.

Recommendation 4 – Work with MWAA to study and recommend nighttime (10 p.m. through 6:59 a.m.) noise abatement procedures and a preferential runway use program should MWAA move forward with increased nighttime cargo activity and/or increased scheduling of nighttime passenger flights at IAD as discussed in the MWAA report.

We look forward to discussing this review and our findings and recommendations with the County planning staff and County decision makers.

Sincerely,

Nick Johnson
Johnson Aviation, Inc.

Table of Contents

1. Peer Review of Ricondo Report

The primary purpose of this report is to provide Fairfax County with a review and assessment of the Dulles International Airport (IAD, Dulles International or Airport), *Aircraft Noise Contour Map Update* prepared by Ricondo & Associates, with Harris, Miller, Miller, & Hanson (Report or Ricondo Report), for the Planning Department of Metropolitan Washington Airport Authority (MWAA)[1]. This peer review includes:

- An examination of the approach, methodology and assumptions used in developing the inputs for the Aviation Environmental Design Tool (AEDT)[2] and generation of long-range noise contours, called the Ultimate Conditions Noise Contours; and
- An assessment of the process to derive the Ultimate Conditions Noise Contours by way of a noise contour composite process using contours for three different runway and airfield configurations.

The approach of using annual service volume (ASV) capacity of an airport's runways to establish long term noise contours for compatible land use planning is unique to only two large hub airports in the United States. Denver International Airport and Dulles International are the only two "green field" large hub airports developed in the U.S. in the last 60 years. All other large hub airports have grown with the increase in demand for air service while the communities around those airports have grown in around them. Quieter aircraft and billions of dollars in noise mitigation have combined over time to reduce the number of people impacted by aircraft noise while the number of aircraft operations have increased dramatically. However, the problem of community aircraft noise impacts is far from eliminated and this spending by the Federal Aviation Administration (FAA) and local communities will continue.

Given the lack of similar examples against which to compare, this review focuses on the documented approach, methodology and assumptions in the Ricondo Report to assess the validity of the results and the applicability to compatible land use planning in Fairfax County. We have found that the approach, methodology and assumptions used in developing the inputs for the AEDT[3] noise model and the generation of ASV contours for Dulles International Airport appear to be well-documented and accurate for its long range planning and surrounding land use policy purposes. The Ricondo team's work appears to be consistent with aviation industry standards for aircraft noise modeling.

The Report includes more aircraft operations, a larger aircraft fleet mix, more night operations and runway utilization that differ from the current operations and show the expected growth, and ultimate capacity of a future airfield. These assumptions also differ from the original assumptions used to create the 1993 Federal Aviation Regulation (FAR) Part 150 analysis and long-range noise contours that are incorporated into the County's existing Airport Noise Impact Overlay District (ANIOD)[4]. The differing assumptions take into account the revised location of Runway 1L/19R, to allow triple simultaneous approaches, and changes in air traffic control technology that allow more operations to use the Airport. Each of these factors contribute to changes in the size of the noise contours and their shape over the surrounding airport

[1] Ricondo & Associates, Inc., Harris Miller Miller & Hanson, Inc., Washington Dulles International Airport Aircraft Noise Contour Map Update, May 2019.

[2] Aviation Environmental Design Tool (AEDT) Version 2d released September 26, 2017 by the FAA was the most recent regulatory version of the model at the time of the Ricondo Study. Since this date, the FAA has released four updates to the AEDT model. The latest is Version 3c released March 6, 2020. FAA requires that all noise and air quality analysis use the latest version of AEDT at the time the "environmental analysis process is underway."

[3] Federal Aviation Administration, https://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/aedt/

[4] Fairfax County, Virginia, Zoning Ordinance, Airport Noise Impact Overlay District, Section 7-400.

environment. The County will need to weigh these factors as it decides the best approach for future airport compatible land use planning.

1.1 MWAA Inputs to AEDT for Ultimate Conditions Contours

The Ricondo report and analysis relies on available IAD Airport facilities and operations information from 2017. This includes existing airport capital improvement plans, flight procedures, aircraft fleet mix and runway utilization. Assumptions about likely changes to each of these parameters are presented and justified in the Report. The time horizon for these changes are projected to occur over more than 80 years and are well beyond a reasonably foreseeable forecast. For perspective, the time period considered is far enough out that it is reasonable to assume that new aircraft would come and go in the fleet over this long time period. It is impossible to know the exact noise profile of these projected future aircraft operations, but it is reasonable to assume that current technology engine and airframe noise is a conservative estimate for planning purposes. This planning is using noise analysis in the FAA's AEDT model of known aircraft in the fleet today and their flight and noise characteristics.

1.1.1 Increased Aircraft Operations

The total number of aircraft operations is projected to increase significantly from 2017 actual operations and from the 1993 projected ultimate capacity. **Table 1.1** provides a comparison of the 1993 five—runway ASV, the current Four-Runway ASV and current Five-Runway ASV relative to the 2017 actual aircraft operations. This comparison shows that the existing airfield is unconstrained from future growth with the existing four runways. This capacity can be expanded even further with the addition of a fifth runway.

Table 1.1
Aircraft Operations Comparison

	2017 Actual	1993 Original Five-Runway ASV	Four-Runway ASV	Five-Runway ASV
Total Operations	294,190	740,000	900,000	1,004,000
AAD Operations	806	2,027	2,466	2,751
Increase over 2017	-	251%	306%	341%

1.1.2 Larger Aircraft Fleet Mix

Airlines are retiring older, noisier and less efficient aircraft at a rapid pace. These changes are reflected in the future fleet mix assumed as part of the ASV and associated noise analysis for Dulles International. **Table 1.2** provides a comparison of the broad categories of aircraft sizes. The most substantial change in aircraft numbers is in the Large Jet category. In 2017 there were 542 AAD operations that are projected to grow to 1,820 AAD operations in the four-runway case and 2,033 AAD operations in the five-runway case.

Table 1.2
Aircraft Size Category Comparison

Aircraft Category	2017 AAD	Four-Runway ASV	Five-Runway ASV
Super Heavy Jet	1%	1%	1%
Heavy Jet	10%	12%	12%
Large Jet	67%	74%	74%
Small Jet	13%	7%	7%
Turbine Propeller	8%	7%	7%
Piston Propeller	1%	0%	0%
Total	**100%**	**100%**	**100%**

1.1.3 Additional Night Operations

A major assumption included in the noise contour analysis is the addition of 24 nighttime cargo operations and 208 nighttime passenger operations. These 232 total additional nighttime operations are added to reflect MWAA's understanding of the cargo potential at IAD and the growing international passenger hub status over time. Additional nighttime operations between 10 p.m. and 7 a.m. would significantly add to the total noise impact given the 10 dBA penalty added to each nighttime operation when calculating DNL.

1.1.4 Changes in Runway Utilization

Assumptions about the redistribution of aircraft making use of each available runway by time of day has a significant impact on the size and shape of the resulting noise contours. **Table 1.3** compares the existing number of AAD operations in north flow versus south flow and split between day and night to each of the four runway and five runway scenarios. While **Table 1.3** gives the AAD comparative numbers, the Ricondo Report shows the runway utilization as if the airport were operated in one direction for an entire day. This presents a worst-case level of operations for a single location near the airport.

Table 1.3
Runway Operating Configuration Comparison - Average Annual Day (AAD)

2017 Configuration	AAD Operations			AAD Share		
	Day	Night	Total	Day	Night	Total
North Flow	404	67	471	50%	8%	58%
South Flow	284	51	335	35%	6%	42%
Total	688	118	**806**	85%	15%	100%

Four-Runway Configuration	AAD Operations			AAD Share		
	Day	Night	Total	Day	Night	Total
North Flow	1,184	173	1,356	48%	7%	55%
South Flow	986	123	1,110	40%	5%	45%
Total	2,170	296	**2,466**	88%	12%	100%

Five-Runway Configuration	AAD Operations			AAD Share		
	Day	Night	Total	Day	Night	Total
North Flow	1,320	193	1,513	48%	7%	55%
South Flow	1,100	138	1,238	40%	5%	45%
Total	2,421	330	**2,751**	88%	12%	100%

Source: Ricondo & Associates, Inc., Harris Miller Miller & Hanson, Inc., Washington Dulles International Airport Aircraft Noise Contour Map Update, May 2019.

To focus on the specific potential change in aircraft operations to Fairfax County, it is easiest to review the proposed change associated with each runway. The Ricondo Report provides a mix of percentage use by runway end by configuration (north flow or south flow). These operations are further split by Day (7 a.m. to 10 p.m.) and Night (10 p.m. to 7 a.m.). **Figure 1.1** depicts the flows of AAD operations that would overfly areas of Fairfax County on arrivals in north flow. **Table 1.4** through **Table 1.8** correspond to **Figure 1.1** and enumerate the change in AAD arrival operations that would overfly areas of Fairfax County. Together, **Figure 1.1** and **Tables 1.4 through 1.8** show that the runway utilization will change dramatically from the existing operation when measured in the change to actual AAD aircraft overflights.

Figure 1.1: Proposed Changes in Runway Utilization Directly Impacting Fairfax County (See Tables)

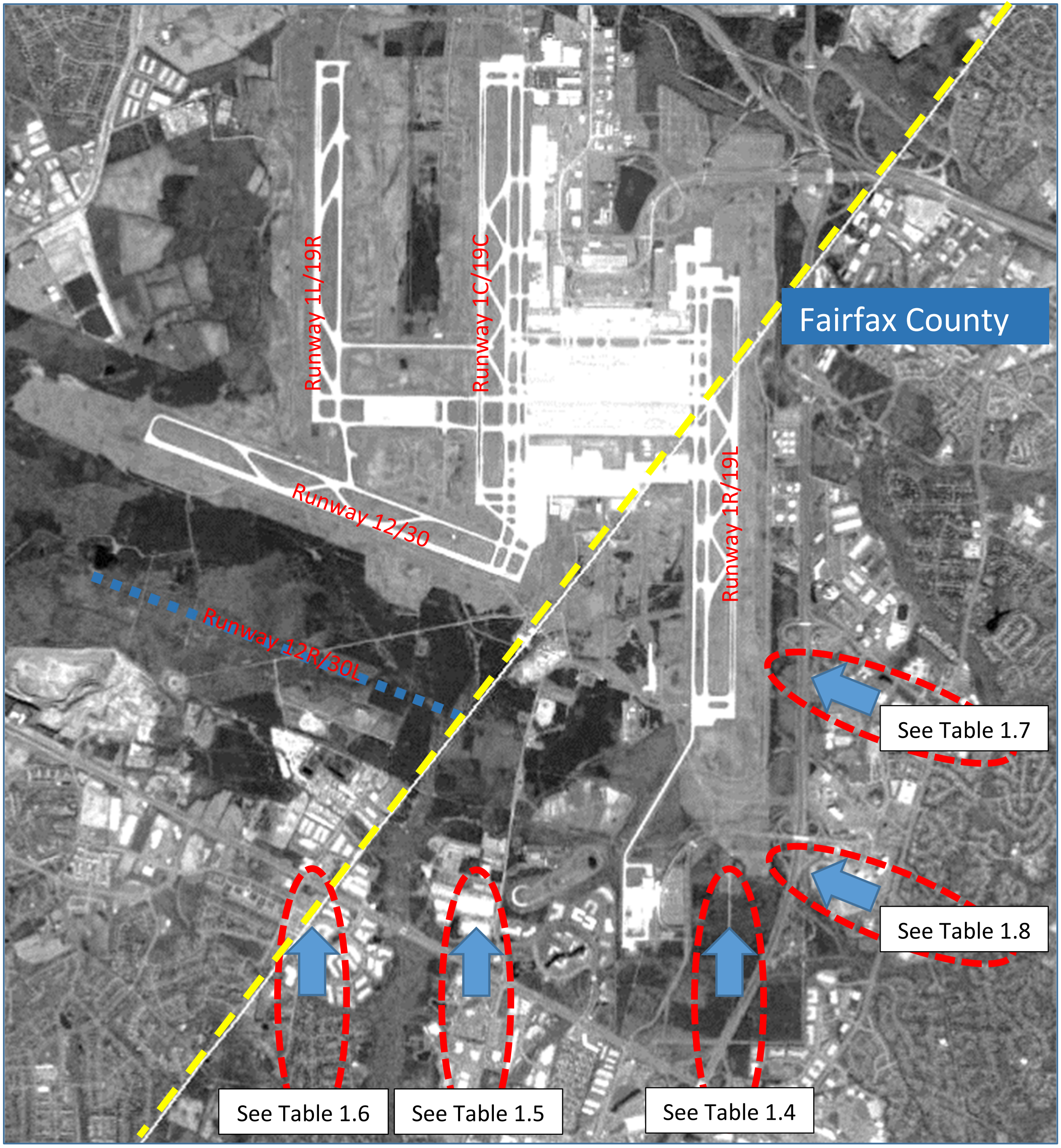


Table 1.4
Existing Runway 1R AAD Arrival Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Arrivals North Flow	209	431	482	482
Total Arrivals (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Arrival Runway Use Percentage	51.9%	35.0%	35.1%	35.1%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.5
Existing Runway 1C AAD Arrival Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Arrivals North Flow	178	408	468	455
Total Arrivals (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Arrival Runway Use Percentage	44.2%	33.1%	34.0%	33.1%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.6
Existing Runway 1L AAD Arrival Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Arrivals North Flow	8	371	400	400
Total Arrivals (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Arrival Runway Use Percentage	2.0%	30.1%	29.1%	29.1%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.7
Existing Runway 30 AAD Arrival Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Arrivals North Flow	8	22	12	25
Total Arrivals (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Arrival Runway Use Percentage	2.0%	1.8%	0.9%	1.8%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.8
Future Runway 30L AAD Arrival Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Arrivals North Flow	0	0	12	12
Total Arrivals (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Arrival Runway Use Percentage	0.0%	0.0%	0.9%	0.9%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Figure 1.2 provides similar overflight comparison information for departure operations in south flow over areas of Fairfax County. **Table 1.9** through **Table 1.13** correspond to **Figure 1.2** and enumerate the change in AAD departure operations that would overfly areas of Fairfax County. Together, **Figure 1.2** and **Tables 1.9 through 1.13** show that the runway utilization on Runways 19L and 19R will change substantially from the existing operation when measured in the change to actual AAD aircraft overflights. Runway 19R and the crosswind runways use would have little change from their current use.

Figure 1.2: Proposed Changes in Runway Utilization Directly Impacting Fairfax County (See Tables)

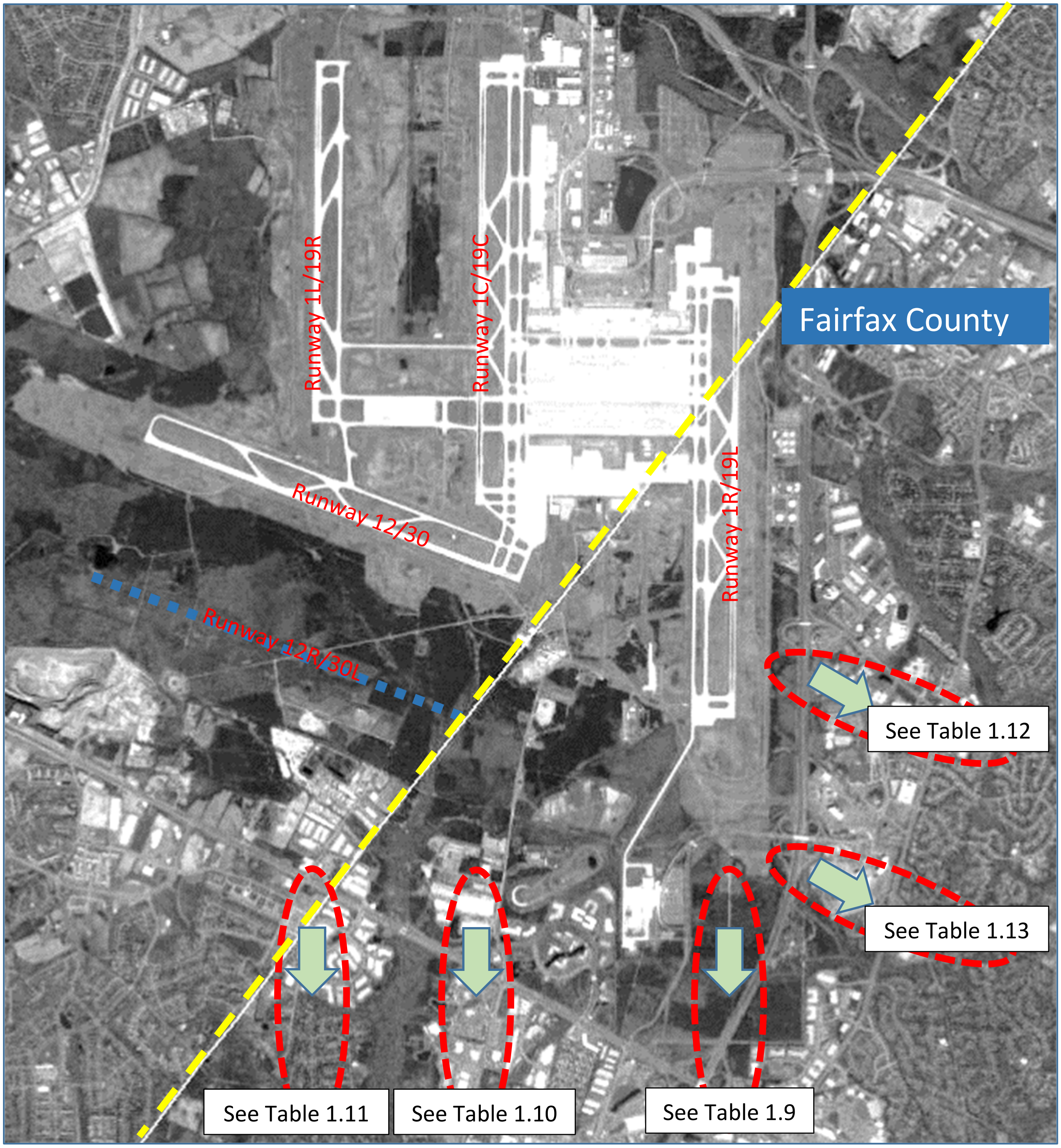


Table 1.9
Existing Runway 19L AAD Departure Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Departures South Flow	111	454	265	265
Total Departures (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Departure Runway Use Percentage	27.5%	36.8%	19.3%	19.3%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.10
Existing Runway 19C AAD Departure Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Departures South Flow	31	121	42	27
Total Departures (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Departure Runway Use Percentage	7.7%	9.8%	3.1%	2.0%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.11
Existing Runway 19R AAD Departure Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Departures South Flow	0	15	0	0
Total Departures (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Departure Runway Use Percentage	0.0%	1.2%	0.0%	0.0%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.12
Existing Runway 12 AAD Departure Operations Change of Use

Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Departures South Flow	0	0	0	0
Total Departures (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Departure Runway Use Percentage	0.0%	0.0%	0.0%	0.0%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

Table 1.13
Future Runway 12R AAD Departure Operations Change of Use

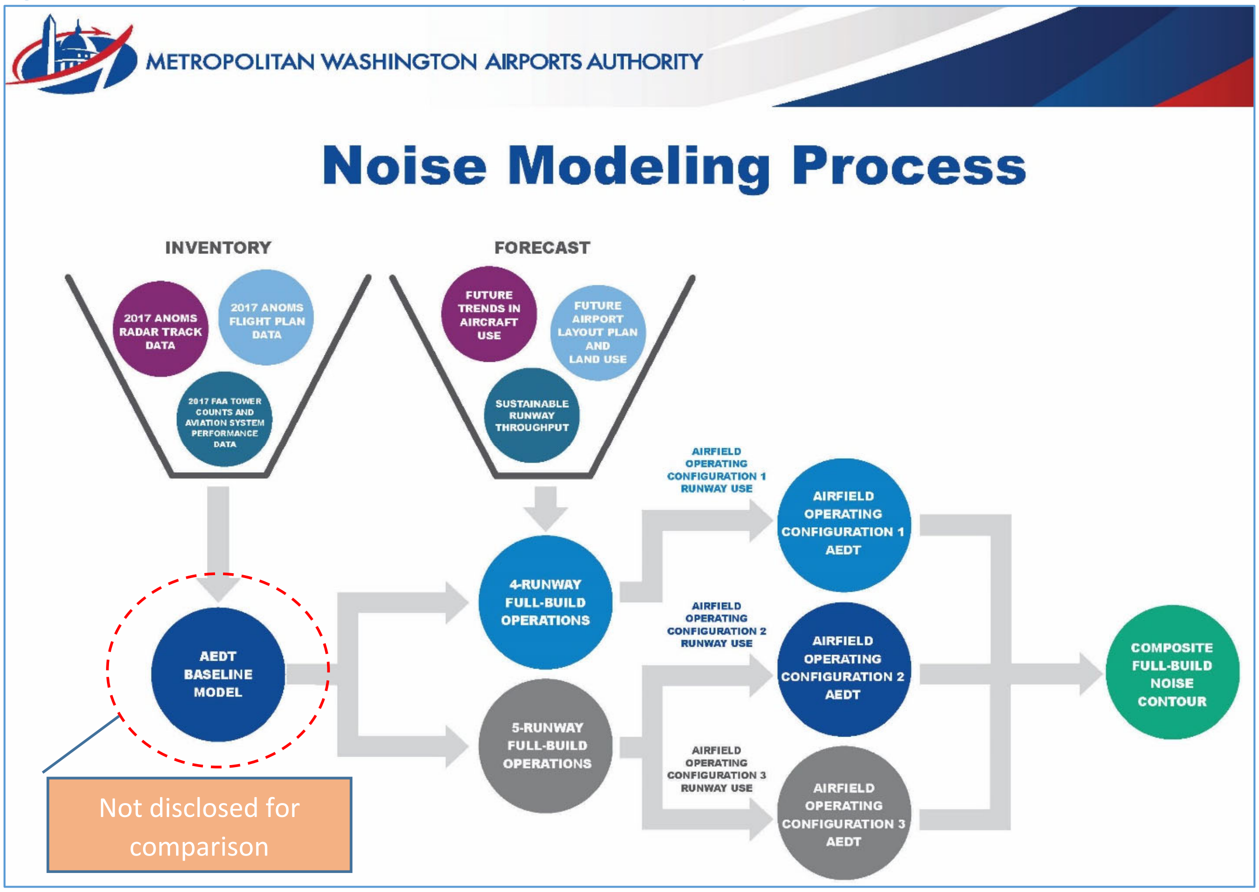
Configuration	Existing (2017)	Four-Runway	Five-Runway a*	Five-Runway b*
Departures South Flow	0	0	0	0
Total Departures (Half of AAD Total)	**403**	**1,233**	**1,375**	**1,375**
Departure Runway Use Percentage	0.0%	0.0%	0.0%	0.0%

*Two different runway use scenarios were studied by Ricondo for the five-runway analysis. "Five-Runway a" assumes cargo development in the southeast quadrant of the Airport and "Five-Runway b" assumes cargo development in the south quadrant.

1.2 Resulting Changes to Composite Noise Contours

The Ricondo Report provides updated composite noise contours based on the changes in airport facilities, operations, flight procedures, aircraft fleet mix and runway utilization. A composite noise contour is developed from each of the three future operating scenarios. These scenarios include: 1) a four-runway case; 2) a five-runway case with new southeast cargo facilities; and 3) a five-runway case with new south cargo facilities. The changes in cargo facility locations adjust the preferential nighttime runway use by future cargo aircraft. The FAA's AEDT noise model assess aircraft operations and noise for each of these scenarios individually. Once the three scenarios are modeled, a composite contour for the 65 DNL and 60 DNL areas was created graphically by connecting the largest portions of each contour. **Figure 1.3** is a slide depicting the Noise Modeling Process followed by Ricondo. Note that the "AEDT Baseline Model" for 2017 was not included in the Ricondo Report, or as part of the Working Group or public involvement processes.

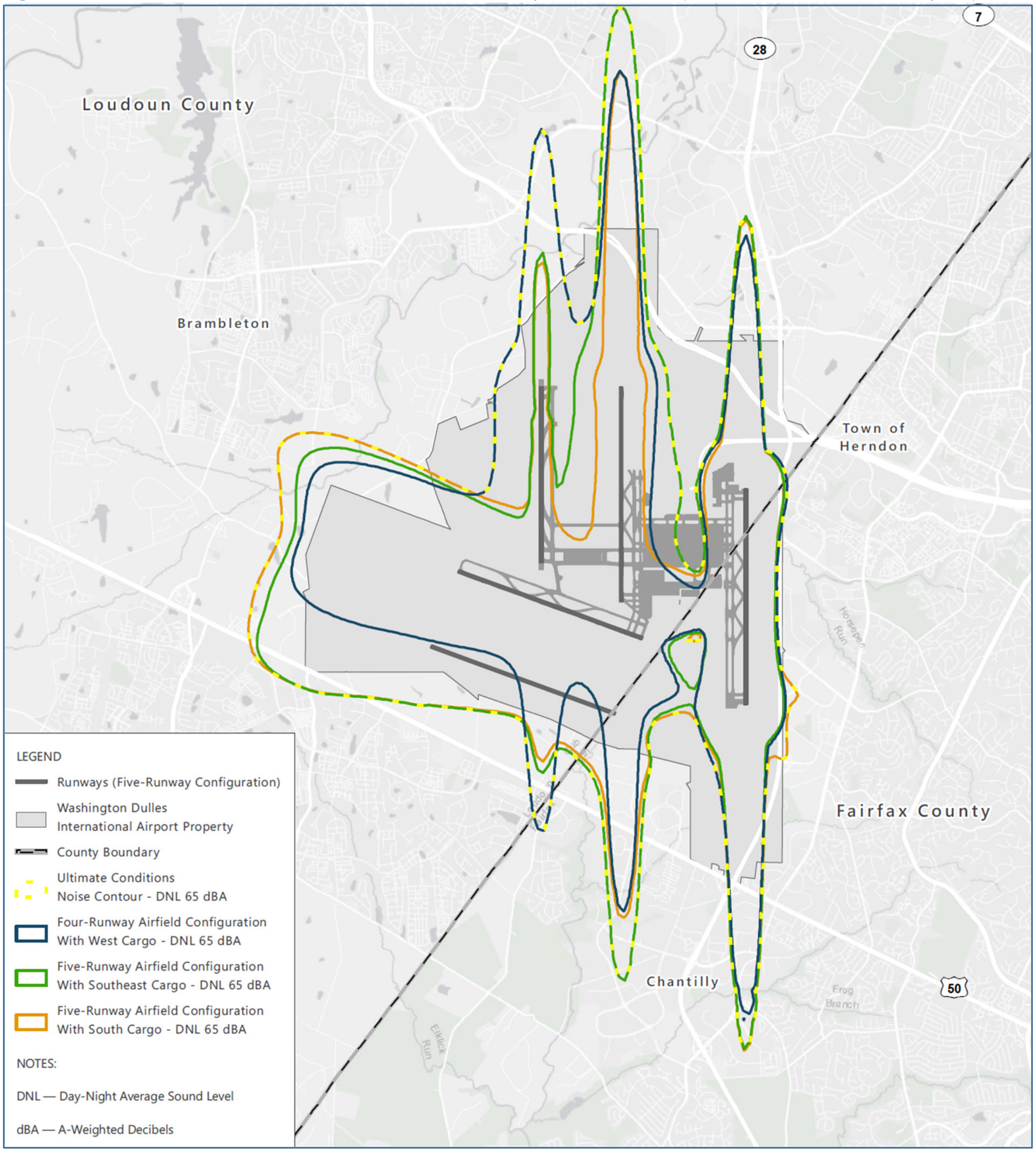
Figure 1.3: MWAA Ultimate Conditions Noise Contours Development Process



Source: Ricondo & Associates, Inc., Harris Miller Miller & Hanson, Inc., Washington Dulles International Airport Aircraft Noise Contour Map Update, Appendix B – Public Outreach and Input, May 2019.

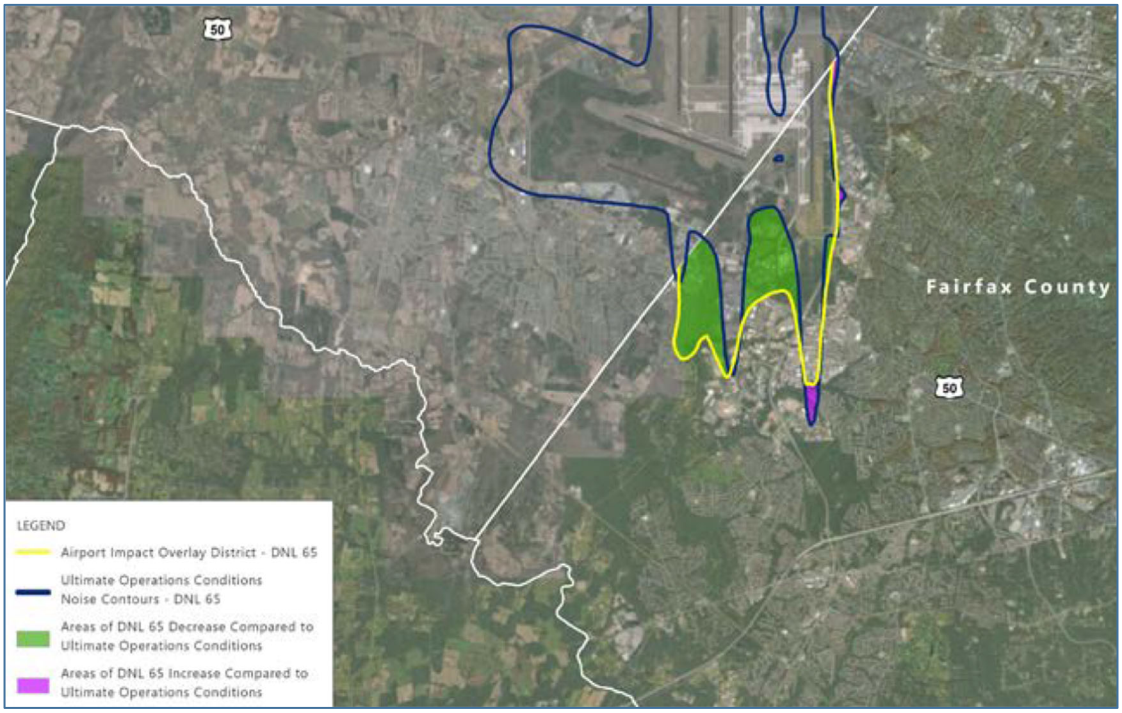
Figure 1.4 depicts the Ultimate Conditions 65 DNL Noise Contour with each of the three airfield configuration contours shown together. The two five-runway scenarios are unlikely to coexist, so this approach protects for either future by creating a "worst-case" Ultimate Condition.

Figure 1.4: Ultimate Conditions – Noise Contour Composite Process (Exhibit 5-16, Ricondo Report)



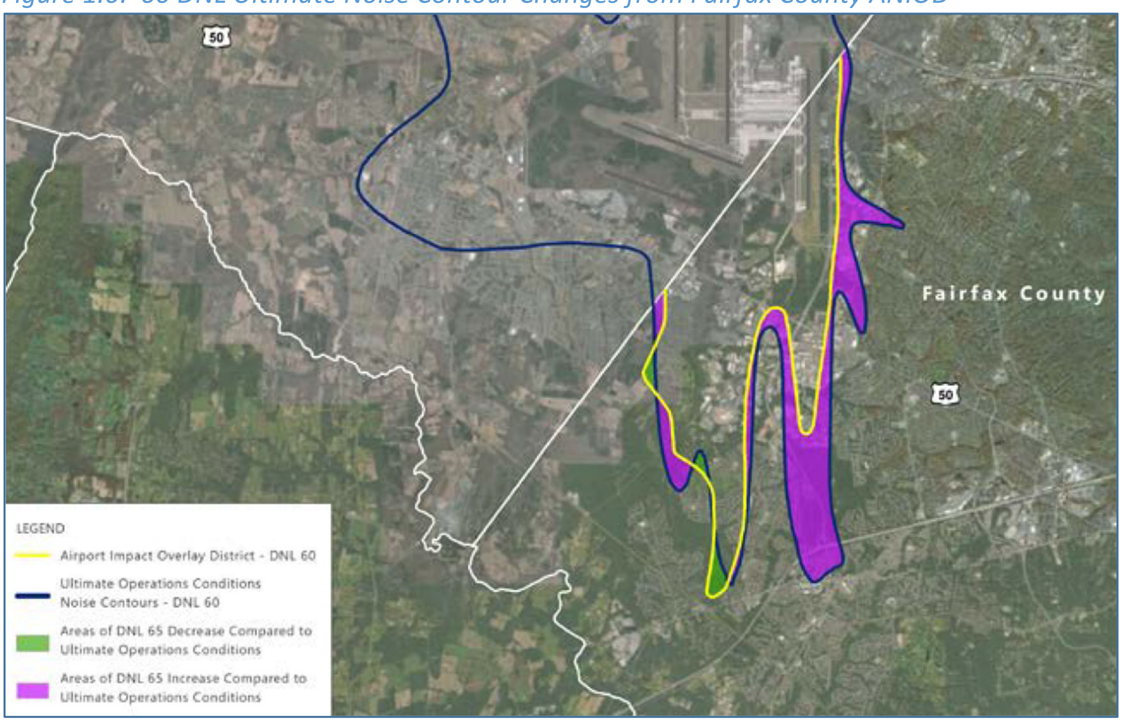
Figures 1.5 depicts the areas of change within Fairfax County in the 65 DNL Ultimate noise contour as compared to the existing Airport Noise Impact Overlay District (ANIOD). **Figure 1.6** depicts the same comparison within the 60 DNL Ultimate noise contour. These are helpful comparisons to see the areas of the County that might be affected by a change to the ANIOD as a result of adopting this Ultimate Condition noise contour. However, the Report does not disclose the "AEDT Baseline Contour" comparison to fully understand and visualize the size difference between today's contour (baseline) and the Ultimate Noise Contour.

Figure 1.5: 65 DNL Ultimate Noise Contour Changes from Fairfax County ANIOD



Source: Ricondo & Associates, Inc., Harris Miller Miller & Hanson, Inc., Washington Dulles International Airport Aircraft Noise Contour Map Update, Appendix A – 6th Working Group Briefing, January 2019.

Figure 1.6: 60 DNL Ultimate Noise Contour Changes from Fairfax County ANIOD



Source: Ricondo & Associates, Inc., Harris Miller Miller & Hanson, Inc., Washington Dulles International Airport Aircraft Noise Contour Map Update, Appendix A – 6th Working Group Briefing, January 2019.

2. Overview of Aircraft Noise

This section provides an overview of the airport compatible land use planning process to provide background and context for the approach to establishing the Dulles International Ultimate Noise Contours as compared to the FAA's Part 150 noise study process.

2.1 Roles and Responsibilities

There are many stakeholders when addressing aircraft noise, each with specific responsibilities. While each individual stakeholder may not have the capacity to fully address noise concerns on their own, the combined efforts of all stakeholders can result in a successful airport noise compatibility plan. The primary stakeholders are:

- Federal Government
- Airport Proprietor
- State and Local Government and Planning Agencies
- Aircraft Operators
- Residents and Prospective Residents
- Business Owners
- Land Developers

2.1.1 Federal Government

The primary goal of the Federal Aviation Administration (FAA) is to provide oversight and set regulatory guidance and rules regarding aircraft development and operations. The FAA 1976 Aviation Noise Abatement Policy specifically described their role in aviation noise as follows:

- Sets noise level requirements for newly certified aircraft
- Provide funding for, and approval of, noise compatibility planning (when appropriate and/or when funds available)
- Manage the air traffic control and airspace system

In 1979 the Aviation Safety and Noise Abatement Act (ASNA) was enacted to provide for noise compatibility programs. The FAA was given the authority to implement and administer the act and required the establishment of a single system for measuring aircraft noise, determining the extent of noise exposure, and identifying compatible and non-compatible land uses with different noise levels.

While noise compatibility planning is voluntary, many airports choose to participate in those planning programs to reduce noise impacts from an airport's operations. The FAA established the FAR Part 150 regulation to govern the technical aspects of aircraft noise analysis and public participation process for preparing noise compatibility plans. Airports that follow the FAR Part 150 process are assured of the FAA's cooperation and become eligible for Federal funding assistance for approved mitigation programs. FAR Part 150 is the only avenue for noise reduction for many airports, who unlike Dulles Airport, were not developed from a green field site and have always had noncompatible land uses in the immediate vicinity of the airport. Dulles is in a unique position that is envied by most airports in that they were able to establish effective land use controls many years ago that most airports do not have the opportunity to pursue.

2.1.2 Airport Proprietors

While the FAA may establish the framework for noise abatement and mitigation programs, it is the airport proprietor that is the driving force behind the development of these programs. As mentioned previously, these are strictly voluntary programs. There may be programs in place that are mandated by intergovernmental agreements, but there are no federal requirements that an airport undertake noise compatibility planning. The role of the airport proprietor in aviation noise can be described as planning and implementing actions that are designed to reduce the adverse effects of noise on residents of the surrounding area. This can be accomplished via:

- Improvements in airport design
- Noise abatement ground procedures
- Land acquisition
- Restrictions on airport use (must meet Federal guidelines)

The general goals of noise compatibility planning are to reduce existing noise levels, reduce noise sensitive land uses near the airport, and to mitigate adverse impacts where feasible.

2.1.3 State and Local Government and Planning Agencies

While airport proprietors are the driving force behind airport noise compatibility planning programs, the state and local governments and planning agencies play a large part in the success of those programs. Airports help establish the parameters of the programs and local jurisdictions implement land use and zoning recommendations. Local jurisdictions are the ones responsible for planning the land uses around an airport in a manner that is compatible with airport and aircraft operations. This can be difficult as noise compatible land uses may not be the best revenue producers for the jurisdictions or allow them to continue growing their community.

2.1.4 Aircraft Operators

Aircraft operators are the source of aircraft noise and a key stakeholder in the success of a noise compatibility planning program. Aircraft operators' primary tasks are to fly quieter aircraft and to fly responsibly. Safety is first and foremost, but there are ways aircraft operators can significantly contribute to noise reduction. These include:

- Use industry recommended noise abatement procedures
- Use preferred noise abatement runways
- Follow airport's published noise abatement procedures
- Follow noise abatement flight tracks

It is always important to know the pilot in command has sole responsibility for the safe operation of his or her aircraft. This responsibility allows them to deviate from noise abatement procedures/programs when deemed necessary for safety reasons.

Associated with aircraft operators are aviation system users that pay for the entire aviation system, including the adverse effects of noise. They finance airport development, maintenance, and the cost of noise-reducing measures, such as:

- New quieter aircraft
- Research and development into noise reducing technologies

- Planning and land use compatibility studies
- Land acquisition and sound insulation programs
- Ground runup enclosures

System users include passengers, air cargo operators, general aviation pilots, corporate aviation, and flight schools.

2.1.5 Residents and Prospective Residents

Residents are often the stakeholder that endures the brunt of aviation noise impacts, but they also have responsibilities in a successful aircraft noise compatibility planning program. Current residents should seek to understand the noise problem and what can be done to minimize its effects. Annoyance with aircraft noise is subjective; what may bother one neighbor may not bother another. Current residents should realize that everybody responds to noise differently and reducing the noise level may not eliminate their annoyance. Prospective residents should also make themselves aware of the potential effects of aircraft noise on their future quality of life and act accordingly. Too often residents move into areas already impacted by aircraft noise only to be immediately bothered by that noise and complain to their local jurisdiction or airport for relief.

2.2 Regulatory Framework

There are both federal and state laws that address noise standards. Federal law sets aircraft noise standards, but also prescribes operating rules, establishes the planning process, and sets limits on the airport proprietor's ability to restrict aircraft operations. State laws typically set forth compatibility planning guidelines and noise standards, while exempting aircraft in flight. Local noise ordinances may also set noise standards and provide for compatible land use planning, but they also exempt aircraft in flight. State and local regulations exempt aircraft in flight from noise standards because federal law preempts state and local regulations and the airspace is controlled by the FAA, a federal agency.

Noise planning is a crucial part of all planning processes an airport may undertake. Master plans and environmental documents must consider 21 environmental categories when evaluating development plans at an airport, including noise. These planning documents typically look at the existing noise condition as well as a future noise condition, typically 20 years, with and without project implementation. The longer timeframe under analysis is necessary due to the extended implementation schedule typically associated with airport development projects. These documents may also include a full build-out contour that predicts the annual service volume (ASV) with all planned runways operational and fully used; these types of full build-out contours may also be included in stand-alone documents. The primary purpose of ASV contours is for land use planning and are most commonly found at green field sites where the goal is to prevent encroachment of non-compatible land uses as the new airport develops. Developing land use plans with the aid of ASV contours is a luxury that most airports in the country do not have due to the airport sites being developed in densely populated and developed locations. This long-term development planning, like that existing for Fairfax County, allows the jurisdiction to effectively mitigate the potential for future noncompatible land uses, which in turn benefits the residents by limiting residential development in potentially high noise areas.

Because noise is a topic of immense public interest, there also exists a process that only looks at aircraft noise impacts. This study is commonly referred to as a FAR Part 150 study. The Part 150 study is based on an FAA regulation known as 14 CFR Part 150 - Airport Noise Compatibility Planning. 14 CFR Part 150 identifies aircraft noise metrics and the methodology to be used in assessing aircraft noise exposure, as well as acceptable noise abatement/mitigation programs to be considered for addressing noise concerns. FAR Part 150 studies typically evaluate noise conditions for the existing condition (year of submittal), and for a future year (five years from submittal). This shorter timeframe, compared to the 20 – 30-year timeframe considered in planning documents, is due to FAA's guidance for airport's to develop mitigation programs that can be funded and implemented in the timeframe of the study analysis (typically five years).

All planning documents developed under FAA guidelines, including FAR Part 150 studies, are required to use the Day-Night Average Sound Level (DNL) for all noise analyses. This metric describes the noise dose for a 24-hour period, providing an additional weighting factor (+10dB) for each nighttime (10:00 p.m. to 7:00 a.m.) arrival or departure. This additional weighting factor equates one nighttime operation to ten daytime operations. Residents are often more sensitive to aircraft operations during the nighttime hours due to generally lower ambient noise levels. This additional weighting factor is meant to adjust noise levels to account for this increased sensitivity. DNL is often difficult for residents to understand because it is a weighted average of sound over a 24-hour period. Even though it is misunderstood, it has been scientifically shown to correlate well with community annoyance.

Noise exposure can be quantified by either measurements or modeling. Measuring sound levels can tell us the sound levels at a specific location for the time period measurements were made, provide a historical record of the sound levels at a specific location, and identify historical trends. Measurement of noise levels cannot predict future noise levels. Modeling of sound can tell us the sound levels over broad geographic areas, produce a historic record, and most importantly – be predictive in showing expected trends. Most noise levels for noise compatibility planning efforts is quantified through modeling efforts as stipulated in FAA guidelines. The FAA also stipulates the process that all noise contour development must follow and mandates that all contours must be produced using the Aviation Environmental Design Tool (AEDT). This process ensures consistency in contour development so that FAA compatibility guidelines are applied consistently across the country.

2.2.1 FAR Part 150 Noise Exposure Maps

FAR Part 150 produce two noise exposure maps (NEMs), an existing conditions contour and a forecast condition contour five years in the future. The 65, 70, and 75 DNL contours are the only contours required by the FAA for inclusion in the FAR Part 150 Study; and are also the only ones accepted by the FAA for official certification of NEMs. The existing and future conditions noise exposure maps are overlaid on a land use map to identify areas of existing and future incompatible land use. Depending on past planning efforts, airports may produce and include maps that include DNL contours below 65 DNL, and for longer time periods than five years. It is important to note that these additional maps are not common in FAR Part 150 studies and are not reviewed for acceptance by the FAA; they are used for informational purposes only and local planning efforts.

Forecasts for the five-year NEM are typically based on the Terminal Area Forecast, which is developed by the FAA and published on a yearly basis. Once an airport participates in the Part 150 program, they are expected to update their NEMs every five years or when changes in the operation of the airport would create new, significant incompatible land use. A significant change in noise to warrant a new NEM is considered to be an increase in DNL of 1.5 dBA for incompatible land uses within the 65 DNL. Once an NEM has been published, no new incompatible development within the 65 DNL will be considered eligible for federal funding participation of sound mitigation unless it can be shown that:

- A significant change in the type or frequency of aircraft operations at the airport
- A significant change in the airport layout
- A significant change in the flight patterns
- A significant increase in nighttime operations occurred after acquiring the property in question

It is important to note that due process of notice of the availability of the NEMs can be as simple as publishing a notice of the existence of the NEMs in a newspaper of general circulation in the area.

2.2.2 Off-Airport Land Use Compatibility Planning

The issue of aviation related noise and its impact on people continues to be a controversial topic in the vicinity of our nation's airports. Airports and communities throughout the United States are constantly concerned by the encroachment of land uses that are not compatible with levels of sound generally associated with ground and flight operations of aircraft. In response to the increasing concerns of these incompatible land uses, airports, working through local units of government, have initiated land use management actions to facilitate the compatibility of development occurring in the airport environs across the United States.

The following, taken primarily from the September, 1999 report *Land Use Compatibility and Airports* prepared by the FAA, presents the FAA actions related to land use planning.

> *"While the FAA can provide assistance and funding to encourage compatible land development around airports, it has no regulatory authority for controlling land uses that would protect airport capacity. The FAA recognizes that state and local governments are responsible for land use planning, zoning and regulation, including that necessary to provide land use compatibility with airport operations.*
>
> *However, pursuant to the Federal Airport and Airway Development Act, as a condition precedent to approval of an FAA-funded airport development project, the airport sponsor must provide the FAA with written assurances that "…appropriate action, including the adoption of zoning laws have been or will be taken, to the extent reasonable, to restrict the use of land adjacent to or in the immediate vicinity of the airport to activities and purposes compatible with normal airport operations including the landing and takeoff of aircraft…"*
>
> *FAA has required the phasing out of noisy Stage 1 and Stage 2 aircraft, consequently the aviation industry has spent substantial monies to meet this requirement. To assist in the compatible land use efforts, the FAA, local airport sponsors, and state aviation agencies have expended significant funds related to airport planning and off-airport noise and land use compatibility planning throughout the United States.*
>
> *Airport master plans have been prepared to identify the near-term and long-range projections for airport activity and the development necessary to meet these activity demands. In addition, noise and land use studies (FAR Part 150 studies) have been conducted to evaluate ways to minimize impacts of aircraft noise, and the FAA and airport sponsors have financed land acquisitions and other noise compatibility measures throughout the United States."*

The FAA has developed land use guidelines that relate the compatibility of aircraft activity to areas surrounding an Airport. These guidelines, provided in **Figure 2.1**, identify land use activities that generally considered acceptable within the 65, 70 and 75 DNL contours. FAA guidance indicates that virtually all land uses below 65 DNL are compatible with the effects of aircraft noise. This guideline was established by the FAA in 1976 and represents a level above which aircraft noise "create[s] a significant annoyance for most residents." These noise thresholds were developed using a dose-response curve created in the 1970's known as the "Schultz Curve." Based on the data available at the time, the Schultz Curve provided a useful method for representing the community response to noise based on annoyance.

In 1992, the Federal Interagency Commission on Noise (FICON) reviewed all relevant information related to noise annoyance, including an updated Schultz curve. As stated in the 1992 FICON report, the DNL annoyance relationship depicted on the Schultz curve "is an invaluable aid in assessing community response as it relates the response to increases in both sound intensity and frequency of occurrence. Although the predicted annoyance, in terms of absolute levels, may vary among different communities, the Schultz curve can reliably indicate changes in the level of annoyance for defined ranges of sound exposure for any given community." It is important to note that the FAA does allow local land use planning agencies to adopt a lower compatibility level that may be more stringent than FAA guidelines.

Attention is focused on areas within the 65+ DNL because the FAA considers these to be the areas significantly exposed to noise and is the limit FAA uses for eligibility of federal funds for noise mitigation measures. It is recognized, however, that noise does not stop at the 65 DNL contour and is heard by those located near approach, departure, and training corridors. Thus, the FAA encourages airport sponsors and local governments to work together to establish land use controls within flight corridors and noise exposure areas beyond the 65 DNL.

Figure 2.1: FAR Part 150 Land Use Guidelines

Land Use	Yearly Day-Night Noise Level (DNL) in decibels					
	Below 65	65-70	70-75	75-80	80-85	Over 85
RESIDENTIAL						
Residential, other than mobile homes and transient lodgings	Y	N(1)	N(1)	N	N	N
Mobile home parks	Y	N	N	N	N	N
Transient lodgings	Y	N(1)	N(1)	N(1)	N	N
PUBLIC USE						
Schools	Y	N(1)	N(1)	N	N	N
Hospitals and nursing homes	Y	25	30	N	N	N
Churches, auditoriums and concert halls	Y	25	30	N	N	N
Government services	Y	Y	25	30	N	N
Transportation	Y	Y	Y(2)	Y(3)	Y(4)	Y(4)
Parking	Y	Y	Y(2)	Y(3)	Y(4)	N
COMMERCIAL USE						
Offices, business and professional	Y	Y	25	30	N	N
Wholesale and retail - building materials, hardware and farm equipment	Y	Y	Y(2)	Y(3)	Y(4)	N
Retail trade - general	Y	Y	25	30	N	N
Utilities	Y	Y	Y(2)	Y(3)	Y(4)	N
Communication	Y	Y	25	30	N	N
MANUFACTURING AND PRODUCTION						
Manufacturing, general	Y	Y	Y(2)	Y(3)	Y(4)	N
Photographic and optical	Y	Y	25	30	N	N
Agriculture (except livestock) and forestry	Y	Y(6)	Y(7)	Y(8)	Y(8)	Y(8)
Livestock farming and breeding	Y	Y(6)	Y(7)	N	N	N
Mining and fishing, resource production and extraction	Y	Y	Y	Y	Y	Y
RECREATIONAL						
Outdoor sports arenas and spectator sports	Y	Y(5)	Y(5)	N	N	N
Outdoor music shells, amphitheaters	Y	N	N	N	N	N
Nature exhibits and zoos	Y	Y	N	N	N	N
Amusements, parks, resorts and camps	Y	Y	Y	N	N	N
Golf courses, riding stables and water recreation	Y	Y	25	30	N	N

Numbers in parenthesis refer to notes.

* The designations contained in this table do not constitute a Federal determination that any use of land covered by the program is acceptable or unacceptable under Federal, State or local law. The responsibility for determining the acceptable and permissible land uses and the relationship between specific properties and specific noise contours rests with the local authorities. FAA determinations under Part 150 are not intended to substitute federally determined land uses for those determined to be appropriate by local authorities in response to locally determined needs and values in achieving noise compatible land uses.

Key to Table 1

SLUCM	Standard Land Use Coding Manual.
Y(Yes)	Land Use and related structures compatible without restrictions.
N(No)	Land Use and related structures are not compatible and should be prohibited.
NLR	Noise Level Reduction (outdoor to indoor) to be achieved through incorporation of noise attenuation into the design and construction of the structure.
25, 30 or 35	Land Use and related structures generally compatible; measures to achieve NLR of 25, 30 or 35 dB must be incorporated into design and construction of structure.

Notes:

(1) Where the community determines that residential or school uses must be allowed, measures to achieve outdoor to indoor NLR of at least 25 dB to 30 dB should be incorporated into building codes and be considered in individual approvals. Normal residential construction can be expected to provide a NLR of 20 dB, thus, the reduction requirements are often stated as 5, 10, or 15 dB over standard construction and normally assume mechanical ventilation and closed windows year round. However, the use of NLR criteria will not eliminate outdoor noise problems.

(2) Measures to achieve NLR of 25 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where normal noise level is low.

(3) Measures to achieve NLR of 30 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where normal noise level is low.

(4) Measures to achieve NLR of 35 dB must be incorporated into the design and construction of portions of these buildings where the public is received, office areas, noise sensitive areas or where normal noise level is low.

(5) Land use compatible provided that special sound reinforcement systems are installed.

(6) Residential buildings require an NLR of 25 dB.

(7) Residential buildings require an NLR of 30 dB.

(8) Residential buildings not permitted.

Source: FAA

Land use changes are classified into two categories: corrective changes and preventive changes. Corrective changes occur primarily within the 65 DNL contour and involve changes to existing land uses. Types of corrective land use changes include property acquisition and sound insulation of incompatible noise sensitive structures. Preventive changes primarily occur outside the 65 DNL contour and are meant to continue compatibility of future development in the airport environs. Types of preventive changes primarily include overlay zones and building codes.

2.2.3 Overlay Zones

One of the more effective tools for maintaining the compatibility of future development in the Airport environs is the establishment of an overlay zone. An overlay zone creates one or more specialized zoning districts that are intended to supplement the underlying jurisdictional zoning regulations. Regulations associated with overlay zones could limit the development of noise sensitive uses; could require new development to incorporate sound insulation into the design of buildings; could require some form of publication (through avigation easement or notification, for example) advising future buyers as to the existence of aircraft overflights and noise, and/or other measures. The determination as to which of the controls should apply for any given situation is based on the extent of the noise exposure at the proposed development site.

2.2.4 Building Codes

Building codes are established to regulate the construction of structures by setting the standards for materials and construction techniques to protect the health and safety of future occupants of those structures. Most building codes address items such as the structural elements of the building, as well as the ventilation and insulation requirements. All three of these elements directly impact the sound attenuation abilities of the structure. By establishing solid building codes, a municipality can ensure that any new construction, or alterations to existing structures, can have sound attenuation properties built into the building to ensure the building is compatible with noise for aircraft operations.

2.3 MWAA Approach Versus Industry Standards

Industry standards for noise compatibility planning is heavily reliant on FAA policy and guidance published in various Federal Aviation Regulations. As mentioned previously, these can range from the industry standard 14 CFR Part 150 regulation to planning activities conducted as part of Airport Master Plans or Environmental Documents. Each serves a specific role, and each has a specific planning timeframe based on that role.

14 CFR Part 150 is considered the primary standard for aircraft noise compatibility planning. The Part 150 Study analyzes all aspects of aircraft noise to determine the extent of noise impacts that exist, and what noise abatement and mitigation programs can be implemented to address those impacts. The timeframe covered in FAR Part 150 studies is relatively short when compared to Master Plans and other environmental documents. The timeline includes a baseline noise condition and a future noise condition (typically five years from date of submittal). These noise conditions are established in the regulation and coincide with a timeframe the FAA considers reasonable for implementation of any approved programs. Once an airport participates in a FAR Part 150 Study, they are expected to update their study every five years, or sooner if conditions warrant. With the frequent updates, the FAA bases their approval of federal funds for program implementation on that five-year timeframe and what can reasonably be funded during that time. Because of the short timeframe, the land use planning aspect of the Study places the greatest emphasis on corrective land use measures (acquisition, sound attenuation, etc.) which are more under the control of the airport proprietor to implement. Preventive land use measures (zoning, land use designations, etc.) are also discussed in the Study, but typically have less of a focus placed on them due to the extended timeframe it takes to implement and the fact that the airport proprietor has virtually no control on the timeframe for implementation.

Because land use planning typically has a long-term horizon for full implementation, a longer study timeframe is needed to accurately assess the future impacts to be addressed. Contours depicting 20 to 30 years in the future are standard in Master Planning and environmental documentation at airports. These contours are based on predictions of future aircraft operations, fleet mix, and airfield configurations based on forecasts prepared by the FAA, and sometimes adjusted for specific local conditions. The most forward-looking contour is known as the ASV contour and is based on absolute capacity of the airfield, either existing airfield or the airfield at some point in the future with additional development. It is common for ASV contours to be based on full build-out of the airfield to show the worst-case scenario for noise impacts.

Deciding which contour is best for land use planning is open to much interpretation. Most airports would consider the 20 to 30-year timeframe as the best for land use planning. This typically coincides with timeframes included in Comprehensive Plans or General Plans developed by jurisdictions. These airports are in jurisdictions that are developed fully and any new development would be considered infill or redevelopment. This scenario makes compatible land use planning much more difficult for all stakeholders. Airports that are new, and on green field sites with little development in the vicinity of the airport, may want to consider an ASV contour based on full build-out of the airfield. This contour will be the most likely to change over time, but provides the best-case scenario for establishing land use compatibility buffers that go a long way to insulate the airport proprietor and local jurisdictions from land use compatibility concerns as the airport grows to meet demand.

Many tools have been used by the County in the execution of mitigating measures for flight path noise mitigation and land use compatibility. As mentioned previously, land use management measures include preventive (land use controls) and corrective (remedial) techniques. A review of County tools indicates the overwhelming preference for preventive land use measures. These measures are most commonly used to prevent the introduction of additional noise-sensitive land uses within existing and future airport noise contours. These measures are implemented by the local jurisdictions and have varying degrees of mitigatory success depending on the strength with which they are observed. Those items having been implemented in line with FAA recommendations include:

- Comprehensive Plan - The preparation and adoption of a comprehensive plan is a critical and effective part of the process of ensuring land use compatibility for communities near airports.
- Zoning Regulations - The use of zoning to control development near airport facilities has realized varied degrees of success. If put in place early enough, such as Fairfax County's proactive Article 7 approach, zoning can be an effective tool to help eliminate or reduce land uses that are not compatible under or near airport flight paths and overflight.
- Subdivision Regulations - Subdivision plat review procedures provide an opportunity for jurisdictions to determine how and if a proposed subdivision design could contribute to the incompatibility of environmental exposure (noise, fumes, particulates, vibration).
- Building Codes - While generally concerned with the functional or structural aspects of buildings or structures, some building codes have special requirements for properties located in high noise exposure areas, such as Fairfax County's sound attenuation requirements.
- Housing Codes - Housing standards usually relate to the minimum that a home would have to meet in order to be decent, safe, and sanitary. To some extent, and in combination with building

codes and performance standards, housing codes may serve as a basis to mitigate noise impacts to residential occupants.

- Capital Improvement Program – The FY2019 to FY 2023 Capital Improvement Program is another tool that may assist the County in realizing the goals, objectives, and recommendations of the adopted Comprehensive Plan. This programming tool could be used in a cooperative manner to encourage or discourage certain types of land development around airport facilities.
- Zoning Ordinance Overlay – Fairfax County has adopted Airport Noise Impact Overlay District map regulations in support of comprehensive plans and zoning decisions. Such maps show the location and extent of existing and proposed development versus defined IAD noise contours.
- Infrastructure Extensions - Provision or extension of basic infrastructure elements such as water, sewer, and roadways can significantly affect the extent and direction of growth and development. Used in conjunction with Area comprehensive plans and the adopted noise contours can allow for land uses to take place in areas that are compatible with aircraft overflight.
- Growth Policies - Some communities are developing comprehensive plans using the concept of controlling growth in specific areas. Identification of airport flight paths, surrounding affected areas, and Master Plan concepts, as part of growth policies planning is critical for successful growth policies planning.
- Transferable Development Rights (TDR)/Purchase of Development Rights (PDR) - Both TDR and PDR involve the relocation of development rights (through transfer or purchase) from one location to another. Either mechanism has the potential to allow Fairfax County to either avoid incompatible development or promote compatible development in specific noise-impacted areas.
- State Airport Zoning Regulations - State statues such as Virginia § 15.2-2294 “Airport safety zoning” and § 15.2-2295 “Aircraft noise attenuation features in buildings and structures within airport noise zones” address airports in a variety of prescribed solutions that Fairfax County has largely addressed.

2.3.1 Performance Standards

Within the existing Fairfax County planning, zoning, land use, and map documentation, many of the typical general tools in above have been addressed and implemented to establish success over time. As the pressure to develop available land increases within the context of the existing tools, the County should further explore additional items to more fully incorporate performance zoning. Aviation specific performance zoning can be used constructively to increase the value and productivity of the affected land. The goal is to minimize the population affected by aircraft noise by introducing zoning that meets aviation driven goals around IAD while still leaving land in private ownership, on the tax rolls, and as economically productive as possible (highest and best use).

The County currently uses exterior to interior noise reduction as a criterion for housing in certain zones. Examples typically include floor area ratio or ‘FAR’ (the ratio of building floor area to lot area), open space ratio (the ratio of open space to overall site area), and livability space ratio (the ratio of non-vehicular space such as lawns or landscaping to total site area). These are often used to address specific site impacts, from shading and open space quality to the size and placement of parking lots. An effective performance zoning approach is typically selectively applied in certain districts, or else combined with other zoning approaches, rather than implemented as a standalone practice. The effect of setting such standards is that enforcement of the ordinance reasonably ensures the community will be developed in the fashion desired based upon these criteria, and it is left to the developer of the property to show how the standards will be met.

Performance zoning could result in such standards being used as a measure of determining the noise level in an arrival air corridor, for example. FAA policies address noise mitigation measures in conjunction with "existing" and "potential new" incompatible development. The presence of these newly revised ultimate buildout noise contours in the Report may make it possible to develop and implement performance noise standards set in the local zoning ordinance. The key considerations for the County would include:

- The underlying criteria;
- The extent to which criteria are applied; and,
- The locational requirements for development.

Performance zoning has the potential to require less administrative involvement, since variances, appeals and re-zonings are not necessary. It also gives more flexibility both to the County and to the developer, allowing more of a range of land uses, if their impact is not negative as an externality and the aircraft overflight is mitigated to the extent deemed necessary. There are advantages and limitations of performance zoning and adoption of standards. The potential advantages include:

- Conserves energy by limiting inappropriate site disturbance and reducing environmental disturbance;
- Ensures that a proposed use is appropriate for the specific character of a site, and can balance the level of development that the site can accommodate with minimizing negative impacts on the environment;
- Promotes natural resource protection and can limit adverse impacts on neighboring properties;
- Directs development to areas served by sewer and water service;
- Establishes objective and quantifiable performance standards based on actual site conditions;
- Performance zoning recognizes the carrying capacity of a site within the development process;
- Provides the developer with the flexibility to respond to changing market conditions;
- Encourages the development of wider range of housing types;
- Reduces potential conflicts between incompatible land uses; and
- Provides more discretion to the private sector in making decisions regarding the location of land uses.

The following limitations are associated with the use of performance zoning:

- Eliminates zoning districts and replaces them with performance standards. Such a significant change can be challenging for a municipality;
- Requires additional technical expertise and cost to evaluate and monitor than required under conventional zoning;
- Reduced effectiveness in municipalities that do not have public water and sewage facilities. Without this infrastructure, there is little ability to build anything other than low-density developments on lots large enough to support on-site water and sewer systems; and
- Permits developers wide discretion in the types of housing that are permitted to be built, but may be opposed by residents if the new dwellings are unlike other dwellings in the area.

An example of aviation-centric performance standards can be found in The State of Minnesota's Airport Compatibility Manual (Chapter 3: Compatible Airport Land Uses):

- Is it tall enough to be hazardous to the navigation of aircraft? This would be determined by the FAA's height analysis process.
- Would it interfere with electronic navigation aids? This would primarily apply to ground based NAVAIDs closer to the airport and may not have any relevance for Fairfax County due to a lack of proximity.
- Would it cause a visual distraction to approaching aircraft? This may include glare intensive commercial buildings, large advertising signs, blinking or flashing lights, etc.
- Does it have the potential to attract wildlife such as birds? This can include food stocks such as open grain fields, bodies of water, and other bird attractants.

Performance zoning is as challenging an idea as form based codes once were, but merits examination in areas of Fairfax County where specific goals may be desired within aircraft overflight affected areas and some flexibility may be afforded the developer to achieve the highest and best use.

2.3.2 Land Use Compatibility with Defined Noise Values

Considering the current Fairfax County policies, guidance, rules, and regulations regarding the promotion or requirement to address aircraft overflight noise, the important perspective is that despite decades of effort to reduce aircraft overflight noise, government has generally been unable to reduce, let alone preclude a citizen from expressing dissatisfaction with aircraft overflight. The 2017 Area III Comprehensive Plan section indirectly acknowledges this reality but leaves open the potential for updates and recommendations that may be considered. The County currently states "…because recreation areas cannot be screened from aircraft noise, in order to avoid exacerbating noise and land use conflicts and to further the public health, safety and welfare, new residential development is not recommended in areas with projected aircraft noise exposures exceeding DNL 60 dBA" (Source: Fairfax County Comprehensive Plan, 2017 Edition, Area III, Area Plan Overview, Amended through 10-16-2018). In contrast, the Report identifies "Appendix A of Title 14 Code of Federal Regulation Part 150, Airport Noise Compatibility Planning, provides land use compatibility guidelines as a function of DNL values. These guidelines identify land uses that normally are compatible or incompatible with various levels of aircraft noise, and they indicate that all land uses, including residential, are considered compatible with aircraft noise levels below DNL 65 dBA" (Source: "Aircraft Noise Contour Map Update," Ricondo/HMMH, Page 5-2). The Report further notes "Importantly, a line drawn on a map does not imply that a particular noise condition exists on one side of that line and not on the other. DNL calculations are merely a means for comparing noise effects, not for precisely defining them relative to specific parcels of land. Nevertheless, DNL contours can be used to:

- highlight an existing or potential aircraft noise problem that requires attention;
- assist in the preparation of noise compatibility programs; and
- provide guidance in the development of land use controls, such as zoning ordinances, subdivision regulations, and building codes, to promote noise-compatible development" (Source: "Aircraft Noise Contour Map Update," Ricondo/HMMH, Page C-12).

The history of the DNL 65 dBA value as that being identified as the threshold of residential land use compatibility is lengthy (dating back to 1964) and historically consistent in that the DNL 65 dBA threshold is overwhelmingly supported by the historical record and intensive technical re-examinations of the threshold. The American National Standards Institute (ANSI) published unsupported recommendations for noise and land use compatibility in 1980 that describes potential noise interference within the DNL 55dBA – DNL 65 dBA range and identifies various residential uses within this range as compatible with insulation to attenuate exterior volumes (Source: American National Standards Institute, "Sound Level Descriptions for Determination of Compatible Land Use", ANSI S3.23. 1980). The Raleigh-Durham Airport Authority went through a legal challenge by local homeowners in the early 1990's and developed a model noise ordinance addressing housing in the DNL 55 dBA to DNL 60 dBA contours to achieve noise level reductions of 30 dBA and 35 dBA reductions in the DNL 60 dBA to DNL 65 dBA (Source: Airport Noise Report, Volume 6, Number 3). An influencing factor in the subtext of aircraft noise annoyance analyses and historic examinations of the DNL 65 dBA standard point to consideration of the background noise levels experienced by potentially affected persons. This consideration emphasizes the difference in perceived single event noise against the background noise of that environment. The higher the ambient background noise levels, in an urbanized area with constant state background noise, the more justification for a DNL 65 dBA threshold with the converse being true.

Fairfax County may seek to evaluate a geographic information system (GIS) driven cost/benefit analysis of a DNL 65 dBA threshold versus a DNL 60 dBA threshold. Such an analysis would yield the opportunity costs of the differences and quantify the policy choices in a manner not previously considered. The important driver is to make a connection between policies and economic outcomes related to land use and zoning decisions driven by long term aircraft overflight impacts. There are a number of economic considerations and models that describe complex transportation impacts, job relocation, employment multipliers and other fiscal concepts. However, accounting for a simple and less time-consuming approach can provide results valuable to policy makers. This information can establish how many potential residences are left unbuilt, some approximation of fiscal impact that would be lost, or what effect these assumptions have on utilities and infrastructure. There could also be a comparison between those residence foregone and compatible uses that may be of a more productive nature in terms of net fiscal dollars or infrastructure impacts. The ability to discern these finer points of local interest can add a data driven dimension to the consideration of using DNL 60 dBA or DNL 65 dBA as an acceptable threshold for residential development.

In summary, land use planning around Dulles International Airport is considered optimal and envied by other airports because of the ability to effectively use the ASV contour. This approach was possible as they are one of only two major international airports in the U.S. that started from a green field site with little local development. The other airport that meets this criterion is Denver International Airport. Both airports, and the surrounding jurisdictions, have taken similar approaches to land use planning and taken advantage of the limited community development that existed at the time each airport was constructed. This forward thinking has allowed a land use compatibility planning buffer to be established that most other airports in the country strive for but never achieve. The use of the ASV contour may seem excessive from a planning standpoint, but is considered the best way to establish a buffer that allows for changes in noise impacts to occur without significantly impacting populations.

3. 60 DNL Land Use Planning Case Studies

In the United States, airports and the FAA have no control over their surrounding land use. They have no authority to enforce zoning laws or prevent noncompatible land use near an airport; they can only control the land they own to operate the airport. The responsibility for compatible land use lies primarily with local jurisdictions and airports strive to work with local jurisdictions to stress the importance of compatible land use with aircraft operations. It is known that airports act as economic engines for entire regions and are vital to the health and growth of those regions. Extreme care must be taken to protect land uses surrounding airports, provide avenues for expansion, and to communicate with citizens and local governments about following established procedures in their plans for expansion as airports grow and change to meet operational demands. Airports must also realize the difficult position that local jurisdictions are placed in and must work collaboratively to identify areas where expansion may take place in the future so communities can successfully plan their growth.

Unfortunately, noise issues do not always align with incompatible land uses and noise concerns are increasingly being generated from areas outside the 65 DNL; making compatible land use planning increasingly more difficult, and sometimes irrelevant. Most noise complaints for airports originate from households located outside the 65 DNL noise contour, often in areas where single event noise levels are below noise levels associated with general speech. In these instances, residents consider any aircraft noise to be annoying, regardless of how loud or quiet it may be. In many instances, these residents feel they were lied to about the potential impacts of aircraft noise and thus any aircraft noise is unacceptable. In theory, airport proprietors only course of action is to inform and work with developers of existing and future potential noise impacts so that potential residents are informed.

There are few airports, and their associated communities, that actively participate in land use planning out to the 60 DNL noise contour. Two of the more well-known airports that do this are Denver International Airport (DEN) and Minneapolis-St. Paul International Airport (MSP). Both airports are known for a progressive stance on addressing noise concerns of local residents. While both are known for being leaders in the field of noise compatibility planning out to the 60 DNL noise contour, they approach their programs very differently. DEN's approach is to focus on land use planning as the primary action item to address land use compatibility. This is possible for DEN because it started as a green field site. MSP is not a green field site and thus their primary approach is focused on corrective mitigation programs for those residents that already live within the 60 DNL noise contour. Two very different ways to achieve the same result; land use compatibility around their respective airports to the extent possible. A discussion on each of these case studies is included below.

3.1 Denver International Airport

In the 1980s, Stapleton International Airport in Denver was at the center of extreme resistance due to rising noise complaints. There were nearly 15,000 residents within the 65 DNL contour, the Airport's capacity was saturated, and expansion of the Airport was not possible due to being land locked with community development. A decision was made to relocate the Airport to a green field site, thus allowing officials to plan for airport growth while minimizing noise impacts. A goal was established to a build new airport with a large land buffer that would succeed in keeping all residential development outside the 60 DNL noise contour while allowing enough room for expansion and growth of the Airport as conditions warranted.

The City and County of Denver annexed a parcel of land from neighboring Adams County that totaled 53 square miles for development of the new airport. An Intergovernmental Agreement (IGA) was established between the City and County of Denver and Adams County on development of the new airport with an emphasis on avoiding unacceptable noise levels in surrounding areas. The IGA set stringent regulations between the Airport and the surrounding community regarding expected noise levels, and established mitigation standards should those levels be exceeded. The goal was to prevent residential incompatible land use that typically results in noise complaints and potential litigation by establishing land use agreements with local jurisdictions.

A Noise Overlay Zone (NOZ) was a product of the Final EIS for the new Airport and established an area for compatible land use planning and where new residential development would be discouraged. The outer limits of the NOZ was based on the 60 DNL noise contour using a full build out scenario of the Airport that was based on the full ASV for all 12 proposed runways, resulting in an ultimate goal of 1.5 million aircraft operations per year. Airport officials hoped by understanding a worst-case scenario of full build-out of the Airport, all surrounding communities would be aware of future airport size and the resulting impact.

The IGA also established Noise Exposure Performance Standards (NEPS) whereby existing noise levels in areas to the north, south, and west of the new airport would not be exceeded. If the NEPS values were exceeded, financial penalties were established that the City and County of Denver would owe to Adams County. These parameters established a relationship where both the airport proprietor and the local jurisdiction had responsibilities for limiting aircraft noise exposure on non-compatible land uses.

Adams County, as a prerequisite to any enforcement of a NEPS violation, had to adopt land use regulations which prohibited new incompatible residential development within the 65 LDN noise contour as determined by the EIS for the new airport. Adams County encourages agricultural use within the 60 DNL contour from the NOZ. In addition, Adams County had to enact a building code or regulation intended to accomplish a 25-dB noise level reduction for the construction of schools, hospitals, nursing homes, churches, auditoriums and concert halls that may take place within the NOZ. The programs have worked to date and no new residential rezoning has taken place within the 60 DNL contour since the development of the NOZ. Those parcels that were already zoned as residential when the Airport was built had to incorporate noise level reduction measures in any new construction to achieve a 45-dB interior A-weighted noise level.

Even with the establishment of the NOZ, pressures continue for development of land in the vicinity of the Airport. Some of the east-west runways are being used more frequently than what was predicted in the EIS for the Airport. This has resulted in operational contours presenting greater noise levels in certain areas than what was identified in the NOZ. If development is allowed to occur up to the limits of the NOZ in these areas, the noise levels experienced by these new residents may exceed 65 DNL. Developers that own land in these areas have refused to limit residential development and claim that residential development is needed as a driver for development of commercial and other airport compatible land uses. This new development also has the potential to limit ultimate build-out of the Airport when needed due to the close proximity of non-compatible land use development in the area. The Airport was concerned with establishing a precedent that would encourage more residential development regardless of the programs established through the IGA.

As a result of increased residential development in the vicinity of the Airport, in areas not covered by the programs associated with the NOZ, airport officials expressed a need to require developers to notify potential residents of the close proximity of the Airport and subsequent impacts associated with that close proximity. Currently developers in the immediate area outside the 65 DNL contour are required to inform future residents of the nearby Airport and that the potential exists for aircraft noise and related annoyances. The typical disclosure statement includes the following notifications:

- In close proximity to the Airport;
- At risk that the property may be subject to overflights by commercial, general aviation, and military aircraft;
- At risk that property may be subject to noise, vibration, exhaust, air and vehicular traffic, and other conditions associated with operation of an international airport;
- Airport has published plans for future airport expansion;
- Developer has not made any agreements with airport relating to potential adverse effects of aircraft overflights.

The disclosures are included in the documents presented at the closing of a property sale and must be signed by the new home buyer.

Denver was designed to be an airport that would not experience any land use/noise compatibility issues; a model for land use management and operational flexibility that would allow the Airport to grow organically and conditions warranted. The site chosen was large (53 sq. miles.) and several agreements were put in place to limit development around the Airport to only those uses needed for successful operation of the facility. Even with this extensive planning effort, and large green field site, the Airport is starting to suffer from the same land use management issues that face most airports. The airfield is not being used in the way it was planned and the result are contours that extend beyond the NOZ in certain areas. These areas do not have the protection of the agreements related to the NOZ and the Airport is facing large non-compatible developments in 65+ DNL contours. Airports fluctuate how they operate and change over time. Even a large land use buffer is not a guarantee for solving the constant struggle airports and local communities face regarding land use compatibility.

3.2 Minneapolis-St. Paul International Airport

In 1992, the Metropolitan Airports Commission (MAC), which owns and operates MSP, began their first 14 CFR Part 150 Program to address noise concerns for those residents that lived within the 65 DNL noise contour. The Airport was in a dense urban environment, needed to ensure it could expand when conditions warranted, and wanted to start the process of compatible land use reform with the local jurisdictions. Homes in the highest noise levels were purchased, while the remaining homes within the 65+ noise contours received sound insulation. Upon completion of the original Part 150 program, a total of $385.6 million had been spent. Wanting to be a good neighbor, the Airport pursued an update to its original Part 150 program where one of the larger discussion items was examining how the Airport could expand noise mitigation efforts beyond the 65 DNL noise contour. The 65 DNL noise contour served as the outer limits for which federal funds could be used under FAA policy and was the limit used when completing the first Part 150 program. The direction to examine the expansion of the program began with the Dual-Track Airport Planning Process that involved a review of whether to move MSP versus continuing to expand in its current location. The updated Part 150 Program recommended a specific mitigation package that would be offered to homes located in the 60-64 DNL noise contour. This mitigation package was to consist of providing central air conditioning to single family homes that did not have it, with a homeowner co-pay based on the degree of noise impact. Funding for this program was to come from the Airport's revenue stream with no participation of Federal funds due to going beyond 65 DNL.

Local jurisdictions were dissatisfied with the expanded noise mitigation proposal and filed suit on the grounds that MAC failed to provide a full 5-decibel Noise Reduction Package (as was provided to residents in the 65+ DNL noise contour in the original Part 150 program. MAC and the local jurisdictions entered into a Consent Decree that settled the litigation by agreeing to a proposal that provided a Full 5-decibel Reduction Package to homes within the 63+ dB DNL noise contour, and a Partial Noise Reduction Package to homes located in the 60-62 dB DNL noise contours. This program was completed in 2014 at a cost of $95 million, raising total expenditures related to noise mitigation as MSP to $482 million.

In 2013, MAC published the Final MSP 2020 Improvements Environmental Assessment and Environmental Assessment Worksheet which reviewed potential and cumulative environmental impacts of MSP terminal and landside developments through the year 2020. Due to concerns expressed by local jurisdictions, the original Consent Decree was amended to extend the Residential Noise Mitigation Program eligibility based on an annual assessment of actual MSP aircraft activity rather than projections. To be eligible for the noise mitigation package, a home must be located within the actual 60 dB DNL noise contour area for three consecutive years. Homes meeting this criterion are mitigated in the year following their eligibility determination. In addition, for homes to be eligible for participation in the MAC Noise Mitigation program, the following must be met by the local jurisdictions:

> *"The community in which the home is located has adopted local land use controls and building performance standards applicable to the home for which mitigation is sought that prohibit new residential construction, unless the construction materials and practices are consistent with the local land use controls and heightened building performance standards for homes within the 60 dB DNL Contour within the community in which the home is located."*

This criterion has been met by all the communities surrounding MSP by incorporating applicable noise level reduction requirements into building codes based on the noise contour level where the structure is to be built. The noise level reduction documentation establishes product-specific Sound Transmission Class (STC) ratings and associated noise level reduction goals.

While the different jurisdictions may have slight variations in what is considered acceptable, and how the noise level reduction criteria are implemented, the overall tenets of their programs are the same. The MAC publishes a map of actual noise contours annually with the preceding year's actual noise contour map being used to the determine the DNL for application of noise attenuation standards. When different land uses are to be contained within a single structure, the more stringent standards apply. **Figure 3.1** represents the tenets of the various programs.

Some communities have chosen to apply higher NLR levels than the ones suggested by the Metropolitan Council in Figure 3.1. It is important to note that some communities have chosen to implement the above criteria for infill development, reconstruction, and additions to existing structures as a recommendation versus a requirement. This allows for rehabilitation of existing home without being a deterrent for homeowners making such improvements.

Figure 3.1: Land Use NLR Guidelines for MSP

Land Use Compatibility Guidelines and Noise Reduction Requirements for Airport Noise										
	Noise Exposure Level (dBA)									
Type of Development	New Development or Major Redevelopment					Infill - Reconstruction or Additions to Existing Structures				
Land Use Category	Zone 1	Zone 2	Zone 3	Zone 4	Buffer Zone	Zone 1	Zone 2	Zone 3	Zone 4	Buffer Zone
	DNL 75+	DNL 74-70	DNL 69-65	DNL 64-60		DNL 75+	DNL 74-70	DNL 69-65	DNL 64-60	
Residential										
Single/Multiplex, with individual entrance	INCO	INCO	INCO	INCO	19	30+	29	24	19	19
Multiplex/Apartment, with shared entrance	INCO	INCO	24	19	COMP	30+	29	24	19	COMP
Mobile Home	INCO	INCO	INCO	19	19	30+	29	24	19	19
Educational, Medical, Schools, Churches, Hospitals, and Nursing Homes	INCO	INCO	INCO	19	19	30+	29	24	19	COMP
Cultural, Entertainment, and Recreation										
Indoor	25+	29	24	19	COMP	30+	29	19	19	COMP
Outdoor	30+	29	24	19	19	30+	29	19	COMP	COMP
Office, Commercial, Retail	30+	29	24	COMP	COMP	30+	29	19	COMP	COMP
Services										
Transportation - Passenger Facilities	30+	29	24	COMP	COMP	30+	29	24	COMP	COMP
Transient Lodging	INCO	29	24	19	COMP	30+	29	24	19	COMP
Other Medical, Health & Education	30+	29	24	COMP	COMP	30+	29	24	COMP	COMP
Other Services	30+	29	24	COMP	COMP	30+	29	24	COMP	COMP
Industrial, Communication, and Utilities	30+	COMP	COMP	COMP	COMP	30+	COMP	COMP	COMP	COMP
Agriculture, Land/Water Areas, and Resource Extraction	COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP	COMP
INCO - Incompatible COMP - Compatible										

Source: Metropolitan Council

The Noise Buffer Zone provides additional protection for noise sensitive uses within the context of preventative land-use measures and allows for contour expansion/contraction over time. The Noise Buffer Zone extends for one mile beyond the extents of the 60 DNL Noise Contour.

Minneapolis is like the majority of all other large commercial service airports in the country in that they are land locked by developed communities. Land use compatibility with aircraft noise is a struggle they have been addressing for the past 30 years by proactively working with the local communities on preventive and corrective measures and remaining flexible in their noise mitigation programs as the Airport changes. They are the only commercial service airport in the U.S. that has used, and continue to use, airport funds to offer corrective land use measures beyond the 65 DNL contour for existing residents. Along with this extraordinary step, they have also worked with local jurisdictions on establishing land use compatibility guidelines beyond the 60 DNL noise contour. This ensures both the Airport and local jurisdictions both have a vested interest in implementing land use compatibility plans.

4. Dulles International Operations Forecast and Projection

To create its Ultimate Conditions Noise Contours for IAD, MWAA projected the ultimate capacity of the existing four runways and the ultimate plan for five runways. This section compares these projected levels of operations to reasonable forecasts of operations demand to understand the timeframe for reaching this Ultimate Condition. This comparison also assesses the fleet mix change assumptions used in the Ultimate Conditions that affect the noise profile of each operation.

Ricondo used the FAA's Terminal Area Forecast (TAF) for Dulles International that is updated by the FAA on an annual basis[5]. This forecast of passenger and operations demand extends to 2045 and has an underlying socio-economic and statistical model that drives the forecast for each airport in the National Airspace System (NAS). In the FY 2017 model used by Ricondo, the 2045 operations totaled 445,628 (less than half of the total 900,000 assumed for the 4-runway ASV). Lower growth in actual operations in 2017, 2018 and now 2019 reduces the 2045 forecast operations total to 424,403.

To develop the ultimate operations and associated aircraft fleet mix, Ricondo extended the FAA TAF using the growth rates from the final five years of the forecast (2041-2045) by the four categories of operations: air carrier, air taxi, general aviation and military. The Ricondo Report provides detail on the operations forecast but leaves out the timeframe estimate of when the ultimate levels of daily and annual operations would be reached.

To assess the reasonableness of a forecast, it needs to be in context with the underlying factors that drive its validity. Ultra-long-range aviation forecasts are difficult to construct because reliable population, employment, income and air service forecasts are difficult to project accurately beyond 20 to 30 years. At best, a projection of compound annual growth rates (CAGR) can be used to very roughly estimate future timeframes when the Dulles International Ultimate Conditions Noise Contours might be reached.

To prepare this estimate, the FAA's latest TAF for FY 2018-2045 was used. To project operations beyond 2045, the CAGR from the last five years of the forecast were applied to the four user categories of operations. Table 4-3 from the Ricondo report provides these growth rates at the time of their analysis. These growth rates are used here even though the air carrier and air taxi growth rates have been reduced in the latest FAA forecast to 1.58 percent and 1.14 percent, respectively.

TABLE 4-3 AVERAGE ANNUAL GROWTH RATES BY USER CATEGORY

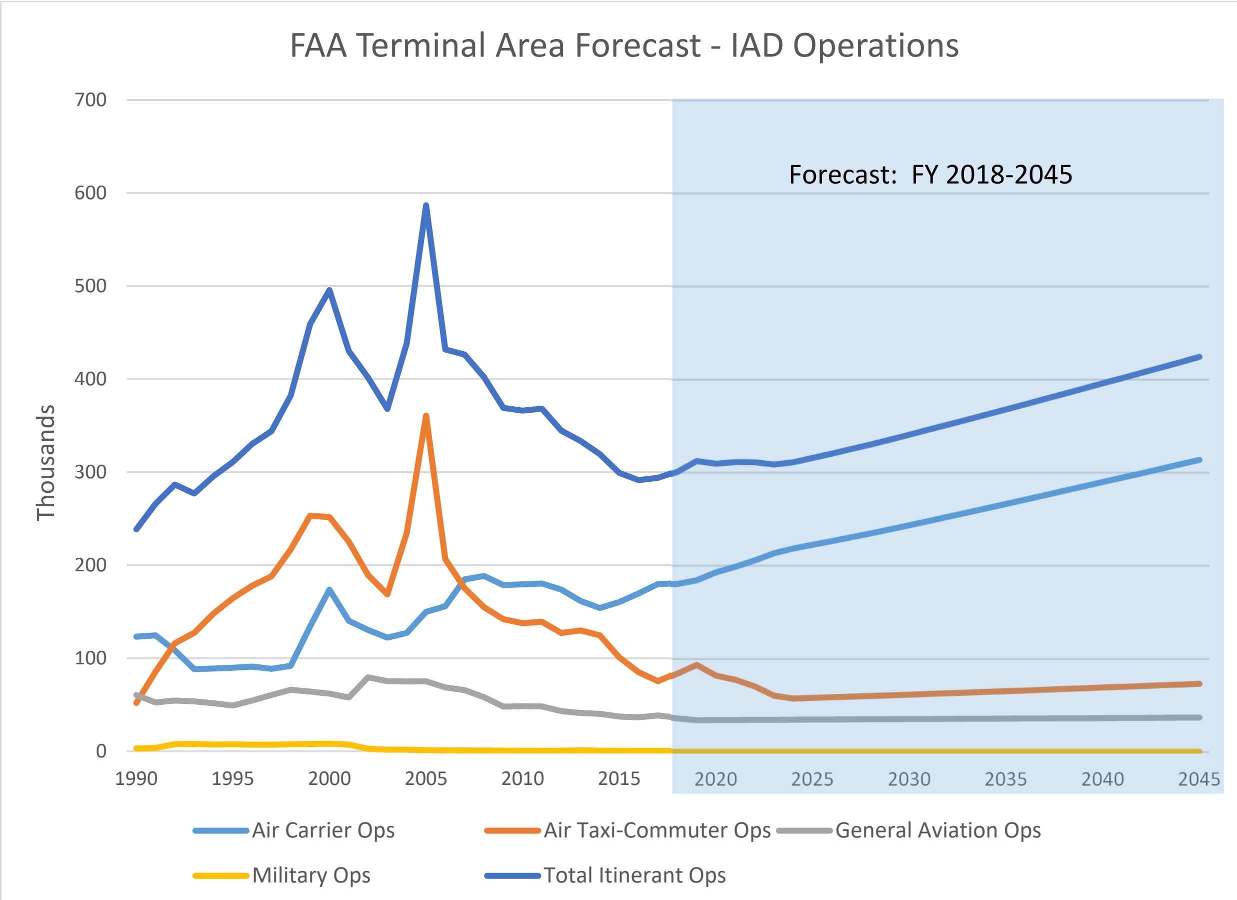
USER CATEGORY	AVERAGE ANNUAL GROWTH RATE BETWEEN 2041 AND 2045
Air Carrier	1.65%
Air Taxi	1.20%
General Aviation	0.30%
Military	0.00%

SOURCE: Federal Aviation Administration, 2017 TAF, https://taf.faa.gov/ (accessed July 17, 2018).

[5] Section 4.2.2 of the Ricondo Report provides the methodology for establishing the 4 and 5-runway ASV average annual day operations used to create the Ultimate noise contours.

Figure 4.1 depicts the FAA's latest demand forecast for Dulles International operations for FY 2018-2045 by the four user categories and the total operations. As stated previously, the 2045 forecast operations total 424,403.

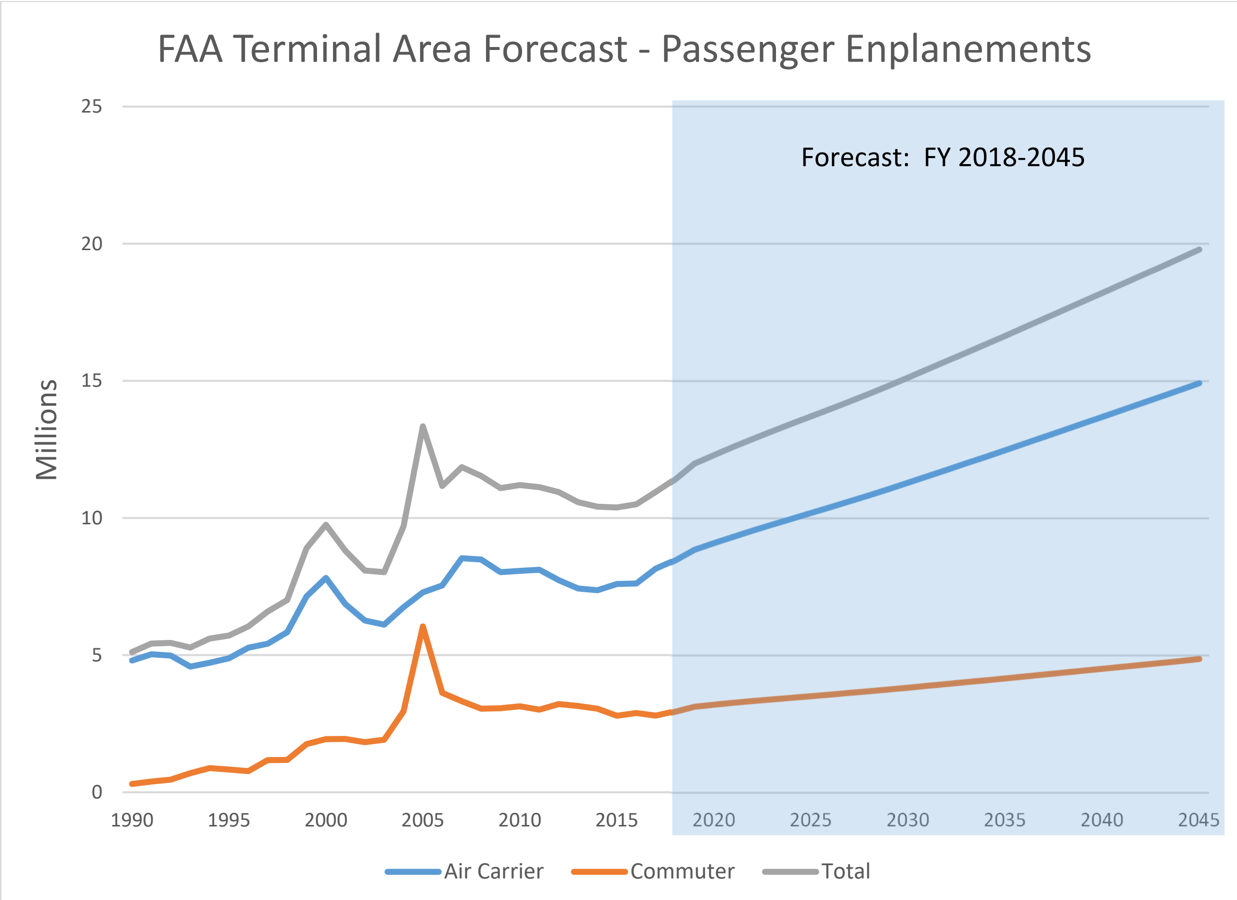
Figure 4.1: FAA Terminal Area Forecast – IAD Operations Demand



Source: FAA Terminal Area Forecast, FY 2018-2045, https://www.faa.gov/data_research/aviation/taf/

Figure 4.2 depicts the FAA's passenger enplanement forecast as general information. Ricondo used the enplanement forecast to estimate the number of seats per operation needed to serve the demand and converted this estimate into the aircraft fleet mix.

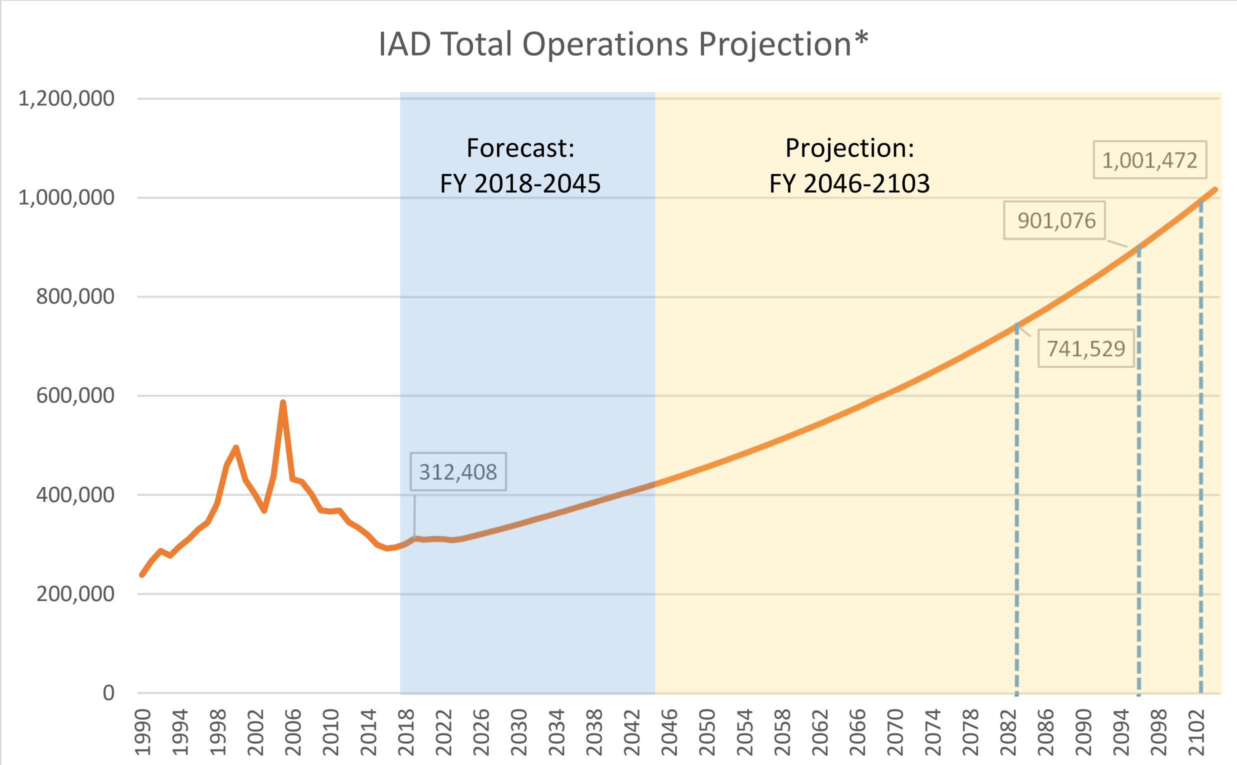
Figure 4.2: FAA Terminal Area Forecast – IAD Passenger Demand (Enplanements)



Source: FAA Terminal Area Forecast, FY 2018-2045, https://www.faa.gov/data_research/aviation/taf/

Figure 4.3 depicts the Ultimate Conditions Forecast for Dulles International aircraft operations. As shown in this projection, the time horizon for the level of operations used in the Ultimate Conditions for the four-runway ASV is over 70 years of growth to reach 900,000 annual operations. The addition of a fifth runway would push the five-runway ASV to over 80 years to reach 1,004,000 annual operations.

Figure 4.3: Ultimate Conditions Forecast – IAD Operations Capacity Horizon



*Projection of FAA Terminal Area Forecast FY 2018-2045 using Air Carrier at 1.65%, Air Taxi at 1.20%, General Aviation at 0.30% and Military at 0.00% beyond 2045 up to the 4-Runway and 5-Runway Annual Service Volumes (ASV) assumed for the Ultimate Conditions Noise Contours.
Source: Johnson Aviation, Inc., January 2020

5. Concentrated Flight Paths Background

The context of aircraft flight path precision, dispersion, and concentration is frequently misunderstood by the general public. This fact is in spite of a combination of generalized capabilities the Federal Aviation Administration touts in promoting satellite-based navigation, a lack of public understanding of the national airspace system, and a general failure to verify the actual operational situation and conditions revealed by accurate flight radar data. In order to fully understand the reality of flight path usage and operation, this section presents information on general air traffic control (ATC) concepts, components of the national air traffic control system, typical arrival and departure procedures, and a summary of how this may change and impact Fairfax County in the future.

5.1 Air Traffic Operational Concepts and Application

Pilots operate aircraft under two distinct categories of flight rules: Visual Flight Rules (VFR) and Instrument Flight Rules (IFR). Under VFR, pilots are responsible to "see and avoid" other aircraft and obstacles such as terrain to maintain safe separation. VFR rules also cover visibility requirements and cloud clearance criteria required to fly with visual reference to the ground and/or horizon and these vary depending on the type of airspace. Under IFR, aircraft operators are required to file flight plans and use navigational instruments to operate within the National Airspace System (NAS) and are in constant contact with, and monitored by, ATC. The airspace for IAD is what is known as Class Bravo or "Class B" airspace and has the most restrictive operating rules of any airspace with regulations on pilot requirements, aircraft operational capability, and other flight specific characteristics. Aircraft can only operate under VFR in the vicinity of IAD if they have been cleared by ATC to enter the busy airspace above and around the Airport.

While weather and operating altitude partially define these flight rules, most commercial air traffic operates under IFR due to the mutual relationship between the flight crews and air traffic personnel to safely operate among other fast-moving aircraft in frequently congested areas. In calendar year 2019 at IAD, 99.6% of all aircraft were operated under IFR and 0.4% operated under VFR (Source: FAA Air Traffic Activity System (ATADS)). Among all aircraft nationally, approximately 27 million flights are conducted per year with 60% operated under IFR and 40% operated under VFR (Source: FAA "Air Traffic By The Numbers 2019"). Commercial airlines and large non-commercial jet and turboprop aircraft make up the vast majority of IFR operations in the national airspace system with the smaller non-commercial (referred to as general aviation) single and multi-engine piston aircraft operating under VFR.

Depending on whether aircraft are operating under IFR or VFR, air traffic controllers apply various techniques to maintain separation between aircraft, including the following:

- Vertical or "Altitude" Separation: separation between aircraft operating at different altitudes;
- Longitudinal or "In-Trail" Separation: separation between two aircraft operating along the same flight route, referring to the distance between a lead and a following aircraft; and,
- Lateral or "Side-by-Side" Separation: separation between aircraft (left or right side) operating along two separate but nearby flight routes.

Air traffic controllers use radar to monitor aircraft and provide services that ensure separation. Published instrument ATC procedures provide predictable, efficient routes that move aircraft through the NAS in a safe and orderly manner. These ATC procedures reduce the need for constant verbal communication between air traffic controllers and pilots. Published instrument ATC procedures are described as "conventional" ATC procedures when they use ground-based navigational aids (NAVAIDs). Ground based NAVAIDs are those that use radio frequency signals emitted from a fixed location on the ground and are received by aircraft instruments to indicate or establish the vertical, horizontal, and time-oriented position of the aircraft. In its effort to modernize the NAS, the FAA continues to develop instrument ATC procedures that build upon new advanced technologies. A primary technology in this effort is area navigation or RNAV. RNAV uses primarily satellite-based technology, including Global Positioning System (GPS), to allow an RNAV-equipped aircraft to fly a more efficient overall route. This route is based on instrument guidance that references an aircraft's three dimensional position and time relative to satellites. Dulles underwent a partial changeover from ground based to satellite-based flight procedure in 2014 as part of the FAA's NextGen program to modernize air traffic systems and aircraft operations. Aircraft operating to and from Dulles have a mixture of ground based (five arrival and one departure) and satellite based (six arrival and nine departure) flight procedures. As technology evolves, the FAA continues to test and deploy multiple air traffic operational and equipment solutions to guide aircraft movements on the ground and in the air.

As an aircraft moves from origin to destination, ATC personnel function as a team and transfer control of the aircraft from one controller to the next and from one ATC facility to the next. The NAS is organized into three-dimensional areas of navigable airspace that are defined by a floor, a ceiling, and a lateral boundary. Each is controlled by different types of ATC facilities including:

- Airport Traffic Control Tower: Controllers at an Airport Traffic Control Tower (ATCT) located at an airport provide air traffic services for phases of flight associated with aircraft takeoff and landing. The ATCT typically controls airspace extending from the airport to five to 10 nautical miles in all directions. Dulles ATCT handles an average of 300,000 annual aircraft operations.
- Terminal Radar Approach Control (TRACON): Controllers at a TRACON provide air traffic service to aircraft as they transition to and from an airport and the high altitude en route phase of flight. This includes the climb, descent, and approach phases of flights. The primary TRACON facility in the Dulles area is the Potomac TRACON (which holds the FAA name code of "PTC").
- Air Route Traffic Control Centers (ARTCCs or "Centers"): Controllers at ARTCCs provide air traffic services during the en route phase of flight. Like TRACON airspace, the Center airspace is broken down into sectors with the primary difference being the coverage extend to a multi-state area. Dulles Traffic interacts with airspace delegated to the Washington Air Route Traffic Control Center ARTCC (ZDC).

The following sections discuss how air traffic controllers at these ATC facilities control the phases of flight for aircraft operating under IFR.

5.1.1 Departure Flow

As an aircraft operating under IFR departs a runway and follows its assigned heading, it moves from the ATCT airspace, through the terminal airspace, and into en route airspace where it proceeds on a specific route to its destination airport.

Within the terminal airspace, TRACON controllers provide services to aircraft departing from the ATCT airspace to departure transfer control points referred to as "exit points." An exit point represents an area along the boundary between terminal airspace and en route airspace. Exit points are generally established near commonly used routes to efficiently transfer aircraft between terminal and en route airspace. When aircraft pass through the exit point, control transfers from TRACON to ARTCC controllers as the aircraft joins a specific route.

Departing IFR aircraft use an ATC procedure called a Standard Instrument Departure (SID). A SID provides pilots with defined lateral and vertical guidance to facilitate safe and predictable navigation from an airport through the terminal airspace to a specific route in the en route airspace. A "conventional" SID follows a route defined by ground-based NAVAIDs and are primarily based on vectoring.

5.1.2 Arrival Flow

An aircraft begins the descent phase of flight within the en route airspace in order to transition to lower altitudes for less restrictive maneuvering and speed reduction. During descent, the aircraft transitions into the terminal airspace through an "entry point," bound for the destination airport. The entry point represents a physical location in the airspace along the boundary between terminal airspace and en route airspace where control of the aircraft transfers from ARTCC to TRACON controllers. Aircraft that arrive in the terminal airspace normally follow an instrument ATC procedure called a Standard Terminal Arrival (STAR) route.

5.1.3 Required Aircraft Separation

As controllers manage the flow of aircraft into, out of, and within the NAS, they maintain some of the following separation distances between aircraft:

- Altitude Separation (vertical): When operating below 41,000 feet above mean sea level (MSL), two aircraft must be at least 1,000 feet above/below each other until lateral separation is ensured.
- In-Trail Separation (longitudinal): Within a radar-controlled area, the minimum distance between two aircraft on the same route (i.e., in-trail) can be between 2.5 to 10 nautical miles, depending on factors such as aircraft class, weight, and type of airspace.
- Side-by-Side Separation (lateral): Similar to in-trail separation, the minimum side-by-side separation must be at least three nautical miles between aircraft in terminal airspace and at least five nautical miles in en route airspace.
- Visual Separation: Aircraft may be separated by visual means when other approved separation is assured before and after the application of visual separation.

5.1.4 Area Navigation (RNAV)

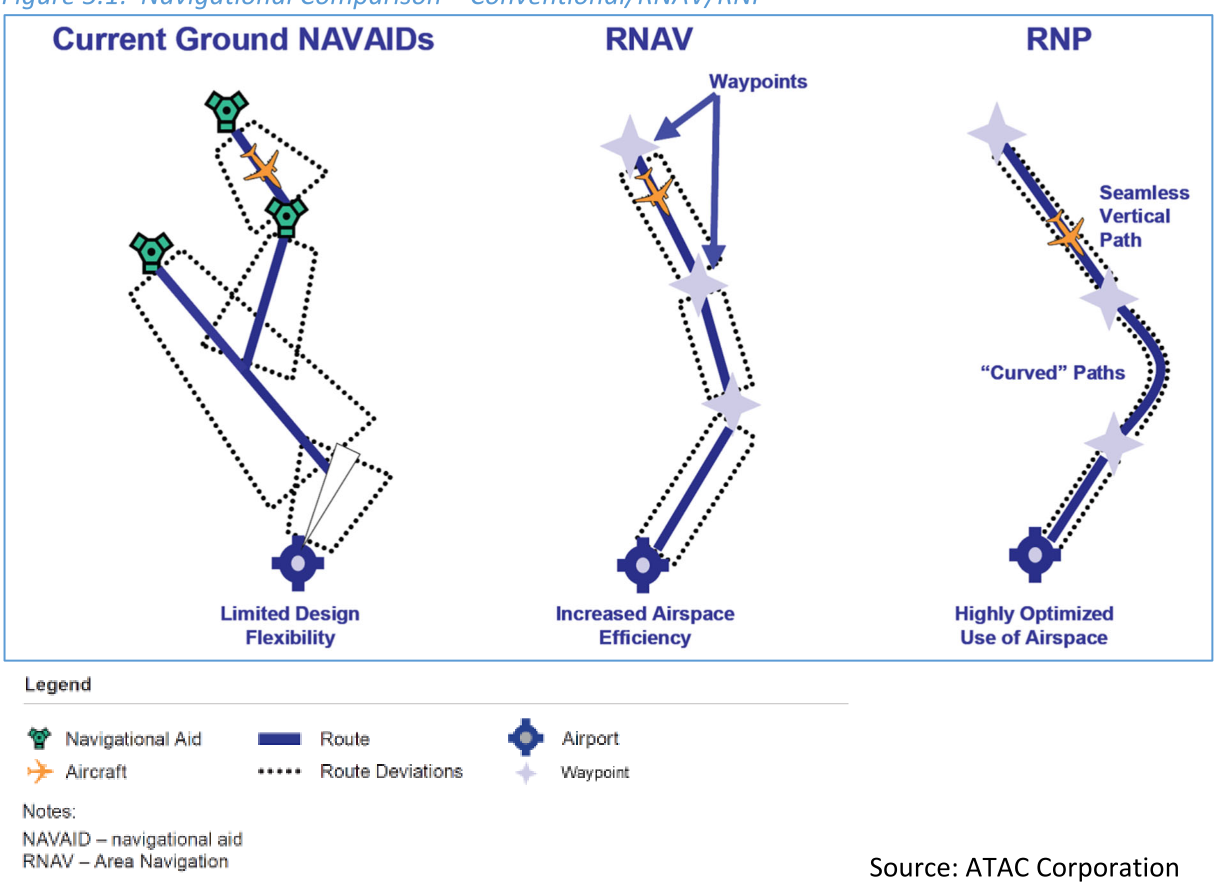
RNAV uses technology, including GPS, to allow an RNAV-equipped aircraft to fly a more efficient route. This route is based on instrument guidance that references an aircraft's position relative to satellites. Because RNAV is generally not reliant on ground-based signals, there is no degradation based on distance from the source. For example, aircraft arriving to an IAD runway can use ground-based instrument landing systems (ILS) or RNAV technologies. The primary difference is that the ILS is less precise the further an aircraft is from the runway whereas RNAV is reliably accurate at any distance from the runway. The ILS is a narrowing funnel with higher sensitivity as an aircraft approaches the runway, while an RNAV approach is consistently sensitive independent of distance from the runway and is a laterally and horizontally defined tube within which the aircraft will stay during the entire approach. Nearly all commercial aircraft RNAV systems are accurate to within .3 nm laterally or roughly 1,800 feet resulting in 3,600 feet of variability laterally at any given point in an approach. RNAV can also be something other than a straight-in approach to a runway using curved segments whereas an ILS is solely for straight-in approaches to a runway.

5.1.5 Required Navigation Performance (RNP)

RNP is an RNAV ATC procedure with signal accuracy that is increased with onboard performance monitoring and alerting systems. An RNP is an RNAV ATC procedure that requires greater accuracy of on-board performance monitoring and alerting equipment, as well as special pilot training. A defining characteristic of an RNP operation is the ability for an RNP-capable aircraft navigation system to monitor the accuracy of its navigation (based on the number of GPS satellite signals available to pinpoint the aircraft location) and inform the crew if the required data becomes unavailable. RNP is most often applied in approach navigation where a steady curve based on a fixed radius is used to guide aircraft. Due to the extra signal reliability indicators and the need for a flight crew with special RNP authorization, RNP is accurate to as close as +/- 608 (0.1 nm) feet from a procedure centerline on a lateral basis.

The following **Figure 5.1** compares conventional, RNAV, and RNP ATC procedures in a general sense and do not represent a specific phase of flight. It shows how an RNP capable aircraft navigation system provides a more accurate and seamless horizontal and vertical location (down to less than one nautical mile from the intended path) and will follow a highly predictable path. The predictability for the controller to know where the aircraft will be dimensionally makes it possible to implement ATC procedures within controlled airspace that are not always possible under conventional procedures, such as precision curved turns.

Figure 5.1: Navigational Comparison – Conventional/RNAV/RNP



Source: ATAC Corporation

Routes based on ground-based NAVAIDs rely on the aircraft equipment directly communicating with the NAVAID radio signal and are often limited by issues such as line-of-sight and signal reception accuracy. NAVAIDs, such as Very High Frequency (VHF) Omnidirectional Ranges (collectively VORs), are affected by variable terrain and other obstructions that can limit their signal accuracy. Consequently, a route that is dependent upon ground-based NAVAIDS requires at least six nautical miles of clearance on either side of its main path to ensure accurate signal reception. As demonstrated by the dashed lines on **Figure 5.1**, this clearance requirement increases the farther an aircraft is from the VOR. In comparison, RNAV signal accuracy for IFR procedures requires only one or two nautical miles of clearance on either side of a route's main path depending on the route design and intended purpose.

5.2 Air Traffic Arriving and Departing IAD

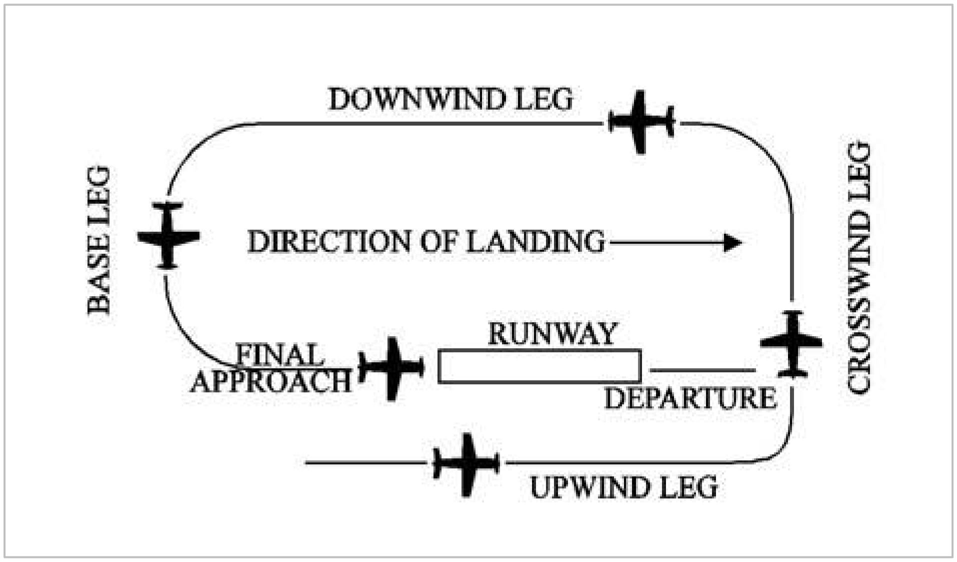
IAD operates in a wind and weather dependent air traffic flow, which is either a north flow or south flow and describes the direction of arrivals and departures. A north flow is characterized by aircraft landing to the north and departing to the north and the opposite is true for a south flow. Arriving air traffic needs to be integrated vertically and laterally with air traffic from other directions. This process involves a mix of aircraft heading, speed, and altitude adjustments in order to sequence aircraft for landing while allowing departing aircraft to be sequenced for the departure and climb out of the area. The same is true for departures with the primary difference being aircraft are generally climbing out of the area at a steady rate to an assigned en route altitude as quickly as possible. As an examination of the IAD arrivals and departures indicate, the location of aircraft at altitudes noticeable by the public are largely in line with runway centerlines due to prescribed IFR arrival and departure procedures. The presence or absence of straight-in RNAV procedures has little effect in those phases of flight where aircraft are lined up with a runway centerline that are covered in the following sections.

5.2.1 IAD Aircraft Sequencing and Final Approach

At large commercial airports a combination of the defined STARs and Air Traffic Control discretion combine to direct aircraft safely through all phases of the arrival pattern, generally represented by **Figure 5.2**. Where an aircraft enters the arrival pattern is dependent on the arriving direction of the aircraft. Despite having generalized corridors for orderly arrivals, there is substantial variability in the vertical and lateral path the aircraft follows until the final approach is established. For instance, in order to sequence arriving aircraft for landing, the downwind leg may be extended substantially to turn an aircraft at the appropriate time behind another aircraft already lined up with the approach runway. This ensures that landing aircraft can land and exit the runway before the next aircraft lands on the same runway. In north flow, these turns (from the downwind leg to the base leg, then to the final leg) frequently occur as far south as Manassas Regional Airport-Harry P. Davis Field (HEF); in south flow these turns occur in the vicinity of the towns of Tuscarora & Dickerson for the east runways and in the vicinity of Lucketts for the west runways. The closer the aircraft gets to the airport on the final leg, the more precise the aircraft observes lateral and vertical position. Fifteen miles from the runway a 200-foot altitude deviation is nearly inconsequential, however one-half mile from the approach end of the runway, 200-feet of altitude variability is a serious issue.

For Dulles, arriving aircraft within five to six miles of the runway have been and will continue to operate with similar precision regardless of the aircraft following RNAV procedures. This is due to many combined factors. All landing aircraft are closely monitored by controllers via their radar information that includes altitude, position, airspeed, groundspeed, and other identifying information. The pilots are simultaneously working to establish the aircraft on a stabilized approach with minimal lateral and vertical variability as the aircraft gets lower and closer to touchdown. As a general characterization, recognizing there are technical caveats related to aircraft type and flight crew qualifications, within five to six miles of the IAD runway the aircraft instruments following radio signals in an instrument landing system enable a similar precision as aircraft instruments following satellite based RNAV guidance. Beyond six miles from IAD runway end, a number of air traffic, weather, and aircraft specific factors combine that result in lateral and vertical variability while on the final approach path to ensure proper sequencing for the landing.

Figure 5.2: Basic Overview of Air Traffic Arrivals



(Source: FAA Airman's Information Manual, Figure 4-3-1)

5.2.3 IAD Aircraft Departures

Aircraft departures from IAD use one of ten defined IFR procedures. Procedures are named with a five letter code and most codes form an approximation to a readable word that carries a person's name, an association with the region, or other random verbiage (e.g. the RNLDI SID is named for Paul Rinaldi, the sixth president of the National Air Traffic Controllers Association). Currently, nine out of ten SIDs are RNAV based procedures. Four of the RNAV SIDs (JERES, BUNZZ, JCOBY, and RNLDI) involve climbing on runway heading (north or south) to 8,200 feet MSL (approximately 7,800 feet above ground level) and then following the prescribed route. The 8,200 foot altitude is not reached by all aircraft at the same point due to a variety of weather, aircraft loading, and aircraft type combinations. Also, flying a runway heading versus flying to a defined waypoint after departure may result in lateral drift for the aircraft, resulting in more variability despite being an RNAV procedure. The remaining five RNAV SIDs (JDUBB, CLTCH, MCRAY, SCRAM, WOOLY) and the lone conventional SID (called the Capital One Departure) also have the runway heading requirement but then rely on air traffic control issued vectors to a defined procedure waypoint. These five RNAV SIDs also have the 8,200 foot requirement but the conventional SID does not have this requirement. The aircraft vectoring that is ATC directed after departure enables ATC to exercise maximum flexibility to efficiently organize and sequence departing traffic from IAD, BWI, and DCA. The average passenger jet aircraft climbs at 2,500 to 4,000 feet per minute and maintains a speed of approximately 250 knots. This means that most aircraft will be reaching that 8,200 foot level at 2:00-3:30 minutes after takeoff and approximately nine to 16 miles from the end of the runway. Thus, Dulles departures, even while flying RNAV procedures, still have substantial variability in their lateral and vertical flight path.

5.2.4 General IAD IFR Arrival and Departure Issues that Constrain IAD Operations

Having presented the airspace procedure and IFR operational concepts, there are several consequences that result from instrument arrivals and departures to and from IAD using common instrument procedures and terminal airspace entry and exit points. In presenting these consequences, the intent is to demonstrate the airspace and airport operational complexity that impacts the ability of IAD to deliver full use of existing capacity. These factors may be exacerbated as flight operations at IAD, DCA, and BWI increase. As mentioned previously, the FAA is constantly developing and testing new air traffic management technology to simplify and add efficiency to the NAS. These existing consequences include:

- The need to merge arriving aircraft into a unified arrival flow at each entry point can increase flight time and distances.
- Gaps in the final arrival flows do not allow for the formation of a constant stream of aircraft to IAD. This impacts the full use of the potential arrival throughput at IAD.
- Merging aircraft from regional airports (IAD, DCA, BWI) into single departure streams for each regional exit point requires controllers to create greater separations between subsequent departures from the same airport than would otherwise be required if the routes were separated or there were only a single airport in operations. Dedicated departure routes for IAD runways somewhat reduce the needed separation but once airspace capacity is saturated under a given operational condition, the runway departure rates are held to that maximum.
- Holding aircraft on the runway to create the necessary gaps in the departure routes leads to departure delays across DC area airports, especially during peak travel periods. This impacts full use of the potential departure throughput at IAD.
- The need for additional controller-to-pilot communication to issue the variety of instructions required to merge and desegregate the flow of aircraft adds to the workload of both controllers and pilots.
- Options for controllers to re-direct aircraft to avoid inclement weather or more efficiently handle sequencing are limited when the pilot does not have the runway in sight due to low visibility.

ATC typically splits arrival and departure control responsibilities. Control of aircraft is passed on from one controller to the next as the aircraft progress through airspace. Vertical separation between aircraft arrivals and departures is maintained primarily through defined ceiling and floor altitudes. An arriving aircraft cannot descend until the aircraft is clear of the dimensional airspace reserved for departures. When an aircraft clears one airspace area, it is transferred by a controller to the next airspace area controlled by another controller. During the time between handoff and transfer of control between controllers, aircraft may have to level off until the next controller acknowledges control and the aircraft is able to resume its climb. The amount of time necessary to transfer control may be directly affected by the extent of controller workload.

5.3 Navigation Precision, Flight Path Dispersion, and Aircraft Concentration

As the prior explanations have presented, RNAV is a method of precision ATC and aircraft navigation. There are any number of conditions that define "precision" differently as it applies to multiple phases of flight. There is variability in any navigational situation to and from IAD and this affects the concepts of aircraft dispersion as it relates to lateral and vertical variance, while "concentration" relates to the number of aircraft on a defined flight path. The vertical and lateral variety of pathways to and from a runway are characterized as dispersion.

5.3.1 IAD Arrival Dispersion & Aircraft Concentration

As has been previously noted, aircraft on final approach within approximately six miles of the runway touchdown point are going to be similarly concentrated over any point in that pathway regardless of the presence or absence of RNAV and the volume of aircraft. Between six and 25 miles away (north or south) from IAD aircraft are generally over 3,000 feet above ground but still on the final approach path in line with the intended runway. Aircraft are being directed by ATC to keep the aircraft generally in line with the runway centerline.

The Metropolitan Washington Airports Authority (MWAA) Aircraft Noise Contour Map Update (the “Report”) states: “The use of RNAV procedures results in little dispersion along the routes due to the predictable and repeatable nature of the GPS-based navigation technology” (Source: “Aircraft Noise Contour Map Update” Ricondo/HMMH, Page 2-6). Based on the preceding review of the IAD SIDs and STARs this statement is true within five to six miles of the landing runway but less true for aircraft on final approach outside of that range. In addition, arrival aircraft can also be vectored to the runway when weather conditions enable the flight crew visual contact with the landing runway and ATC can safely expedite the arrival.

The Report states “Through the noise model flight track creation process, 538 noise model flight tracks were defined. Each consisted of a centerline track (backbone track) and 0 to 8 additional dispersed tracks (sub-tracks) flanking the centerline track to model the appropriate width of a traffic corridor” (Source: “Aircraft Noise Contour Map Update” Ricondo/HMMH, Page 5-17). The Report flight track dispersion appears to mimic actual departure radar flight track dispersion and is consistent with generally applied modeling methodology. The Report presents arrival and departure operations for the examined scenarios on a runway by runway basis for north flow and south flow. Each runway has a daytime and nighttime split that enables the reader to infer what runway is forecast to be the busiest runway in each scenario. Specific aircraft type operations are also broken out for the total percentage of operations that the Report relies upon for noise modeling input. Of particular note are the RNP defined future procedures in the ultimate buildout scenario that do not exist today. The Report notes “Aircraft are expected to follow these RNP approach paths with very little dispersion in the long-term future” (Source: “Aircraft Noise Contour Map Update” Ricondo/HMMH, Page 4-47).

5.3.2 IAD Departure Dispersion & Aircraft Concentration

Departing IFR aircraft use RNAV SIDs that prescribe ATC vectored headings after reaching a defined altitude that result in lateral and vertical dispersion due to the variance in aircraft climb rates and weather influences. As stated previously, aircraft take between nine and 16 miles to reach the IFR procedure prescribed vectoring altitude and will likely be narrowly dispersed along the departure runway heading until that point. RNP departures are unusual in the US and the Report does not indicate any RNP departure procedures were used in any scenario. When looking to ultimate buildout conditions, the Report states: “The FAA has no long-term plans to develop and implement RNAV-type procedures causing narrower departure paths from the departure end of a runway” (Source: “Aircraft Noise Contour Map Update,” Ricondo/HMMH, Page 4-47). The Report Departure Noise Model Backbone Tracks (see the Report, Chapter 4, generally) indicate substantial dispersion for departures.

5.3.3 Dispersion & Concentration Summary

As discussed in this section, the movement of air traffic is a complicated issue with many moving parts and variables that can change on a daily, hourly, and minute-by-minute timeframe. To counter this constant change, the FAA is continually looking for ways to simplify the NAS by reviewing and incorporating new technologies that build upon consistency. This has provided some momentum for aircraft movements to be more precise, which in turn can mean more narrowly defined flight corridors. The RNAV and RNP procedures discussed in this section are the primary components of this emerging technology. RNAV is becoming more common across the country, whereas RNP is still considered in its infancy but likely represents the future of aircraft movement. Widespread use of RNP is likely years, if not decades, away from becoming a standard. It is important to note that RNP may never become the standard across the country and may only be airport specific where curved approaches are better suited for a particular airspace.

Specifically, for IAD and Fairfax County, the location and altitude of aircraft in line with the centerline of a runway will continue as it exists today and are expected to be similarly concentrated as separation standards are not expected to change. It is important to note that an increase in operations does not impact the concentration of aircraft on approach, but rather increases the amount of time that arrivals would be operating. No changes can be expected for arrival flight patterns within five to six miles of a runway as aircraft must be lined up with the runway during this phase of flight. Their path and altitude is guided by the precision approach system for the runway and is not expected to change even if newer technologies are implemented.

From six to 25 miles away from the Airport, aircraft are generally above 3,000 feet AGL, but still considered on final approach path for the intended runway. In this phase of flight, a number of parameters can influence aircraft flight tracks, altitudes, and separation. These parameters include other air traffic, weather, and aircraft specific factors. Aircraft in this area are being guided by ATC to stay generally in line with the intended runway but some aircraft may be vectored into the pattern at any point if conditions permit and ATC determines it is beneficial for the safe and efficient movement of air traffic. There may be variability in the altitude, location, and concentration of aircraft while in this phase of flight and that is expected to continue for the foreseeable future.

No changes to departure patterns are expected either with the forecasted increase in operations. Aircraft typically take between nine and 16 miles to reach the IFR procedure prescribed vectoring altitude and that is not expected to change. Today aircraft in this phase of flight are narrowly dispersed along the departure runway heading and that is expected to continue. Implementation of RNP procedures can narrow the dispersion during this phase of flight, but are unusual in the U.S. and no RNP departure procedures were used in any of the modeling scenarios for IAD. Beyond nine to 16 miles from the departure runway, aircraft dispersion is expected to continue the patterns experienced today.

6. Recommendations

Based on the findings of this review and assessment and our experience with airport compatible land use planning, we recommend that the County focus on the reasonably foreseeable potential noise and overflight impacts of Dulles International aircraft operations. We offer the following recommendations to help guide the County's airport compatible land use planning.

Recommendation 1

Using the ultimate ASV contours as a guide for land use planning, concentrate on the Ultimate 65 DNL contour and apply the County's existing Noise Level Reduction (NLR) criteria for new residential construction to that area. While the ASV contours are based on an operational capacity projection far into the future and would not likely be achieved in the typical 20-30 year planning time frame, the ultimate 65 DNL contour could be used as guidance since it accounts for any potential increase in the actual 65 DNL noise contour up to and beyond a 30-year timeframe in projected aircraft operations growth at Dulles International.

Recommendation 2

Undertake a GIS-based analysis using the Ultimate ASV area between the 60 DNL and 65 DNL contours to assess the amount of potential residential land uses that would be newly impacted and those areas which may no longer be located within the 60-65 DNL impact areas and consider changes to land use policies that permit residential uses in those areas, balancing potential noise impacts with other county goals such as economic development and placemaking.

Recommendation 3

Consider establishing noise notification guidelines for concentrated overflight areas within the Ultimate 60 to 65 DNL noise contours to ensure the County has adequately provided notice to future residents that they are moving into an area located in close proximity to a major international airport and may be impacted by aircraft noise and overflights. The guidance provided for residential development in Land Unit J is consistent with guidelines adopted by other jurisdictions and can be used as a model as it has largely addressed the issue.

Recommendation 4

Work with MWAA to study and recommend nighttime (10 p.m. through 6:59 a.m.) noise abatement procedures and a preferential runway use program should MWAA move forward with increased nighttime cargo activity and/or increased scheduling of nighttime passenger flights at IAD as discussed in the MWAA report.

Appendix A - Noise Fundamentals

While a great deal is known about aircraft noise, the methods used to calculate noise exposure can be difficult to understand. Determining aircraft noise impacts involves logarithmic averages and the noise energy from single events. In 14CFR150, (Part 150), The FAA required primary metric for assessing aircraft noise impacts is the Day-Night Average Sound Level (DNL). The DNL combines the noise energy from all aircraft operations occurring from the events in one day into an average, even applying a penalty to nighttime events, between the hours of 10:00 pm and 7:00 am, when people are more negatively affected by unwanted sound and more susceptible to noise impacts. This section of the report will go into detail on what noise is, what metrics exist (including DNL) to measure noise impacts, and how certain metrics relate to one another.

Characteristics of Sound

Amplitude and Frequency

Sound can be technically described in terms of its sound pressure (amplitude) and frequency (similar to pitch).

Amplitude is a direct measure of the magnitude, or loudness, of a sound without consideration for other factors that may influence its perception. The ranges of sound pressures that occur in the environment are so large that they are expressed on a logarithmic scale. The standard unit of measurement of sound is the decibel (dB). A sound pressure level in dB describes the pressure of a sound relative to a reference pressure. By using a logarithmic scale, the wide range in sound pressures is compressed to a more usable range of numbers.

For example, a sound level of 70 dB has 10 times as much acoustic energy as a level of 60 dB; while a sound level of 80 dB has 100 times as much acoustic energy as a level of 60 dB. In terms of human response to noise, the perception is very different. A sound 10 dB higher than another sound is usually judged to be twice as loud; 20 dB higher four times as loud; and so forth.

The frequency of sound is expressed as Hertz (Hz) or cycles per second. The normal audible frequency range for young adults is 20 Hz to 20,000 Hz. The prominent frequency range for community noise, including aircraft and motor vehicles, is between 50 Hz and 5,000 Hz. The human ear is not equally sensitive to all frequencies, with some frequencies judged to be louder for a given signal than others. As a result, research studies have analyzed how individuals make relative judgments as to the “loudness” or “annoyance” to a sound. The most prominent of these scales include Loudness Level, Frequency-Weighted Contours (such as the A-weighted scale), and Perceived Noise Level. Noise metrics used in aircraft noise assessments are based upon these frequency weighting scales, which are discussed in the following paragraphs.

Loudness Level

This scale has been devised to approximate the human subjective assessment to the “loudness” of a sound. Loudness is the subjective judgment of an individual as to how loud or quiet a particular sound is perceived. This sensitivity difference varies for different sound pressure levels.

Frequency-Weighted Contours (dBA, dBB, and dBC)

In order to simplify the measurement and computation of sound loudness levels, frequency-weighted networks have obtained wide acceptance. The equal loudness level contours for 40 dB, 70 dB, and 100 dB have been selected to represent human frequency response to low, medium, and loud sound levels. By inverting these equal loudness level contours, the A-weighted, B-weighted, and C-weighted frequency weightings were developed. Figure 1 presents these frequency-weighted contours.

The most common weighting is the A-weighted noise curve. The A-weighted decibel scale (dBA) performs this compensation by discriminating against frequencies in a manner approximating the sensitivity of the human ear. In the A-weighted decibel, everyday sounds normally range from 30 dBA (very quiet) to 100 dBA (very loud). Most community noise analyses are based upon the A-weighted decibel scale. Figure 2 presents examples of various sound environments expressed in dBA.

Some interest has developed by communities close to some airports in utilizing a noise curve other than A-weighting for lower frequency noise sources. For example, the C-weighted curve is used for the analysis of the noise impacts from artillery noise. For evaluation of aircraft noise, A-weighting is used because the majority of noise associated with aircraft operations is better suited to the A-weighting; no mitigation methods have been proven to be effective for C-weighted noise (i.e., sound insulation), which is the minority portion of the noise associated with aircraft operations.

Perceived Noise Level

Perceived noisiness is another method of rating sound. It was originally developed for the assessment of aircraft noise. Perceived noisiness is defined as "the subjective impression of the unwantedness of a not-unexpected, nonpain, or fear-provoking sound as part of one's environment," (Kryter, 1970). "Noisiness" curves differ from "loudness curves" in that they have been developed to rate the noisiness or annoyance of a sound as opposed to the loudness of a sound.

As with loudness curves, noisiness curves have been developed from laboratory psychoacoustic surveys of individuals. However, in noisiness surveys, individuals are asked to judge in a laboratory setting when two sounds are equally noisy or disturbing if heard regularly in their own environment. These surveys are more complex and are therefore subject to greater variability.

Figure 1 – Frequency Weighted Curves

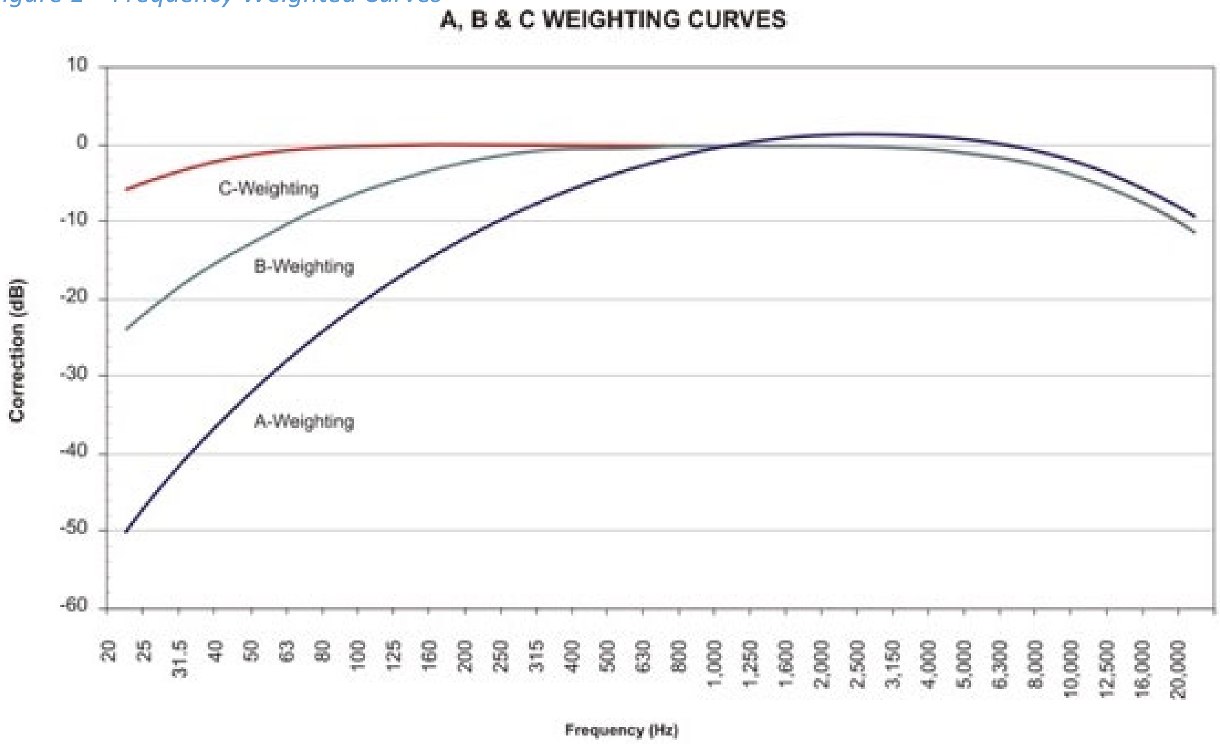
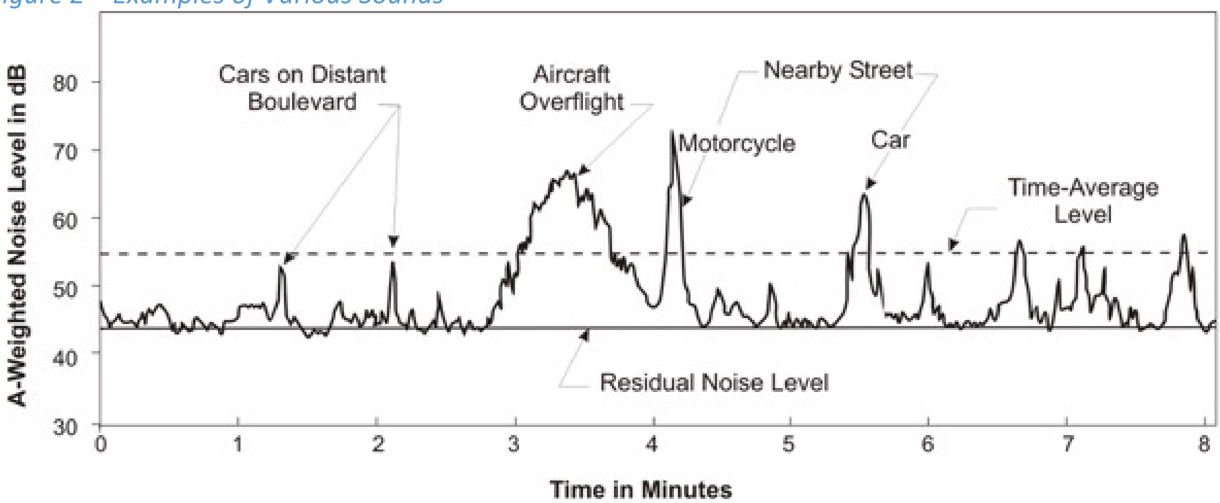


Figure 2 – Examples of Various Sounds



Propagation of Noise

Outdoor sound levels decrease as a function of distance from the source, and as a result of wave divergence, atmospheric absorption, and ground attenuation. If sound is radiated from a source in a homogenous and undisturbed manner, the sound travels as spherical waves. As the sound wave travels away from the source, the sound energy is distributed over a greater area, dispersing the sound power of the wave. Spherical spreading of the sound wave reduces the noise level, for most sound sources, at a rate of 6 dB per doubling of the distance.

Atmospheric absorption also influences the levels that are received by the observer. The greater the distance traveled, the greater the influence of the atmosphere and the resultant fluctuations. Atmospheric absorption becomes important at distances of greater than 1,000 feet. The degree of absorption is a function of the sound frequency, of the sound as well as the humidity and temperature of the air. For example, atmospheric absorption is lowest at high humidity and higher temperatures. Turbulence and gradients of wind, temperature, and humidity also play a significant role in determining the degree of attenuation. Certain conditions, such as inversions, can also result in higher noise levels that would result from spherical spreading as a result of channeling or focusing the sound waves.

Absorption effects in the atmosphere vary with frequency. The higher frequencies are more readily absorbed than the lower frequencies. Over large distances, the lower frequencies become the dominant sound as the higher frequencies are attenuated.

The effects of ground attenuation on noise propagation are a function of the height of the source and/or receiver and the characteristics of the terrain. The closer the source of the noise is to the ground, the greater the ground absorption. Terrain consisting of soft surfaces, such as vegetation, provide for more ground absorption than hard surfaces such as a body of water. Ground attenuation is important for the study of noise from airfield operations (such as thrust reversals) and in the design of noise berms and engine run-up facilities.

These factors are an important consideration for assessing in-flight and ground noise in the Austin region. Atmospheric conditions will play a role in affecting the sound levels on a daily basis and how the population perceives these sounds are perceived by the population.

Duration of Sound

Research has shown that the annoyance from a noise event increases as the duration of the event increases. The "effective duration" of a sound is the time between when a sound rises above the background sound level until it drops back below the background level. Psychoacoustic studies have determined a relationship between duration and annoyance. These studies determined the amount a sound must be reduced to be judged equally annoying for increased duration (longer durations at low sound levels are equally annoying as shorter durations at higher levels). Duration is an important factor in describing sound in a community setting.

The relationship between duration and noise level is the basis of the equivalent energy principal of sound exposure. Reducing the acoustic energy of a sound by one half results in a 3 dB reduction. Doubling the duration of the sound increases the total energy of the event by 3dB. This equivalent energy principal is based upon the premise that the potential for a noise event to impact a person is dependent on the total acoustical energy content of the noise.

Change in Noise

The concept of change in ambient sound levels can be understood with an explanation of the hearing mechanism's reaction to sound. Under controlled laboratory conditions, listening to a steady unwavering pure tone sound that can be changed to slightly different sound levels, a person can just barely detect a sound-level change of approximately 1 dB for sounds in the mid-frequency range. When ordinary noises are heard, a young healthy ear can detect changes of 2 to 3 dB. A 5 dB change is readily noticeable, while a 10 dB change is judged by most people as a doubling or halving of the loudness of sound.

Masking Effect

Another characteristic of sound is its ability to interfere with the ability of the listener to hear another sound. This interference is defined as the masking effect. The presence of one sound effectively raises the threshold of audibility for the hearing of a second sound. For a signal to be heard, it must exceed the threshold of hearing for that particular individual and exceed the masking threshold for the background noise.

The masking characteristics of sound depend upon many factors, including the spectral (frequency) characteristics of the two sounds, the sound pressure levels, and the relative start time of the sounds. The masking effect is greatest when the masking frequency is closest to the frequency of the signal. Low frequency sounds can mask higher frequency sounds; however, the reverse is not true.

Sound Rating Scales

The description, analysis, and reporting of community sound levels is made difficult by the complexity of human response to sound and the myriad of sound-rating scales and metrics that have been developed for describing acoustic effects. Various rating scales have been devised to approximate the human subjective assessment to the "loudness" or "noisiness" of a sound. Noise metrics have been developed to account for additional parameters, such as duration and cumulative effect of multiple events.

Noise metrics can be categorized as single-event metrics and cumulative metrics. Single-event metrics describe the noise from individual events, such as an aircraft flyover. Cumulative metrics describe the noise in terms of the total noise exposure throughout the day.

Single Event Metrics

- Frequency-Weighted Metrics (dBA) – In order to simplify the measurement and computation of sound loudness levels, frequency-weighted networks have obtained wide acceptance. The A-weighting (dBA) scale has become the most prominent of these scales and is widely used in community noise analysis. Its advantages are that it has shown good correlation with community response and is easily measured.
- Maximum Noise Level – The highest noise level reached during a noise event is called the "Maximum Noise Level," or Lmax. For example, as an aircraft approaches, the sound of the aircraft begins to rise above ambient noise levels. The closer the aircraft gets, the louder the sound until the aircraft is at its closest point. As the aircraft passes, the noise level decreases until the sound settles to ambient levels. It is this metric to which people generally respond to when an aircraft flyover occurs. An aircraft flyover is graphically illustrated at the top of Figure 3.

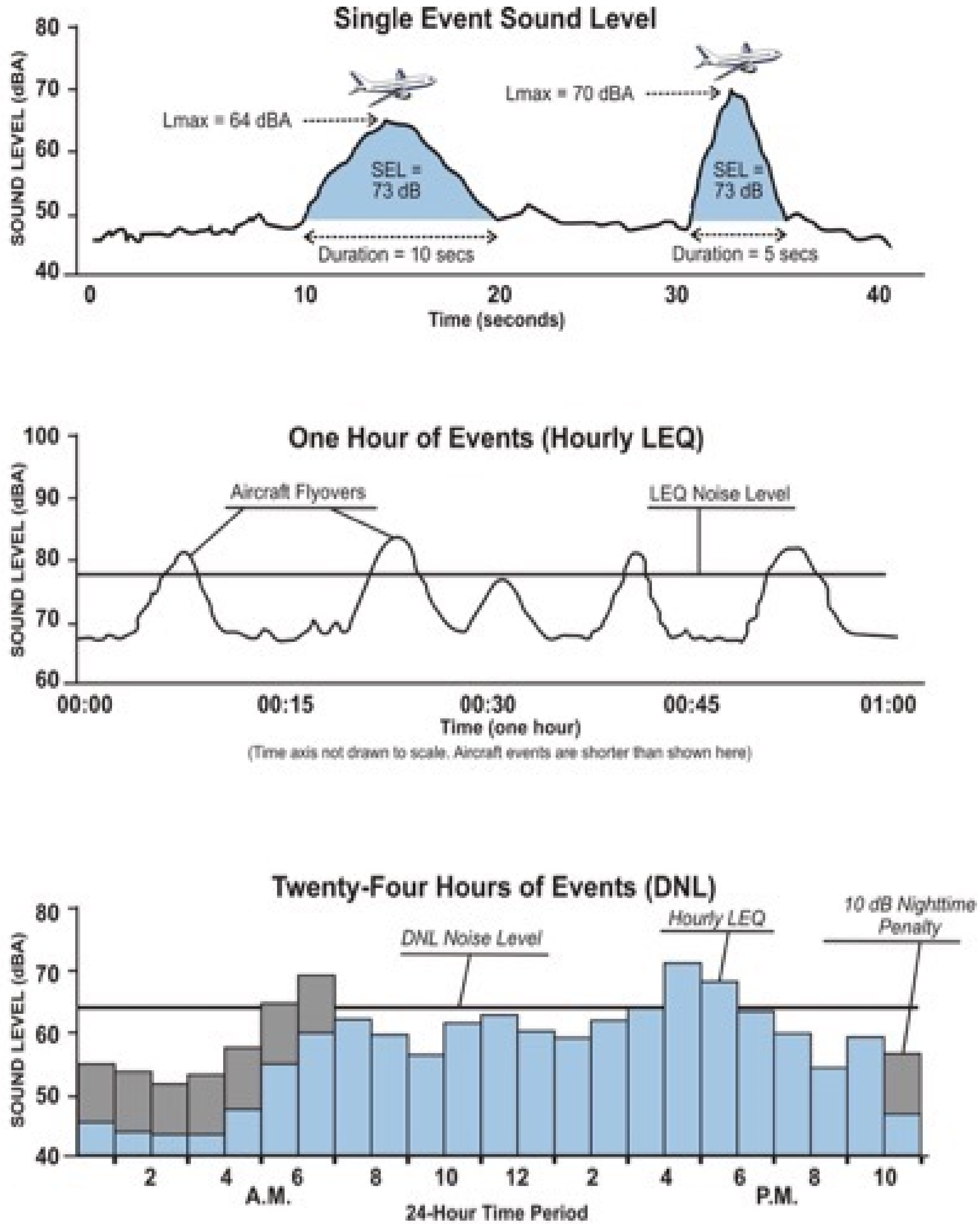
Supplemental Metrics

- Time Above (TA) – The FAA has developed the Time Above metric as a second metric for assessing the impacts of aircraft noise around airports. The TA index refers to the total time in seconds or minutes that aircraft noise levels exceed certain dBA noise levels in a 24-hour period. It is typically expressed as Time Above 75 and 85 dBA sound levels. While this metric is not widely used, it may be used by the FAA in environmental assessments of airport projects that show a significant increase in noise levels (a 1.5 DNL increase within the 65 DNL contour due to a project). There are no noise/land use standards in terms of the TA index.
- Sound Exposure Level (SEL) – Another metric that is reported for aircraft flyovers is the Sound Exposure Level (SEL) metric. It is computed from dBA sound levels. Referring again to the top of

Figure 3, the shaded area, or the area within 10 dB of the maximum noise level, is the area from which the SEL is computed. The SEL value is the integration of all the acoustic energy contained within the event into a time period of 1 second. Speech and sleep interference research can be assessed relative to Single-Event Noise Exposure Level data.

This metric takes into account the maximum noise level of the event and the duration of the event. For aircraft flyovers, the SEL value is typically about 10 dBA higher than the maximum noise level. Single event metrics are a convenient method for describing noise from individual aircraft events. This metric is useful in that airport noise models contain aircraft noise curve data based upon the SEL metric. In addition, cumulative noise metrics such as Equivalent Noise Levels (Leq) and DNL can be computed from SEL data.

Figure 3 – SEL, LEQ and DNL Illustrations



Cumulative Metrics

Cumulative noise metrics have been developed to assess community response to noise. They are useful because these scales attempt to include the loudness of the noise, the duration of the noise, the total number of noise events, and the time of day these events occur into one single number rating scale.

- Equivalent Noise Level (Leq) – Leq is the sound level corresponding to a steady-state, A-weighted sound level containing the same total energy as a time-varying signal over a given sample period. Leq is the "energy" average noise level during the time period of the sample. It is based on the observation that the potential for a noise to impact people is dependent on the total acoustical energy content of the noise. It is the energy sum of all the sound that occurs during that time period. This is graphically illustrated in the middle graph of Figure 3. Leq can be measured for any time period, but is typically measured for 15 minutes, 1 hour, or 24 hours.
- Day-Night Average Sound Level (DNL) – The DNL index is a 24-hour, time-weighted energy average noise level based on the A-weighted decibel. It is a measure of the overall noise experienced during an entire day. The time-weighting refers to the fact that noise occurring during certain sensitive time periods is penalized for occurring at these times. In the DNL scale, noise occurring between the hours of 10 p.m. to 7 a.m. is penalized by 10 dB. This penalty was selected to attempt to account for the higher sensitivity to noise in the nighttime and the expected further decrease in background noise levels that typically occur in the nighttime. The FAA specifies DNL for airport noise assessment, and the EPA specifies DNL for community noise and for airport noise assessments. DNL is graphically illustrated in the bottom of Figure 3.