# Appendix C - Noise Methodology

## C.1 Characteristics of Sound

Sound is created by a source that induces vibrations in the air. The vibration produces alternating bands of relatively dense and sparse particles of air, spreading outward from the source like ripples on a pond. Sound waves dissipate with increasing distance from the source. Sound waves can also be reflected, diffracted, refracted, or scattered. When the source stops vibrating, the sound waves disappear almost instantly and the sound ceases.

Sound conveys information to listeners. It can be instructional, alarming, pleasant, relaxing, or annoying. Identical sounds can be characterized by different people or even by the same person at different times, as desirable or unwanted. Unwanted sound is commonly referred to as "noise."

Sound can be defined in terms of three components:

1) Level (amplitude)
2) Pitch (frequency)
3) Duration (time pattern)

### C.1.1 Sound Level

The level or amplitude of sound is measured by the difference between atmospheric pressure (without the sound) and the total pressure (with the sound). Amplitude of sound is like the relative height of the ripples caused by the stone thrown into the water. Although physicists typically measure pressure using the linear Pascal scale, sound is measured using the logarithmic decibel (dB) scale. This is because the range of sound pressures detectable by the human ear can vary from 1 to 100 trillion units. A logarithmic scale allows us to discuss and analyze noise using more manageable numbers. The range of audible sound ranges from approximately 1 to 140 dB, although everyday sounds rarely rise above about 120 dB. The human ear is extremely sensitive to sound pressure fluctuations. A sound of 140 dB, which is sharply painful to humans, contains 100 trillion ($10^{14}$) times more sound pressure than the least audible sound. **Exhibit C-1, *Comparison of Sound***, shows a comparison of common sources of indoor and outdoor sounds measured on the dB scale.

By definition, a 10 dB increase in sound is equal to a tenfold ($10^{1}$) increase in the mean square sound pressure of the reference sound. A 20 dB increase is a 100 fold ($10^{2}$) increase in the mean square sound pressure of the reference sound. A 30 dB increase is a 1,000-fold ($10^{3}$) increase in mean square sound pressure.

A logarithmic scale requires different mathematics than used with linear scales. The sound pressures of two separate sounds, expressed in dB, are not arithmetically additive. For example, if a sound of 80 dB is added to another sound of 74 dB, the total is a 1 dB increase in the louder sound (81 dB), not the arithmetic sum of 154 dB (See **Exhibit C-2, *Example Addition of Two Decibel Levels***). If two equally loud noise events occur simultaneously, the sound pressure level from the combined events is 3 dB higher than the level produced by either event alone.

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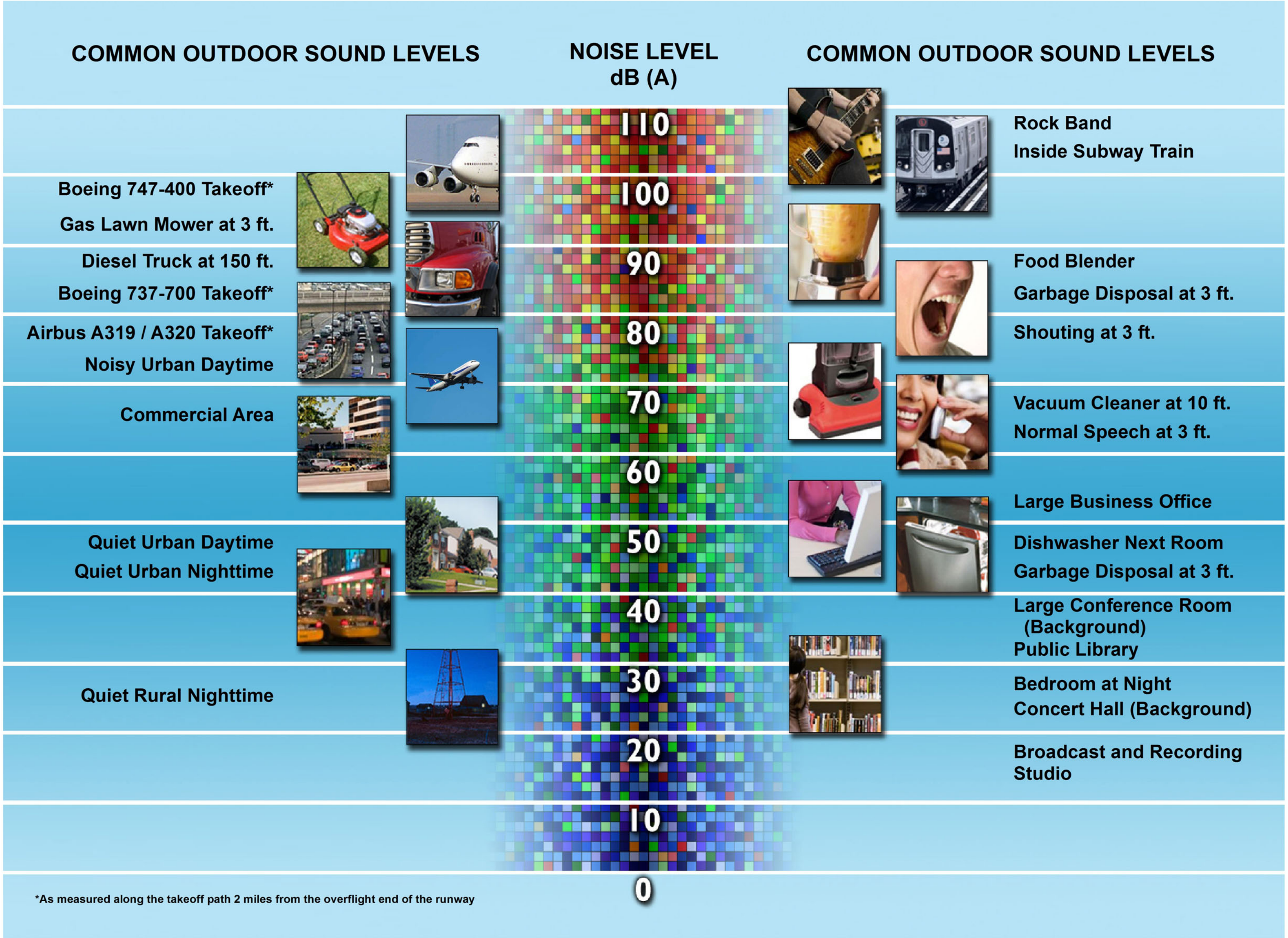
## Exhibit C-1 Comparison of Sound



*As measured along the takeoff path 2 miles from the overflight end of the runway

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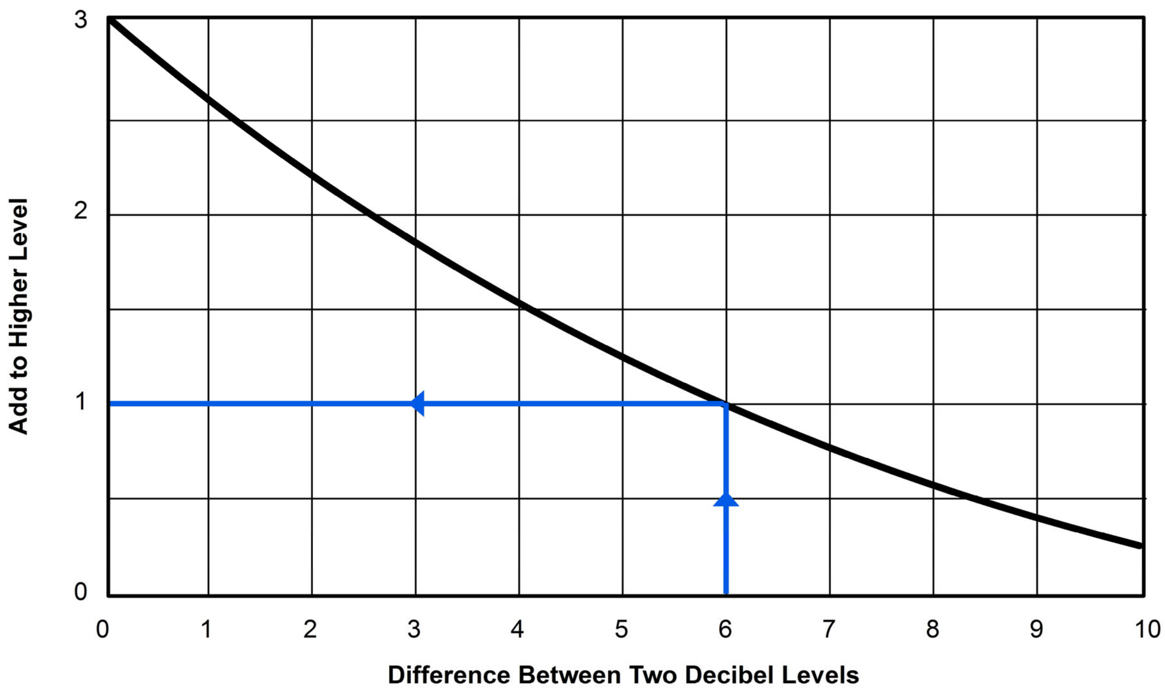
**Exhibit C-2 Example Addition of Two Decibel Levels**



Example:

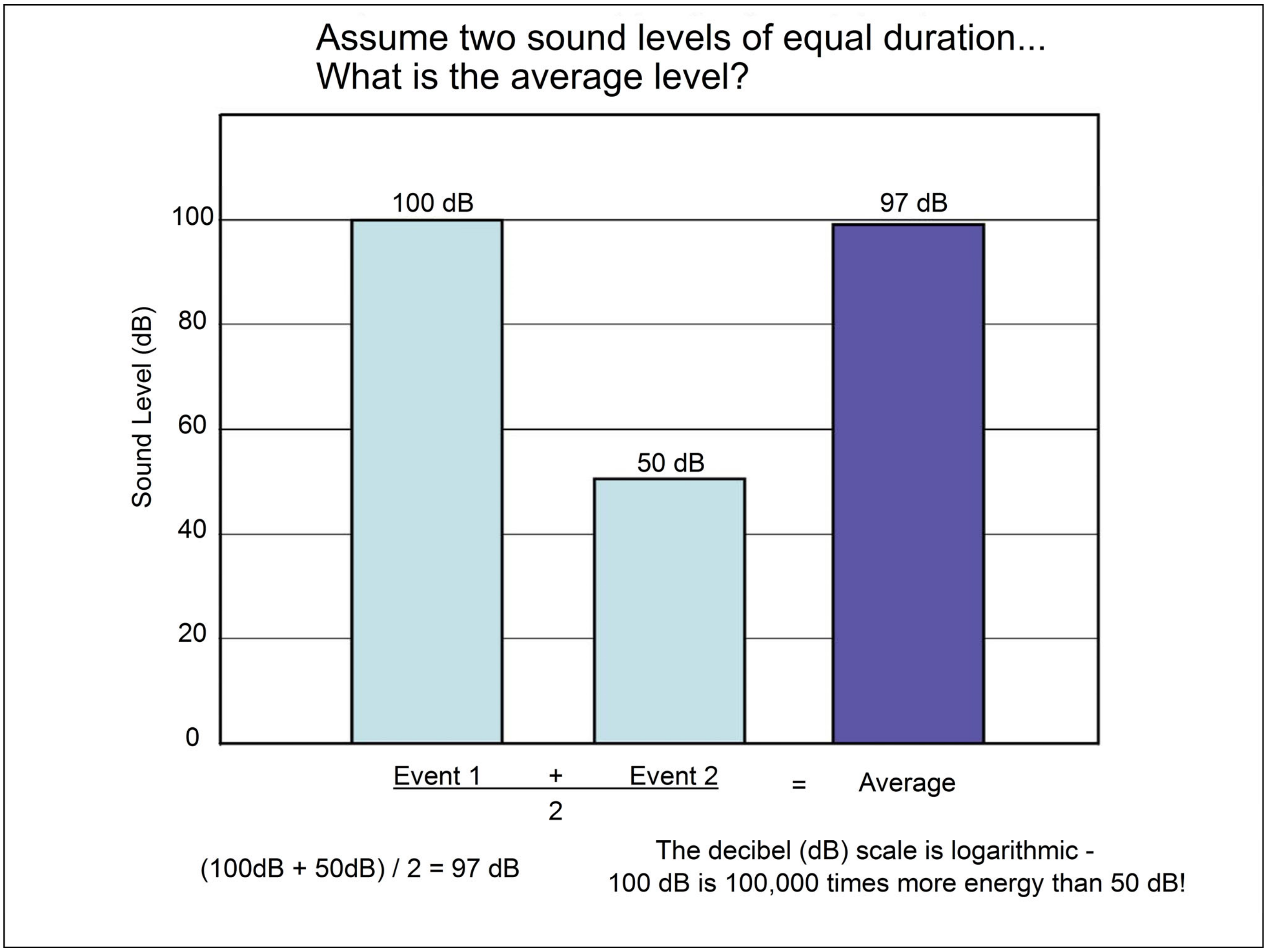
80 dB + 74 dB = 81 dB

Source: Information on Levels of Environmental Noise. USEPA. March 1974.

Logarithmic averaging also yields results that are quite different from simple arithmetic averaging. Consider the example shown in **Exhibit C-3,** ***Example of Sound Level Averaging***. Two sound levels of equal duration are averaged. One has a maximum sound level (Lmax) of 100 dB, the other 50 dB. Using conventional arithmetic, the average would be 75 dB. The true result, using logarithmic math, is 97 dB. This is because 100 dB has far more energy than 50 dB (100,000 times as much!) and is overwhelmingly dominant in computing the average of the two sounds.

Human perceptions of changes in sound pressure are less sensitive than a sound level meter. People typically perceive a tenfold increase in sound pressure, a 10 dB increase, as a doubling of loudness. Conversely, a 10 dB decrease in sound pressure is normally perceived as half as loud. In community settings, most people perceive a 3 dB increase in sound pressure (a doubling of the sound pressure or energy) as just noticeable. (In laboratory settings, people with good hearing are able to detect changes in sounds of as little as 1 dB.)

**Exhibit C-3 Example of Sound Level Averaging**



## C.1.2 Sound Frequency

The pitch (or frequency) of sound can vary greatly from a low-pitched rumble to a shrill whistle. If we consider the analogy of ripples in a pond, high frequency sounds are vibrations with tightly spaced ripples, while low rumbles are vibrations with widely spaced ripples. The rate at which a source vibrates determines the frequency. The rate of vibration is measured in units called "Hertz" – the number of cycles, or waves, per second. One's ability to hear a sound depends greatly on the frequency composition. Humans hear sounds best at frequencies between 1,000 and 6,000 Hertz. Sound at frequencies above 10,000 Hertz (high-pitched hissing) and below 100 Hertz (low rumble) are much more difficult to hear.

When attempting to measure sound in a way that approximates what our ears hear, we must give more weight to sounds at the frequencies we hear well and less weight to sounds at frequencies we do not hear well. Acousticians have developed several weighting scales for measuring sound. The A-weighted scale was developed to correlate with the judgments people make about the loudness of sounds. The A-weighted decibel scale (dBA) is used in studies where audible sound is the focus of inquiry. **Exhibit C-4, *Sound Frequency Weighting Curves***, shows the A, B, and C sound weighting scale. The U.S. Environmental Protection Agency (USEPA) has recommended the use of the A-weighted decibel scale in studies of environmental noise.[22] Its use is required by the Federal Aviation Administration (FAA) in airport noise studies.[23] For the purposes of this analysis, dBA was used as the noise metric and dB and dBA are used interchangeably.

## C.1.3 Duration of Sounds

The duration of sounds – their patterns of loudness and pitch over time – can vary greatly. Sounds can be classified as *continuous* like a waterfall, *impulsive* like a firecracker, or *intermittent* like aircraft overflights. Intermittent sounds are produced for relatively short periods, with the instantaneous sound level during the event roughly appearing as a bell-shaped curve. An aircraft event is characterized by the period during which it rises above the background sound level, reaches its peak, and then recedes below the background level.

## C.1.4 Perceived Noise Level

Perceived noisiness is another method of rating sound that was originally developed for the assessment of aircraft noise. Perceived noisiness is the subjective measure of the degree to which noise is unwanted or causes annoyance to an individual. To determine perceived noise level, 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 inherently subjective and thus subject to greater variability. For example, two separate events of equal noise energy may be perceived differently if one sound is more annoying to the listener than the other.

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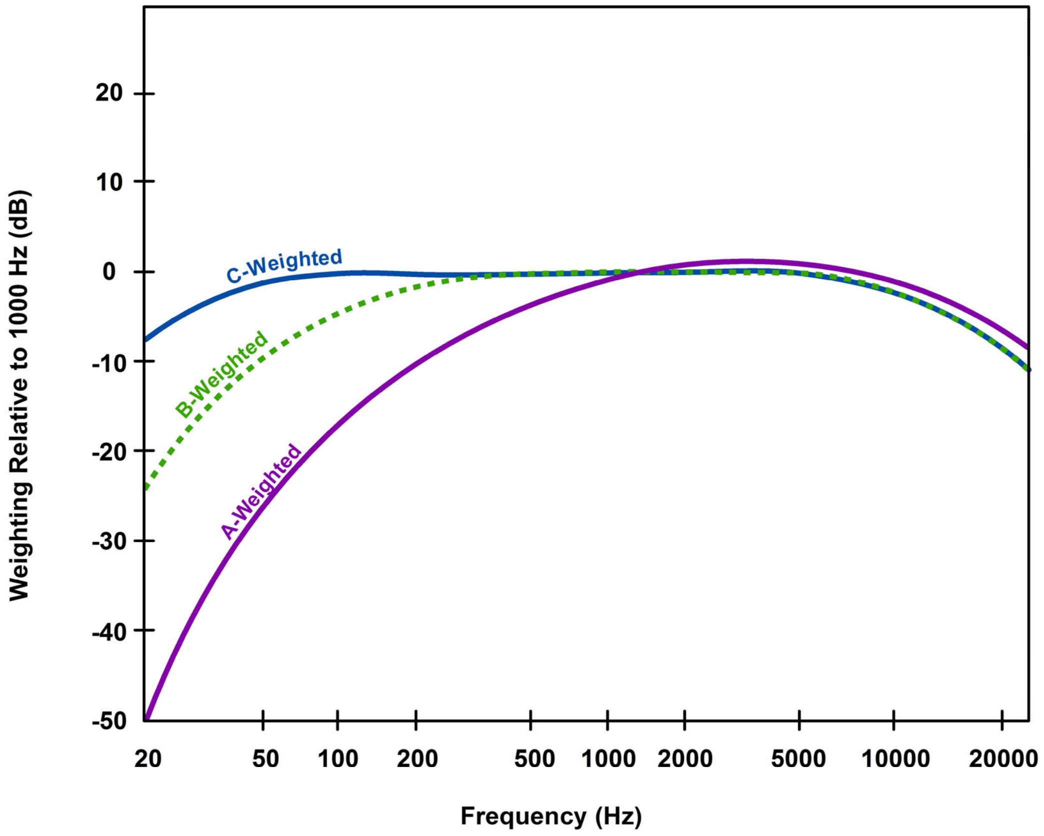
[22] Information on Levels of Environmental Noise Requisite to Protect Health and Welfare with an Adequate Margin of Safety. U.S. Environmental Protection Agency, Office of Noise Abatement and Control. 1974, P. A-10.

[23] "Airport Noise Compatibility Planning." 14 CFR Part 150, Sec. A150.3.

## Exhibit C-4 Sound Frequency Weighting Curves



Source: Federal Highway Administration

### C.1.5 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 an homogeneous 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 energy of the wave. Spherical spreading of the sound wave reduces the noise level 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 frequency of the sound as well as the humidity and temperature of the air.

The rate of atmospheric absorption varies with sound 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.

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 than would result from spherical spreading as a result of channeling or focusing the sound waves.

The effect of ground attenuation on noise propagation is a function of the height of the source and/or receiver and the characteristics of the terrain. The closer the source of 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. Ground attenuation is important for the study of noise from airfield operations (such as, thrust reversals) and in the design of noise berms or engine run-up facilities.

## C.2 Factors Influencing Human Response to Sound

Many factors influence how a sound is perceived and whether or not it is considered annoying to the listener. These factors include not only physical (acoustic) characteristics of the sound but also secondary (non-acoustic) factors, such as sociological and external factors.

Sound rating scales are developed to account for the factors that affect human response to sound. Nearly all of these factors are relevant in describing how sounds are perceived in the community. Many of the non-acoustic parameters play a prominent role in affecting individual response to noise. Background sound (ambient noise) is also important in describing sound in rural settings. Some non-acoustic factors that may influence an individual's response to aircraft noise include:

- Predictability of when the sound/noise will occur;
- How the noise affects certain activities;
- Fear of an aircraft crashing;
- Belief that aircraft noise could be prevented or reduced by aircraft designers, pilots, or authorities related to airlines or airports; and
- Sensitivity to noise in general.

Thus, it is important to recognize that non-acoustic factors such as those described above, as well as acoustic factors, contribute to human response to noise.

## C.3 Standard Noise Descriptors

Given the multiple dimensions of sound, a variety of descriptors, or metrics, have been developed for describing sound and noise. Some of the most commonly used metrics are discussed in this section. They include:

1) Maximum Level (**Lmax**)
2) Time Above Level (**TA**)
3) Sound Exposure Level (**SEL**)
4) Equivalent Sound Level (**Leq**)
5) Day-Night Average Sound Level (**DNL**)

### C.3.1 Maximum Level (Lmax)

Lmax is simply the highest sound level recorded during an event or over a given period of time. It provides a simple and understandable way to describe a sound event and compare it with other events. In addition to describing the peak sound level, Lmax can be reported on an appropriate weighted decibel scale (A-weighted, for example) so that it can disclose information about the frequency range of the sound event in addition to the loudness.

Lmax, however, fails to provide any information about the duration of the sound event. This can be a critical shortcoming when comparing different sounds. Even if they have identical Lmax values, sounds of greater duration contain more sound energy than sounds of shorter duration. Research has demonstrated that for many kinds of sound effects, the total sound energy, not just the peak sound level, is a critical consideration.

### C.3.2 Time Above Level (TA)

The “time above,” or TA, metric indicates the amount of time that sound at a particular location exceeds a given sound level threshold. TA is often expressed in terms of the total time per day that the threshold is exceeded. The TA metric explicitly provides information about the duration of sound events, although it conveys no information about the peak levels during the period of observation.

### C.3.3 Number of Events Above Level (NA)

Similar to TA, the Number of Events Above (NA) metric indicates the total number of aircraft events at particular location that exceed a given sound level threshold in dB. The NA metric explicitly provides information about the number of sound events, although it conveys no information about the duration of the event(s).

### C.3.4 Sound Exposure Level (SEL)

The sound exposure level, or SEL metric, provides a way of describing the total sound energy of a single event. In computing the SEL value, all sound energy occurring during the event, within 10 dB of the peak level (Lmax), is mathematically integrated over one second. (Very little information is lost by discarding the sound below the 10 dB cut-off, since the highest sound levels completely dominate the integration calculation.) Consequently, the SEL is always greater than the Lmax for events with a duration greater than one second. SELs for aircraft overflights typically range from five to 10 dB higher than the Lmax for the event.

**Exhibit C-5, *Measurement of Different Types of Sound***, shows graphs of instantaneous sound levels for three different events: an aircraft flyover, steady roadway noise, and a firecracker.

The Lmax and the duration of each event differ greatly. The pop of the firecracker is quite loud, 102 dB but lasts less than a second. The aircraft flyover has a considerably lower Lmax at 90 dB, but the event lasts for over a minute. The Lmax from the roadway noise is even quieter at only 72 dB, but it lasts for 15 minutes. By considering the loudness and the duration of these very different events simultaneously, the SEL metric reveals that the total sound energy of all three is identical. This can be a critical finding for studies where total noise dosage is the focus of study. As it happens, research has shown conclusively that noise dosage is crucial in understanding the effects of noise on animals and humans.

### C.3.5 Equivalent Sound Level (Leq)

The equivalent sound level (Leq) metric may be used to define cumulative noise dosage, or noise exposure, over a period of time. In computing Leq, the total noise energy over a given period of time, during which numerous events may have occurred, is logarithmically averaged over the time period. The Leq represents the steady sound level that is equivalent to the varying sound levels actually occurring during the period of observation. For example, an 8-hour Leq of 67 dB indicates that the amount of sound energy in all the peaks and valleys that occurred in the 8-hour period is equivalent to the energy in a continuous sound level of 67 dB. Leq is typically computed for measurement periods of 1 hour, 8 hours, or 24 hours, although any time period can be specified.

**Exhibit C-6, *Relationship Among Sound Metrics***, shows the relationship of Leq to Lmax and SEL. In this example, a single aircraft event lasting 18 seconds is represented. The instantaneous noise levels for the event range from 64 to an Lmax of 101 dBA. The area under the curve represents the sound energy accumulated during the entire event. The compression of this energy into a single second results in an SEL of 105 dBA. The Leq average of the sound energy for each second during the event would be 93 dB. If this event were the only event to occur during an hour, the aircraft sound energy for the other 3,582 seconds would be considered to be zero. When converted to an hourly Leq, the level would be nearly 70 dB of Leq. This again indicates the dominance of loud events in noise summation and averaging computations.

Leq is a critical noise metric for many kinds of analysis where total noise dosage, or noise exposure, is under investigation. As already noted, noise dosage is important in understanding the effects of noise on both animals and people. Indeed, research has led to the formulation of the “equal energy rule.” This rule states that it is the total acoustical energy to which people are exposed that explains the effects the noise will have on them. That is, a very loud noise with a short duration will have the same effect as a lesser noise with a longer duration if they have the same total sound energy.

### C.3.6 Day-Night Average Sound Level (DNL)

The Day-Night Average Sound Level (DNL) metric is really a variation of the 24-hour Leq metric. Like Leq, the DNL metric describes the total noise exposure during a given period. Unlike Leq, however, DNL, by definition, can only be applied to a 24-hour period. In computing DNL, an extra weight of 10 dB is assigned to any sound levels occurring between the hours of 10:00 p.m. and 7:00 a.m. This is intended to account for the greater annoyance that nighttime noise is presumed to cause for most people. Recalling the logarithmic nature of the dB scale, this extra weight treats one nighttime noise event as equivalent to 10 daytime events of the same magnitude.

As with Leq, DNL values are strongly influenced by the loud events. For example, 30 seconds of sound of 100 dB, followed by 23 hours, 59 minutes, and 30 seconds of silence would compute to a DNL value of 65 dB. If the 30 seconds occurred at night, it would yield a DNL of 75 dB.

This example can be roughly equated to an airport noise environment. Recall that an SEL is the mathematical compression of a noise event into one second. Thus, 30 SELs of 100 dB during a 24-hour period would equal DNL 65 dB, or DNL 75 dB if they occurred at night.

This situation could actually occur in places around a real airport. If the area experienced 30 overflights during the day, each of which produced an SEL of 100 dB, it would be exposed to DNL 65 dB. Recalling the relationship of SEL to the peak noise level (Lmax) of an aircraft overflight, the Lmax recorded for each of those overflights (the peak level a person would actually hear) would typically range from 90 to 95 dB.

### C.3.7 Federal Requirements to Use DNL in Environmental Noise Studies

As noted in **Appendix A**, Section A.1.11, the DNL metric is the standard noise metric for use in FAA studies and decision-making purposes. The FAA uses the DNL metric for purposes of determining an individual's cumulative noise exposure, for land use compatibility under 14 CFR part 150, and for assessing the significance of predicted noise impacts under NEPA. The FAA uses the DNL metric for purposes of determining an individual's cumulative noise exposure, for land use compatibility under 14 CFR part 150, and for assessing the significance of predicted noise impacts under NEPA. Ongoing research activities sponsored by the FAA and the broader research community are working to develop a greater understanding of other noise-related impact criteria. This research may expand the use of supplemental metrics, including new metrics designed to measure speech interference (N75), Percent Awakening, Learning (Leq(8)), and rattling from low frequency noise Lmax(c).[24]

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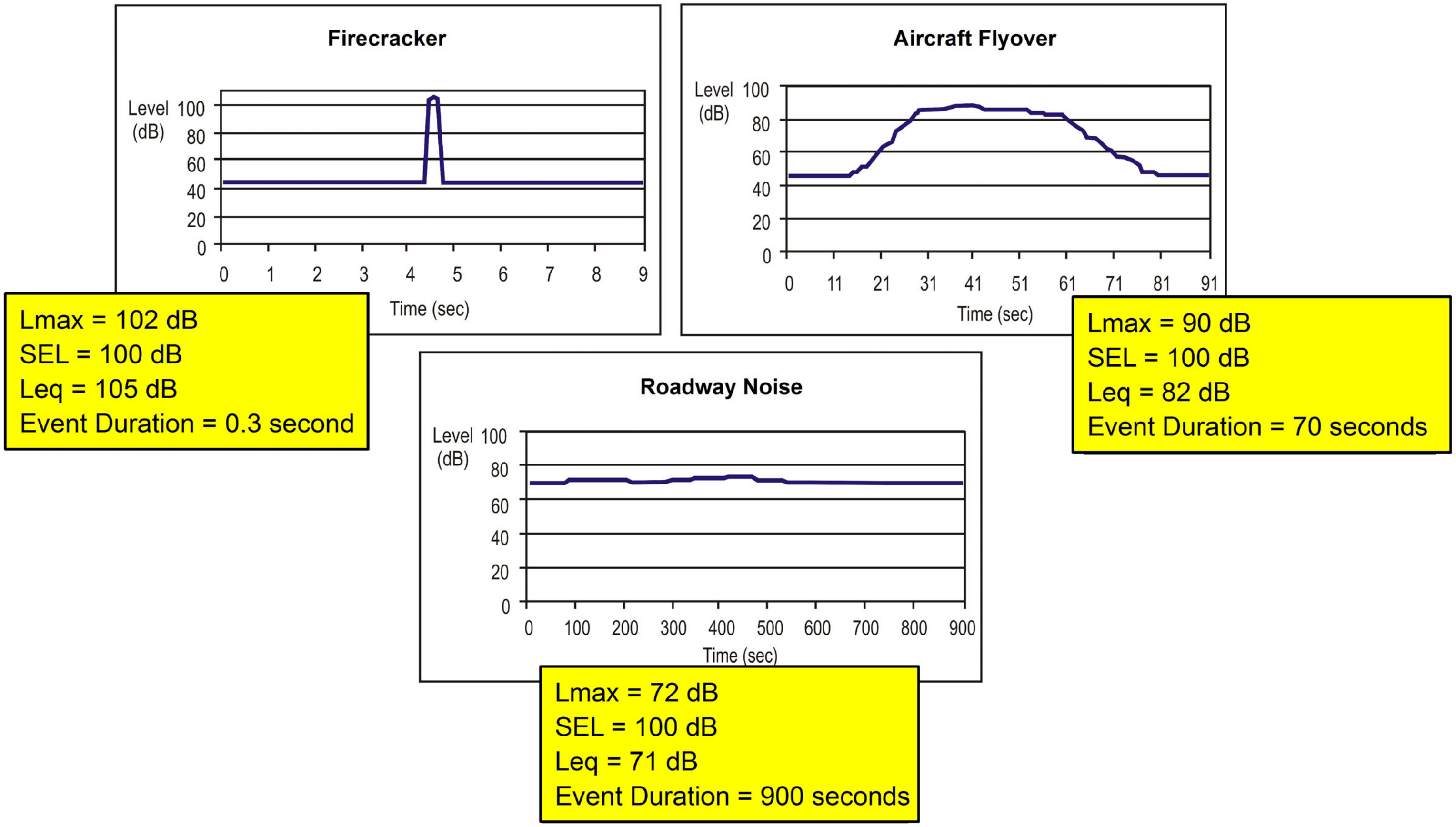
[24] *Report to Congress, FAA Reauthorization Act of 2018 (Pub. L. 115-254), Section 188 and Sec 173.* Federal Aviation Administration, 2020.

## Exhibit C-5 Measurement of Different Types of Sound



Lmax = 102 dB
SEL = 100 dB
Leq = 105 dB
Event Duration = 0.3 second

Lmax = 90 dB
SEL = 100 dB
Leq = 82 dB
Event Duration = 70 seconds

Lmax = 72 dB
SEL = 100 dB
Leq = 71 dB
Event Duration = 900 seconds

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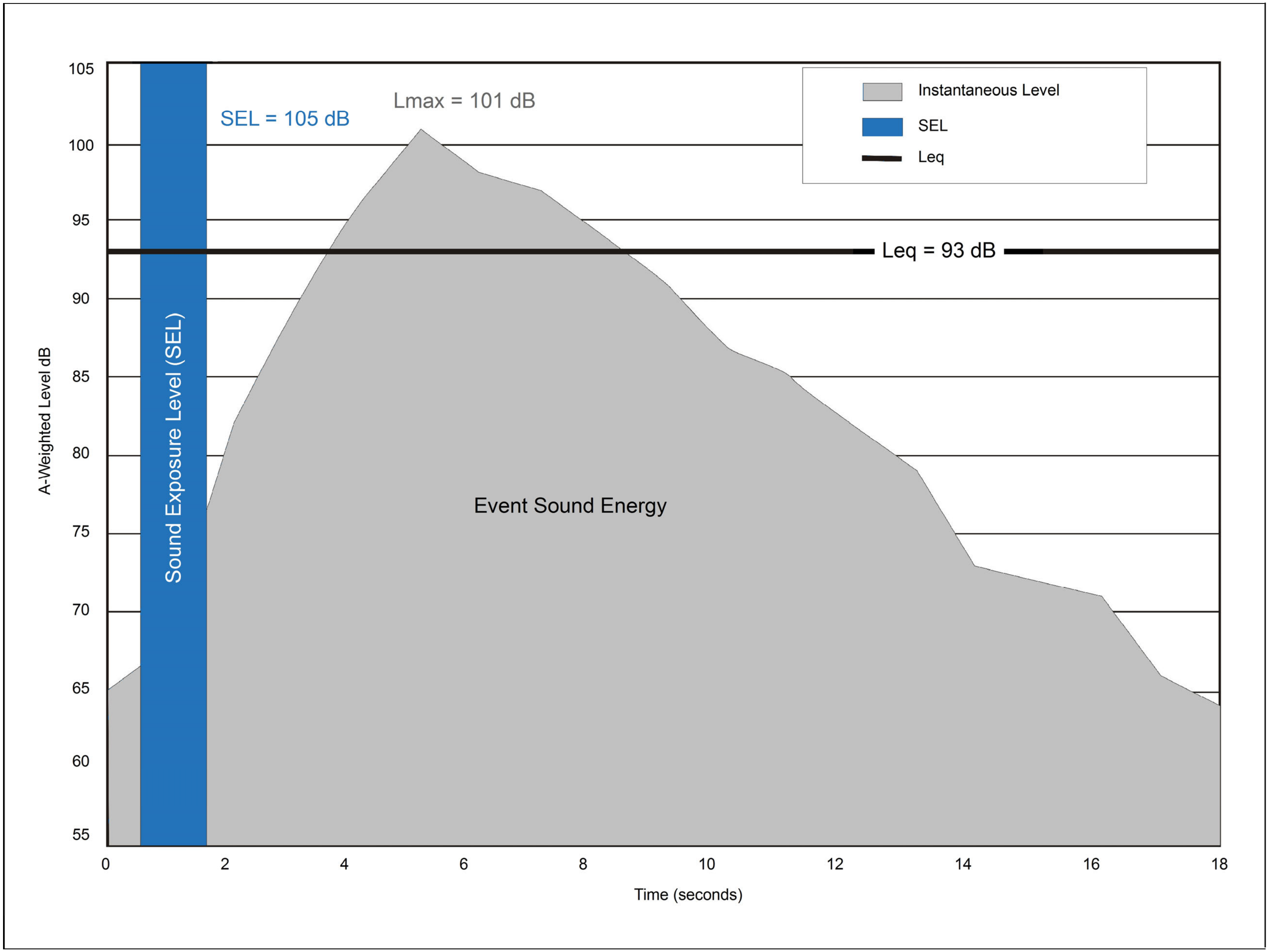
**Exhibit C-6 Relationship Among Sound Metrics**



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## C.4 Health Effects of Noise

A considerable amount of research has been conducted to identify, measure, and quantify the potential effects of aviation noise on health. The various methods by which noise can be measured (e.g. single dose, long-term average, number of events above a certain level, etc.), and difficulties in separating other lifestyle factors from the analysis, increases the complexity of determining the health effects of noise, and has caused considerable variability in the results of past studies. The health effects of noise are often divided into the following topics: cardiovascular effects, hearing loss, sleep disturbance, and speech/communication interference.

### C.4.1 Cardiovascular Effects

Several studies have suggested that increased hypertension or other cardiovascular effects, such as increased blood pressure, and change in pulse rate, may be associated with long-term exposure to high levels of environmental noise. When conducting cross-sectional studies of environmental noise exposure, it is difficult to control for other important variables. Subsequent reviews of past research have pointed out that such studies "…are notoriously difficult to interpret. They often report conflicting results, generally do not identify a cause and effect relationship, and often do not report a dose-response relationship between the cause and effect."[25] In 2018, the World Health Organization (WHO) published its Environmental Noise Guidelines report (WHO report) with reference to recent research related to aircraft noise and human response.[26] The WHO report references two ecological studies that provide information on the relationship between aircraft noise and incidence of ischemic heart disease (IHD); however, this "…evidence was rated low quality." Additionally, the WHO report reference one cohort study and several cross-sectional studies of the relationship between aircraft noise and hypertension. The WHO report noted "…inconsistency across studies" and the "…evidence was rated low quality." Similar studies of the relationship between aircraft noise and cases of stroke were reviewed. The WHO report noted that this "…evidence was rated very low quality." Therefore, it is difficult to draw any conclusions about the relationship between aircraft noise exposure and cardiovascular effects.

### C.4.2 Hearing Loss

The potential for noise-induced hearing loss is commonly associated with occupational noise exposure from working in a noisy work environment or recreational noise such as listening to loud music. Recent studies have concluded that "because environmental noise does not approximate occupational noise levels or recreational noise exposures…it does not have an effect on hearing threshold levels." Furthermore, "aviation noise does not pose a risk factor for child or adolescent hearing loss, but perhaps other noise sources (personal music devices, concerts, motorcycles, or night clubs) are a main risk factor."[27] This conclusion is supported by the 2018 WHO Environmental Noise Guidelines which notes that "(n)o studies were found, and therefore no evidence was available on the association between aircraft noise and hearing impairment and tinnitus."[28] Because aviation noise levels near airports do not approach levels of occupational or recreational noise exposures associated with hearing loss, hearing impairment is likely not caused by aircraft noise for populations living near an airport.

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[25] Airport Cooperative Research Program, Transportation Research Board, Effects of Aircraft Noise: Research Update on Selected Topics, 2008.

[26] World Health Organization, Regional Office for Europe, Environmental Noise Guidelines for the European Region, 2018.

[27] Airport Cooperative Research Program, Transportation Research Board, Effects of Aircraft Noise: Research Update on Selected Topics, 2008.

[28] World Health Organization, Regional Office for Europe, Environmental Noise Guidelines for the European Region, 2018.

### C.4.3 Sleep Disturbance

Sleep disturbance is a common complaint from people who live in the vicinity of an airport. A large amount of research has been published on the topic of sleep disturbance caused by environmental noise. This research has produced variable results due to differing definitions of sleep disturbance, different ways for measuring sleep disturbance (behavioral awakenings or sleep interruption), and different settings in which to measure it (laboratory setting or field setting).

In 1992, the Federal Interagency Committee on Noise (FICON) recommended an interim dose-response curve to predict the percent of the exposed population expected to be awakened (percent awakening) as a function of the exposure to single event noise levels expressed in terms of the Sound Exposure Level (SEL). This interim curve was based on statistical adjustment of previous analysis and included data from both laboratory and field studies. In 1997, Federal Interagency Committee on Aviation Noise (FICAN) recommended a revised sleep disturbance relationship based on data and analysis from three field studies.

**Exhibit C-7, *Sleep Disturbance Dose-Response Curves***, show the results of the 1992 and 1997 analyses. The top graph shows a comparison of the 1992 FICON and 1997 FICAN curves. The 1997 FICAN curve represents the upper limit of the observed field data and should be interpreted as predicting the "maximum percent of the exposed population expected to be behaviorally awakened", or the "maximum percent awakened" for a given residential population.

In 2008, FICAN recommended the use of a revised method to predict sleep disturbance in terms of percent awakenings based on data published by the American National Standards Institute (ANSI).[29] In contrast to the earlier FICAN recommendation, the 2008 ANSI standard indicates that the probability of awakening is lower for a single noise event in cases where the population is exposed to the given noise source for a long period of time (more than one year) compared to the probability of awakening for sound that is new to an area. In Exhibit C-7, the lower graph shows these two relationships, with Equation 1 (blue dotted line) representing percent awakenings from long-term noise and Equation B1 (pink dashed line) representing percent awakenings from a new noise source based on the 1997 FICAN results. As shown in this exhibit, at an indoor Sound Exposure Level (SEL) of 100 dB, the probability of awakenings would be expected to exceed 15 percent for a new noise source; yet for long-term noise sources, the probability of awakening is expected to be less than 10 percent.

The numerous studies and reports that have been developed on the subject of sleep disturbance related to environmental noise over the past several decades have produced varied results. A review of past studies conducted by the Airport Cooperative Research Program suggests that in-home sleep disturbance studies clearly demonstrate that it requires more noise to cause awakenings than was previously theorized based on laboratory sleep disturbance studies.[30] The 2018 WHO Environmental Noise Guidelines references six studies that attempted to measure sleep disturbance at noise levels between 40 dB and 65 dB. Over 11% of the population was characterized as highly sleep-disturbed at nighttime levels of 40 dB. These studies were based on self-reporting and the "…evidence was rated moderate quality…" for an association between aircraft noise and probability of awakenings.[31]

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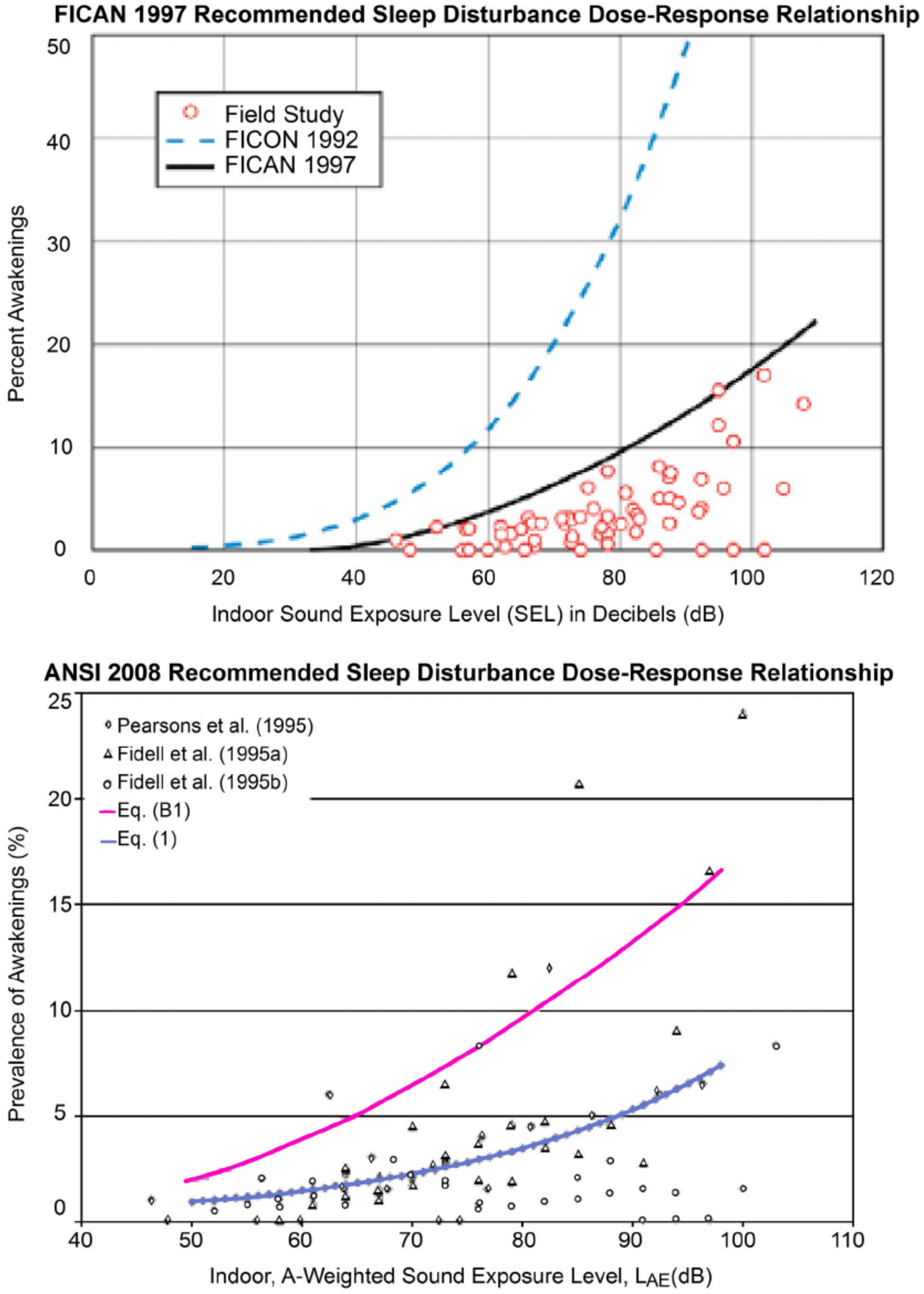
[29] ANSI S12.9-2008, Quantities and Procedures for Description and Measurement of Environmental Sound — Part 6: Methods for Estimation of Awakenings Associated with Outdoor Noise Events Heard in Homes, 2008.

[30] Airport Cooperative Research Program, Transportation Research Board, Effects of Aircraft Noise: Research Update on Selected Topics, 2008.

[31] World Health Organization, Regional Office for Europe, Environmental Noise Guidelines for the European Region, 2018.

**Exhibit C-7 Sleep Disturbance Dose-Response Curves**



Sources: Federal Interagency Committee on Aviation Noise (FICAN), June 1997; American National Standards Institute, 2008.

Due to the variability of study methodologies, particularly studies outside of a laboratory, and other influencing factors, it is difficult to determine the noise level at which a high percentage of the population would be expected to be awakened by aircraft noise. No definitive conclusions have been drawn on the percent of a population that is estimated to be awakened by a certain level of aircraft noise and recent studies have cautioned about the over interpretation of the data.[32]

### C.4.4 Communication Interference

Communication interference can impact activities such as personal conversations, classroom learning, and listening to radio and television. Most studies have focused on communication interference due to continual noise sources. In 1974, the USEPA published *Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety*, which is one of the few studies to focus on intermittent noise. The study concluded that for voice communication, an indoor Leq of 45 dB allows normal conversation at distances up to 2 meters with 95 percent sentence intelligibility. **Exhibit C-8, *Noise Effects on Distance Necessary for Speech Communication***, shows the required distance between talker and listener based on the type of speech communication (normal voice, loud voice, etc.) and the environmental noise level from the 1974 USEPA report.

Noise can also impact communication between student and teacher necessary for learning in a classroom setting. It is usually accepted that noise levels above a certain Leq may affect a child's learning experiences. Research has shown a "decline in reading when outdoor noise levels equal or exceed Leq of 65 dBA."[33] Furthermore, a study conducted by FICAN in 2007 found: "(1) a substantial association between noise reduction and decreased failure (worst-score) rates for high-school students, and (2) significant association between noise reduction and increased average test scores for student/test subgroups. In general, the study found little dependence upon student group and upon test type."[34] A study of noise exposure and the effects on school test scores between 2000/01 and 2008/09 found "…statistically significant associations between airport noise and student mathematics and reading test scores, after taking demographic and school factors into account."[35] This study also found that schools that had been provided sound insulation had better test scores than schools that were not sound insulated. This Study made no recommendation regarding the noise level at which impacts upon learning may occur.

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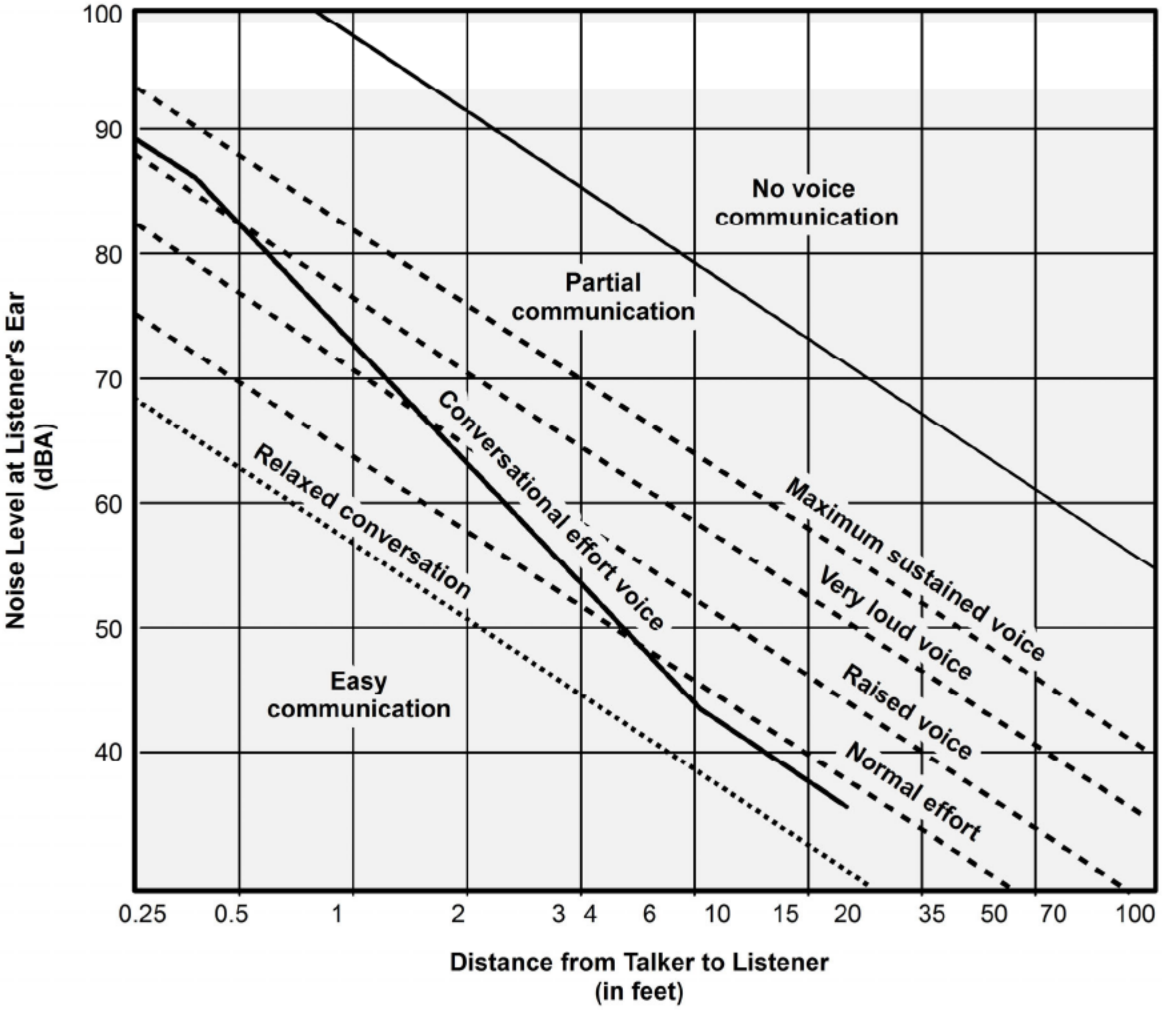
[32] Airport Cooperative Research Program, Transportation Research Board, Effects of Aircraft Noise: Research Update on Selected Topics, 2008.

[33] Airport Cooperative Research Program, Transportation Research Board, Effects of Aircraft Noise: Research Update on Selected Topics, 2008.

[34] Federal Interagency Committee on Aviation Noise (FICAN), Findings of the FICAN Pilot Study on the Relationship between Aircraft Noise Reduction and Changes in Standardized Test Scores, July 2007.

[35] National Academies of Sciences, Engineering, and Medicine; Assessing Aircraft Noise Conditions Affecting Student Learning, Volume 1: Final Report; 2014.

## Exhibit C-8 Noise Effects on Distance Necessary for Speech Communication



Source: FICON, 1992; from USEPA, 1974.

## C.5 Baseline Noise Modeling Methodology

The following sections describe the noise modeling methodology and assumptions for the Existing (2020) Baseline and Future (2025) Baseline Noise Exposure Contours for CMH, and presents the noise modeling results.

The analysis of noise exposure around CMH was prepared using the FAA Aviation Environmental Design Tool (AEDT) Version 3b, which was the current version at the time the noise modeling began. Inputs to the AEDT include runway definition, number of aircraft operations during the time period evaluated, the types of aircraft flown, the time of day when they are flown, how frequently each runway is used for arriving and departing aircraft, the routes of flight used when arriving to and departing from the runways, and departure profiles. The AEDT calculates noise exposure for the area around an airport and outputs contours of noise exposure using the Day/Night Average Sound Level (DNL) metric. Noise exposure contours for the levels of 60, 65, 70, and 75 DNL will be calculated to represent average-annual day conditions at CMH.

### C.5.1 Existing (2020) Baseline Noise Exposure Contour Input Data

**Runway Definition:** CMH has two east/west parallel runways (10L/28R and 10R/28L) spaced approximately 3,400 feet apart. Runway 10R/28L is the longest runway on the airfield at 10,113 feet in length and is 150 feet wide and is equipped with a CAT-II ILS on both ends. Runway 10L/28R is 8,001 feet long and 150 feet wide and is equipped with a CAT-I ILS on both ends. **Exhibit C-9, *Current Airfield Layout*** shows the existing airfield layout. The following provides the current runways and lengths at CMH:

| Runway | Length (feet) |
|---|---|
| 10L/28R | 8,001 |
| 10R/28L | 10,113 |

**Number of Operations and Fleet Mix:** The number of annual operations at CMH was based on Air Traffic Control Tower (ATCT) counts for the period from September 2018 through August 2019.[36] During that period, 134,999 annual operations occurred at CMH. When divided by 365, the result is 369.9 average-annual day operations. Specific aircraft types and times of operation were developed from a combination of landing fee reports, Airport Noise and Operations Management System (ANOMS) data,[37] and Official Airline Guide (OAG) data for the same period. **Table C-1**, which provides a summary of the average annual day operations by aircraft category and time of day, shows that large passenger jets made up the majority (65 percent) of all operations at CMH for the Existing (2020) Baseline period. **Table C-2** shows the average daily number of arrivals and departures by the individual aircraft types. Aircraft that were most commonly flown at CMH during the Existing (2020) Baseline period include the Boeing 737-700 series and the Embraer EMB-170 series jets.

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[36] See Section C.5.3 of this Appendix for a comparison of the baseline data collection period to current conditions.

[37] Data was obtained from the Airport Noise and Operations Management System (ANOMS) operated by the Columbus Regional Airport Authority (CRAA). The ANOMS receives radar data from the FAA's secure data clearinghouse and includes location, time, and operational information such as operation type, aircraft type, airline operator, and runway used for landing or takeoff.

**Table C-1 Summary of Average-Annual Day Operations – Existing (2020) Baseline**

| Aircraft Type | Arrivals | | Departures | | Total | Percent of Total |
|---|---|---|---|---|---|---|
| | Daytime | Nighttime | Daytime | Nighttime | | |
| Large Jets | 93.5 | 26.7 | 97.8 | 22.4 | 240.3 | 65% |
| Regional / Air Taxi Jets | 28.8 | 3.8 | 29.5 | 3.1 | 65.1 | 18% |
| Commuter / Air Taxi Props | 2.2 | 1.2 | 2.9 | 0.6 | 6.9 | 2% |
| General Aviation Jets | 16.4 | 1.8 | 16.5 | 1.7 | 36.4 | 10% |
| General Aviation Props | 9.7 | 0.9 | 10.1 | 0.5 | 21.2 | 6% |
| **Total** | 150.6 | 34.3 | 156.7 | 28.2 | 369.9 | 100% |

Notes: Total may not equal sum total due to rounding.
Daytime = 7:00am – 9:59pm, Nighttime = 10:00pm – 6:59am.

Source: Federal Aviation Administration (FAA) Operations Network (OpsNet) data, CRAA Landing Fee Reports, CMH ANOMS data, Landrum & Brown analysis, 2020.

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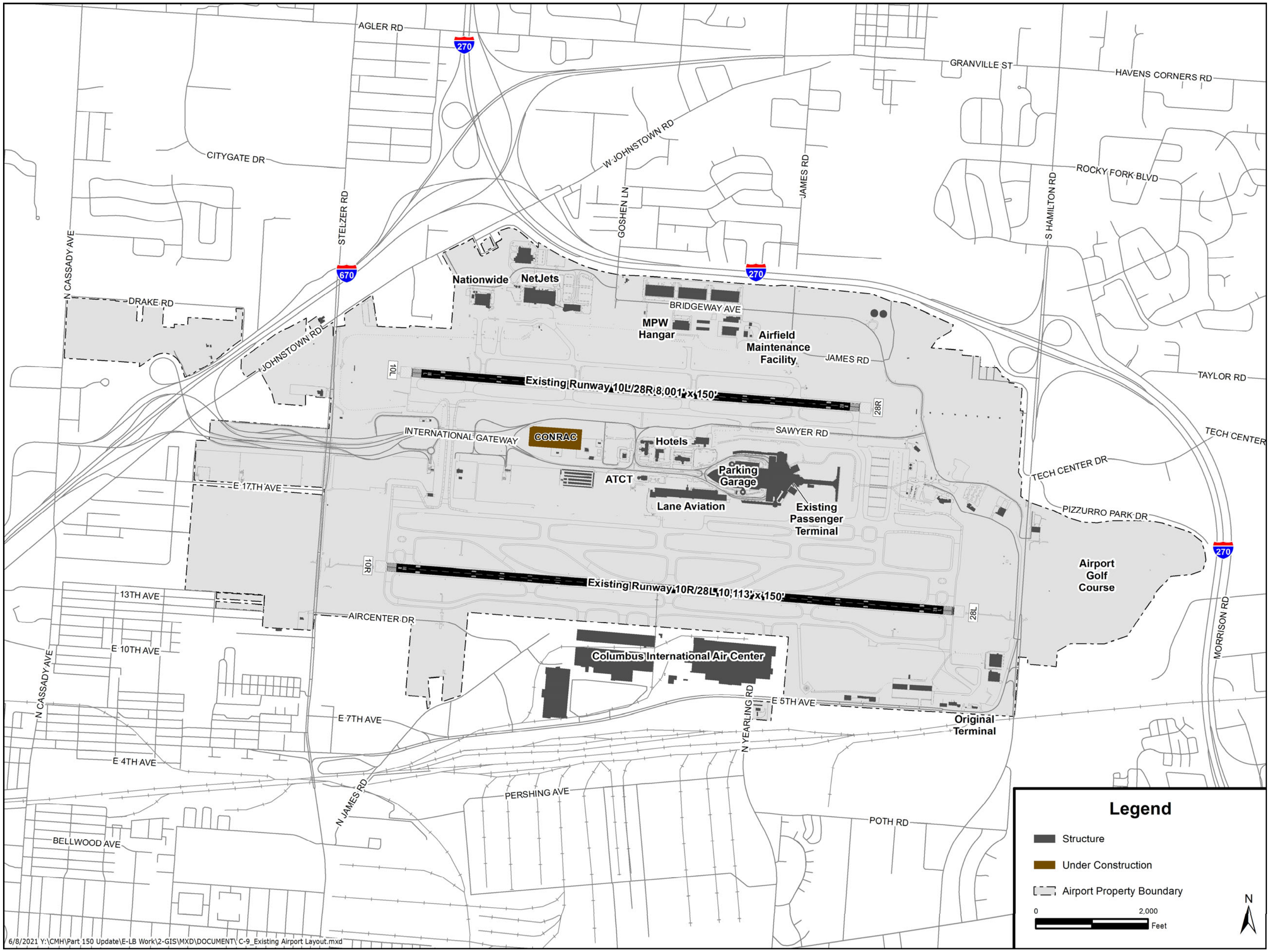
## Exhibit C-9 Current Airfield Layout



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## Table C-2 Existing (2020) Average-Annual Day Operations by Aircraft Type

| Aircraft Type | AED ANP Model ID | Arrivals | | Departures | | Total |
|---|---|---|---|---|---|---|
| | | Day | Night | Day | Night | |
| **Large Passenger Jets** | | | | | | |
| Boeing 717-200 | 717200 | 0.1 | 0.1 | 0.2 | 0.1 | 0.5 |
| Boeing 737-400 | 737400 | 0.3 | 0.2 | 0.4 | 0.2 | 1.1 |
| Boeing 737-700 | 737700 | 21.0 | 5.9 | 22.0 | 4.9 | 53.9 |
| Boeing 737-800 | 737800 | 9.9 | 5.6 | 12.2 | 3.3 | 30.9 |
| Boeing 737-800 MAX | 737MAX8 | 0.4 | 0.1 | 0.4 | 0.0 | 0.8 |
| Airbus A319-100 | A319-131 | 3.9 | 2.5 | 4.9 | 1.4 | 12.7 |
| Airbus A320-200 | A320-211 | 0.5 | 0.3 | 0.7 | 0.1 | 1.6 |
| Airbus A320-200 | A320-232 | 3.8 | 2.1 | 5.1 | 0.8 | 11.7 |
| Airbus A320neo | A320-271N | 0.2 | 0.1 | 0.2 | 0.0 | 0.5 |
| Airbus A321-200 | A321-232 | 0.1 | 0.1 | 0.1 | 0.1 | 0.5 |
| Bombardier CRJ-900 | CRJ9-ER | 13.3 | 2.7 | 13.6 | 2.3 | 31.8 |
| Embraer EMB170 | EMB170 | 10.3 | 2.7 | 10.8 | 2.2 | 26.0 |
| Embraer EMB175 | EMB175 | 23.4 | 4.1 | 20.5 | 6.9 | 54.9 |
| Embraer EMB190 | EMB190 | 0.2 | 0.0 | 0.2 | 0.0 | 0.4 |
| McDonnell-Douglas MD80 Series | MD83 | 6.0 | 0.3 | 6.2 | 0.1 | 12.6 |
| McDonnell-Douglas MD90 Series | MD9025 | 0.2 | 0.1 | 0.2 | 0.0 | 0.5 |
| Subtotal | | 93.5 | 26.7 | 97.8 | 22.4 | 240.3 |
| **Regional / Air Taxi Jets** | | | | | | |
| Bombardier Global Express | BD-700-1A10 | 0.3 | 0.1 | 0.4 | 0.0 | 0.8 |
| Bombardier CRJ-200 Regional Jet | CL600 | 8.3 | 0.8 | 7.9 | 1.3 | 18.3 |
| Cessna 525C CitationJet | CNA525C | 0.8 | 0.1 | 0.8 | 0.1 | 1.8 |
| Cessna 550 Citation Bravo | CNA55B | 1.5 | 0.1 | 1.5 | 0.1 | 3.2 |
| Cessna 560 Citation Excel | CNA560XL | 1.7 | 0.1 | 1.7 | 0.1 | 3.6 |
| Cessna 680 Citation Sovereign | CNA680 | 2.2 | 0.2 | 2.2 | 0.2 | 4.8 |
| Cessna 750 Citation X | CNA750 | 0.8 | 0.1 | 0.9 | 0.0 | 1.8 |
| Embraer ERJ-145 | EMB145 | 11.7 | 2.2 | 12.8 | 1.1 | 27.7 |
| Gulfstream G5 | GIV | 0.3 | 0.0 | 0.4 | 0.0 | 0.7 |
| Learjet 35 | LEAR35 | 0.6 | 0.0 | 0.6 | 0.1 | 1.3 |
| Mitsubishi MU-3001 | MU3001 | 0.5 | 0.1 | 0.5 | 0.0 | 1.0 |
| Subtotal | | 28.8 | 3.8 | 29.5 | 3.1 | 65.1 |
| **Commuter / Air Taxi Props** | | | | | | |
| Beech 58 Baron | BEC58P | 0.3 | 0.4 | 0.3 | 0.4 | 1.5 |
| Cessna 208 Caravan | CNA208 | 1.2 | 0.8 | 1.9 | 0.1 | 3.9 |
| DeHavilland Dash 6 Twin Otter | DHC6 | 0.7 | 0.0 | 0.7 | 0.0 | 1.4 |
| Subtotal | | 2.2 | 1.2 | 2.9 | 0.6 | 6.9 |

**Table C-2 Existing (2020) Average-Annual Day Operations by Aircraft Type *(Continued)***

| Aircraft Type | AED ANP Model ID | Arrivals | | Departures | | Total |
|---|---|---|---|---|---|---|
| | | Day | Night | Day | Night | |
| **General Aviation Jets** | | | | | | |
| Bombardier Global Express | BD-700-1A10 | 0.8 | 0.1 | 0.8 | 0.1 | 1.8 |
| Bombardier Challenger 300 | CL600 | 1.2 | 0.1 | 1.1 | 0.2 | 2.6 |
| Cessna 525C CitationJet | CNA525C | 4.0 | 0.6 | 4.0 | 0.7 | 9.2 |
| Cessna 550 Citation Bravo | CNA55B | 1.2 | 0.1 | 1.2 | 0.1 | 2.5 |
| Cessna 560 Citation Ultra | CNA560U | 0.7 | 0.1 | 0.7 | 0.1 | 1.4 |
| Cessna 560 Citation Excel | CNA560XL | 0.7 | 0.0 | 0.7 | 0.0 | 1.4 |
| Cessna 680 Citation Sovereign | CNA680 | 0.6 | 0.1 | 0.6 | 0.1 | 1.3 |
| Cessna 750 Citation X | CNA750 | 1.6 | 0.1 | 1.7 | 0.1 | 3.5 |
| Eclipse Aerospace EA500 | ECLIPSE500 | 0.5 | 0.0 | 0.5 | 0.0 | 1.0 |
| Embraer ERJ-145 | EMB145 | 0.8 | 0.2 | 0.9 | 0.1 | 1.9 |
| Falcon 900 | FAL900EX | 0.3 | 0.0 | 0.3 | 0.0 | 0.6 |
| Gulfstream G4 | GIV | 0.6 | 0.1 | 0.6 | 0.0 | 1.3 |
| Learjet 35 | LEAR35 | 2.6 | 0.2 | 2.6 | 0.3 | 5.7 |
| Mitsubishi MU-3000 | MU3001 | 1.0 | 0.1 | 1.0 | 0.1 | 2.2 |
| Subtotal | | 16.4 | 1.8 | 16.5 | 1.7 | 36.4 |
| **General Aviation Props** | | | | | | |
| Beech 58 Baron | BEC58P | 1.1 | 0.1 | 1.1 | 0.1 | 2.3 |
| Cessna 172 Skyhawk | CNA172 | 1.2 | 0.0 | 1.2 | 0.0 | 2.5 |
| Cessna 182 Skylane | CNA182 | 0.7 | 0.0 | 0.7 | 0.0 | 1.4 |
| Cessna 208 Caravan | CNA208 | 0.7 | 0.4 | 1.1 | 0.1 | 2.3 |
| Cessna 441 Conquest II | CNA441 | 0.8 | 0.1 | 0.8 | 0.0 | 1.6 |
| Cirrus SR-22 Single-Engine Prop | COMSEP | 1.8 | 0.1 | 1.7 | 0.1 | 3.7 |
| General Aviation Single Engine Prop | GASEPF | 0.2 | 0.0 | 0.2 | 0.0 | 0.4 |
| General Aviation Single Engine Prop | GASEPV | 1.5 | 0.0 | 1.5 | 0.0 | 3.1 |
| Piper PA28 Cherokee | PA28 | 0.8 | 0.1 | 0.8 | 0.1 | 1.7 |
| Piper PA31 Cherokee Six | PA31 | 1.0 | 0.1 | 1.0 | 0.0 | 2.1 |
| Subtotal | | 9.8 | 0.9 | 10.1 | 0.5 | 21.2 |
| **Grand Total** | | **150.6** | **34.3** | **156.7** | **28.2** | **369.9** |

Notes: Total may not equal sum total due to rounding.
Daytime = 7:00am – 9:59pm, Nighttime = 10:00pm – 6:59am.
* The 737-800 MAX was grounded by FAA on March 13, 2019. Prior to that the aircraft operated at CMH. Therefore, this aircraft is modeled for existing conditions based on usage from September 1, 2018 through March 12, 2019. The grounding was lifted by FAA on November 18, 2020.

Source: Federal Aviation Administration (FAA) Operations Network (OpsNet) data, CRAA Landing Fee Reports, CMH ANOMS data, Landrum & Brown analysis, 2020.

**Runway End Utilization:** Average-annual runway end utilization was derived from analysis of ANOMS data from September 2018 through August 2019. Runway use was derived for aircraft types and summarized by category. During the daytime (7:00 a.m. to 9:59 p.m.), the Airport is operated in one of two operating configurations—west flow (approximately 75 percent of the time) or east flow (approximately 25 percent of the time). The primary flow during the Existing (2020) Baseline period was west flow due to the prevailing southwest winds. When the airport operated in this configuration, aircraft arrive from the east heading west and depart to the west on Runways 28L and 28R. During east flow operations, aircraft arrive from the west heading east and depart to the east on Runways 10L and 10R. **Table C-3** summarizes the percentage of use by each aircraft category on each of the runways at CMH during the daytime (7:00 a.m. – 9:59 p.m.) and nighttime (10:00 p.m. – 6:59 a.m.) periods.

**Table C-3 Existing (2020) Runway End Utilization**

| Aircraft Category | Runway End | | | | Total |
|---|---|---|---|---|---|
| | 10L | 10R | 28L | 28R | |
| **Daytime Arrivals** | | | | | |
| Large Jets | 11.8% | 11.6% | 36.3% | 40.4% | 100.0% |
| Regional / Air Taxi Jets | 11.9% | 11.2% | 35.9% | 41.0% | 100.0% |
| Commuter / Air Taxi Props | 1.3% | 20.9% | 71.7% | 6.0% | 100.0% |
| General Aviation Jets | 6.2% | 14.9% | 57.3% | 21.5% | 100.0% |
| General Aviation Props | 6.0% | 17.1% | 52.4% | 24.5% | 100.0% |
| **Nighttime Arrivals** | | | | | |
| Large Jets | 8.6% | 19.1% | 50.5% | 21.8% | 100.0% |
| Regional / Air Taxi Jets | 11.0% | 16.7% | 46.9% | 25.5% | 100.0% |
| Commuter / Air Taxi Props | 1.0% | 41.9% | 55.8% | 1.2% | 100.0% |
| General Aviation Jets | 5.5% | 24.7% | 57.6% | 12.1% | 100.0% |
| General Aviation Props | 4.8% | 35.7% | 50.4% | 9.1% | 100.0% |
| **Daytime Departures** | | | | | |
| Large Jets | 11.5% | 12.1% | 35.0% | 41.5% | 100.0% |
| Regional / Air Taxi Jets | 12.2% | 11.1% | 34.7% | 42.0% | 100.0% |
| Commuter / Air Taxi Props | 1.0% | 21.1% | 73.1% | 4.8% | 100.0% |
| General Aviation Jets | 5.9% | 15.7% | 56.9% | 21.5% | 100.0% |
| General Aviation Props | 4.9% | 18.0% | 56.1% | 21.0% | 100.0% |
| **Nighttime Departures** | | | | | |
| Large Cargo Jets | 10.8% | 12.4% | 40.2% | 36.6% | 100.0% |
| Heavy Jets | 11.5% | 10.7% | 38.4% | 39.4% | 100.0% |
| Passenger Jets | 3.2% | 23.4% | 66.7% | 6.7% | 100.0% |
| General Aviation Jets | 4.8% | 20.6% | 57.4% | 17.2% | 100.0% |
| General Aviation Props | 3.7% | 23.6% | 64.6% | 8.2% | 100.0% |

Notes: Daytime = 7:00 a.m. – 9:59 p.m., Nighttime = 10:00 p.m. – 6:59 a.m.
Total may not equal sum total due to rounding.

Source: CMH ANOMS data, Landrum & Brown analysis, 2020.

**Flight Tracks:** A flight track is the path over the ground as an aircraft flies to or from the airport. For this Part 150 Study, the existing flight tracks were evaluated to ensure that the flight tracks used in the modeling of aircraft noise are representative of where aircraft are flying at CMH. Flight tracks locations and percent distribution for the Existing (2020) Baseline Noise Exposure Contour was derived primarily from analysis of radar data from the ANOMS collected at CMH from September 2018 through August 2019. This data was analyzed to verify the location, density, and width of existing flight corridors. Consolidated flight tracks were developed from this radar data and used in the AEDT to model the flight corridors present around the Airport.

**Exhibit C-10, Exhibit C-11**, and **Exhibit C-12** depict the flight corridors representative of arrival and departure flight corridors in east flow operations for all large jets, regional jets and propeller aircraft, respectively. **Exhibit C-13**, **Exhibit C-14**, and **Exhibit C-15** depict flight corridors for west flow operations for these aircraft types. **Exhibit C-16** depicts flight tracks representative of touch-and-go operations that touch down and take off again as one continuous event. This activity is typically conducted by small aircraft for training purposes.

In order to model the flight corridors in AEDT, consolidated flight tracks were developed from this radar data. The tracks are composed of both backbone and sub-tracks that account for the dispersion of operations across a corridor of flight, rather than along a single constrained path. This is most useful at airports where wide flight corridors are present, such as are used by departures at CMH. The use of sub-tracks for the definition of baseline noise patterns allows a more definitive description of overall operating characteristics. **Table C-4**, **Table C-5**, and **Table 6** provide the proportion of operations assigned to each of the flight tracks indicated on the exhibits for the Existing (2020) Baseline condition.

Current procedures instruct departures by jet aircraft to follow runway heading until reaching five miles or 3,500 feet Mean Sea Level (MSL) before turning on course. This results in aircraft being at a higher altitude before turning over residential land uses. Propeller aircraft departures, in both east and west flow, turn as soon as directed by ATCT to allow jet aircraft to depart more quickly. The arrival corridors for jet and propeller aircraft generally follow a straight in procedure on their final approach for approximately five nautical miles.

## Exhibit C-10 East Flow Large Jet Tracks

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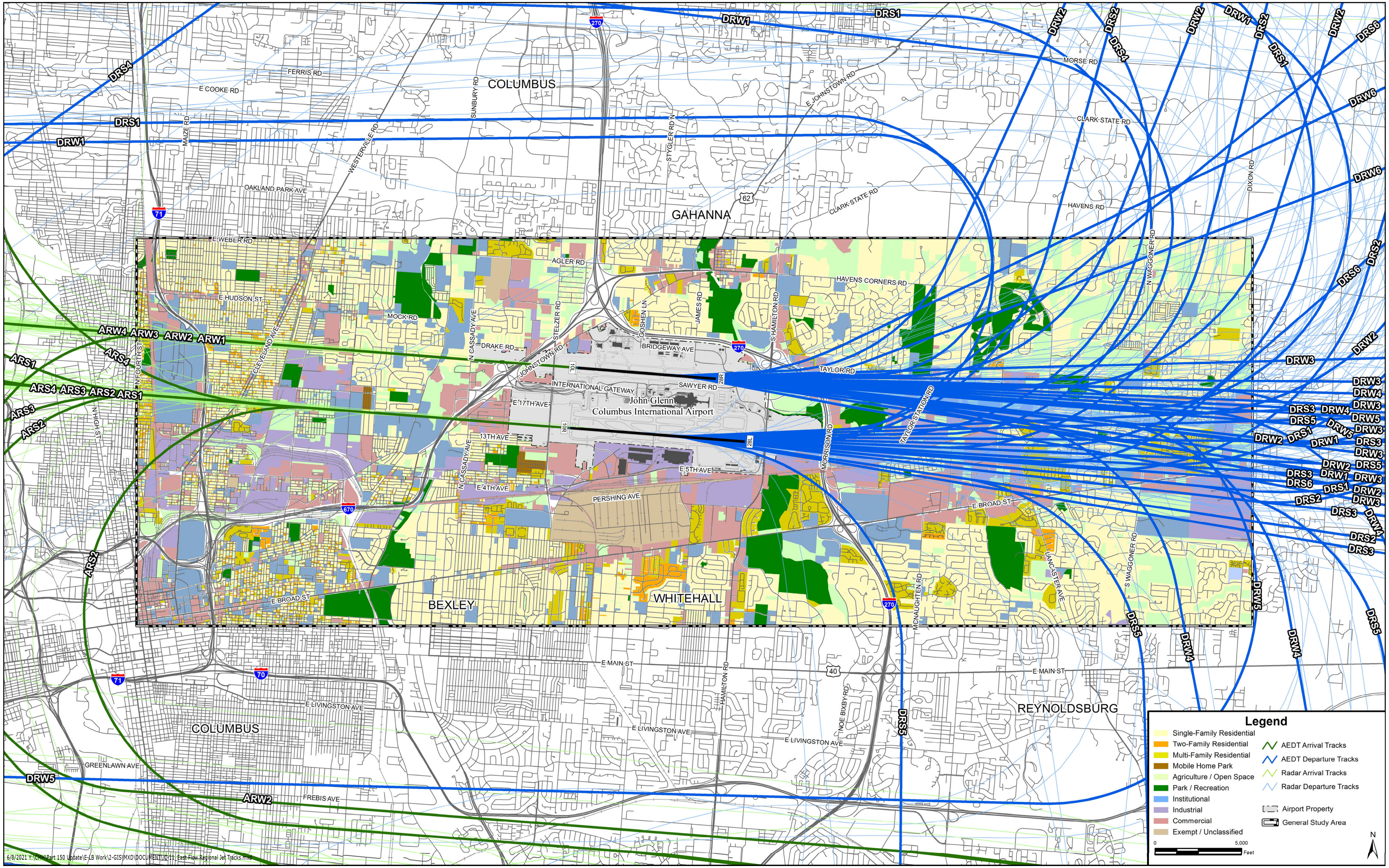
## Exhibit C-11 East Flow Regional Jet Tracks



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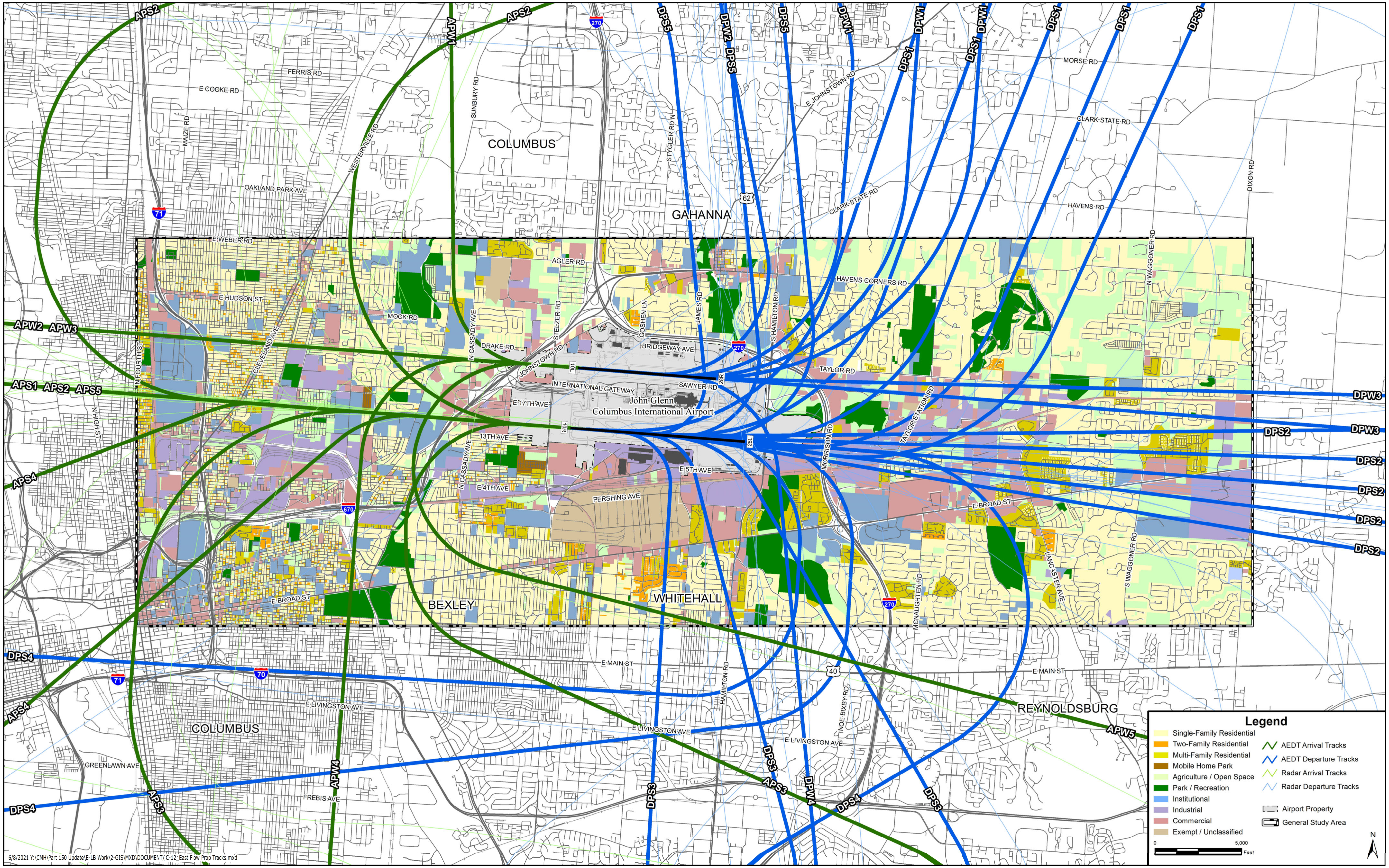
## Exhibit C-12 East Flow Prop Aircraft Tracks



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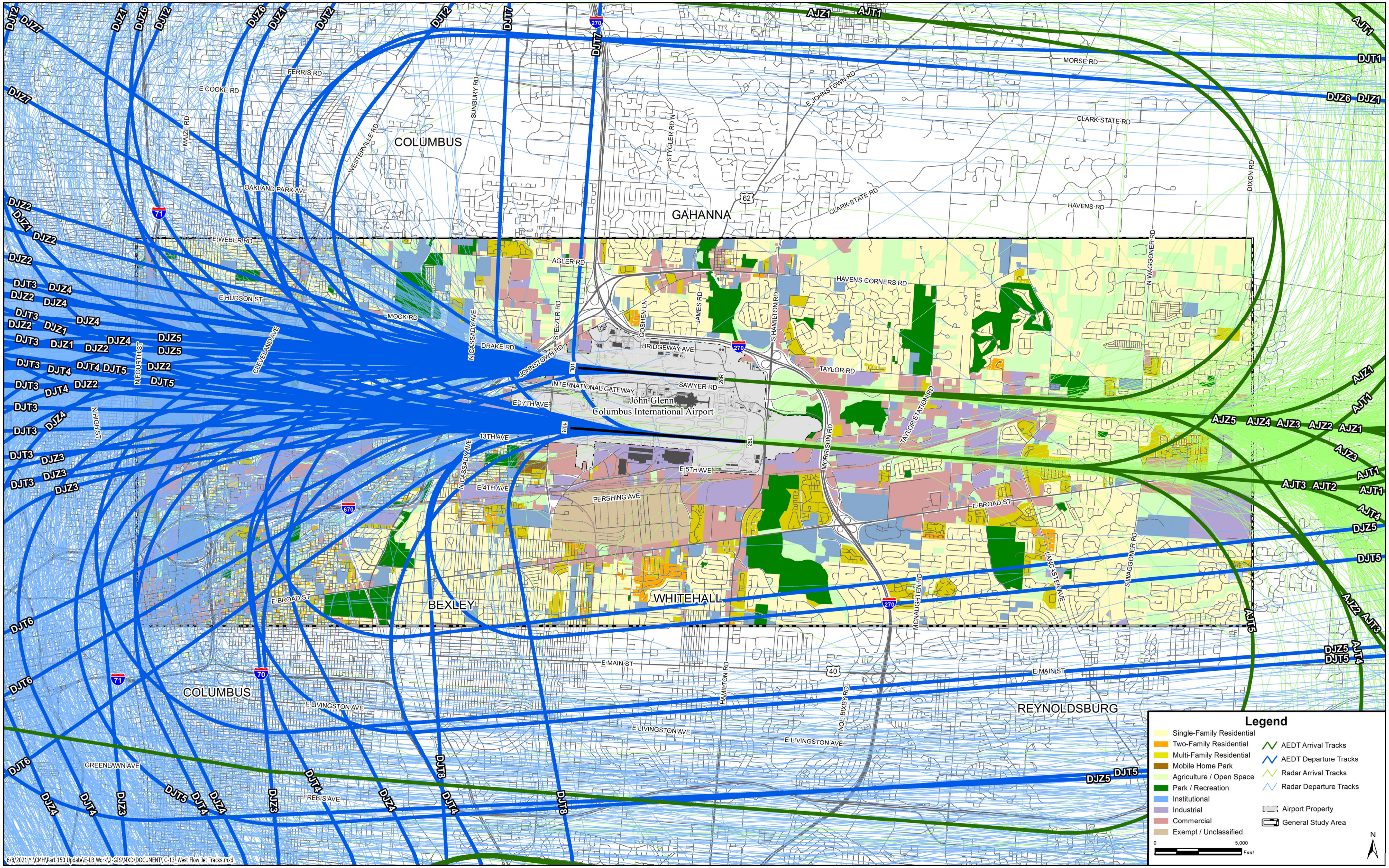
## Exhibit C-13 West Flow Large Jet Tracks



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## Exhibit C-14 West Flow Regional Jet Tracks

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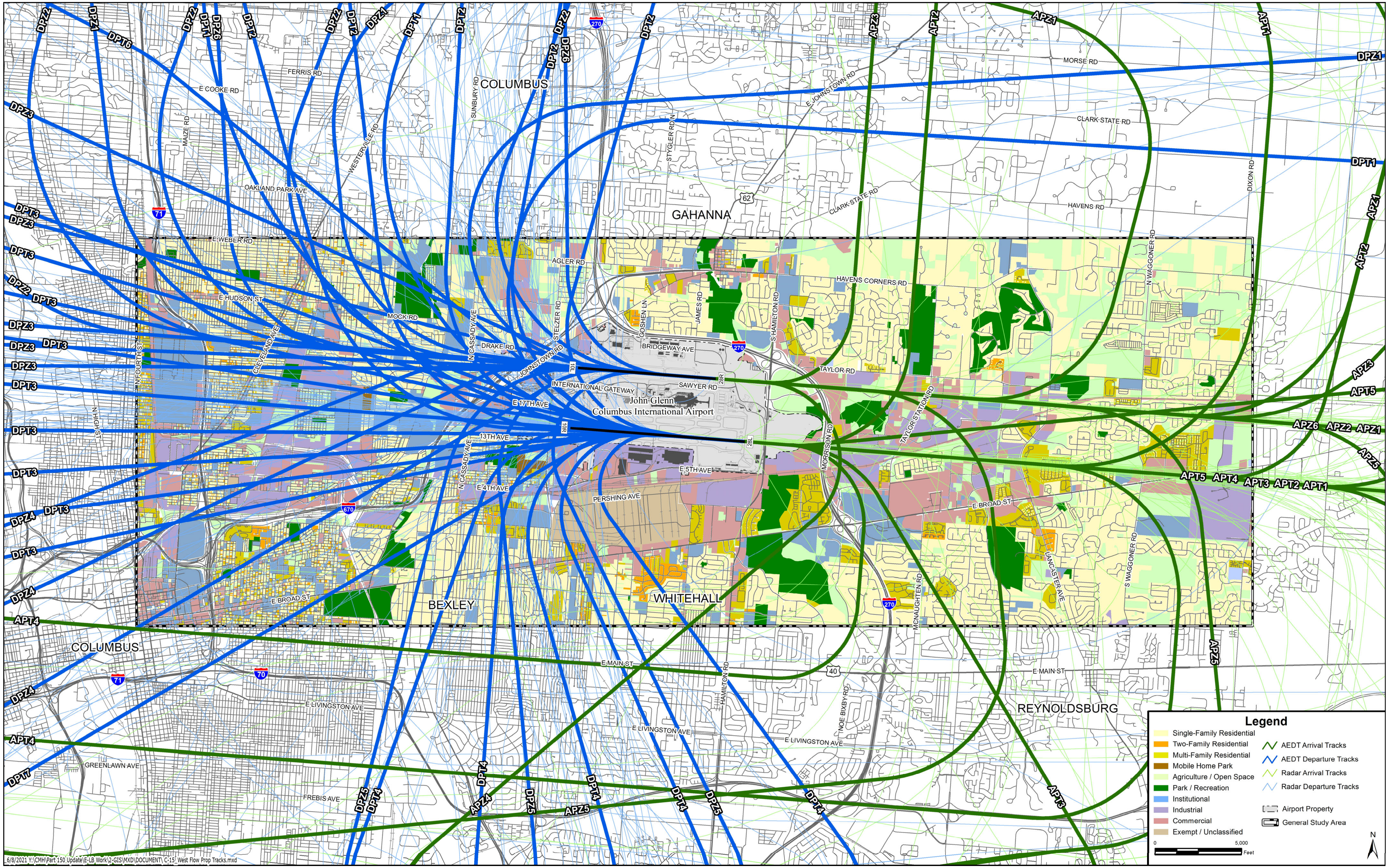
## Exhibit C-15 West Flow Prop Aircraft Tracks



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## Exhibit C-16 Touch-and-Go Tracks

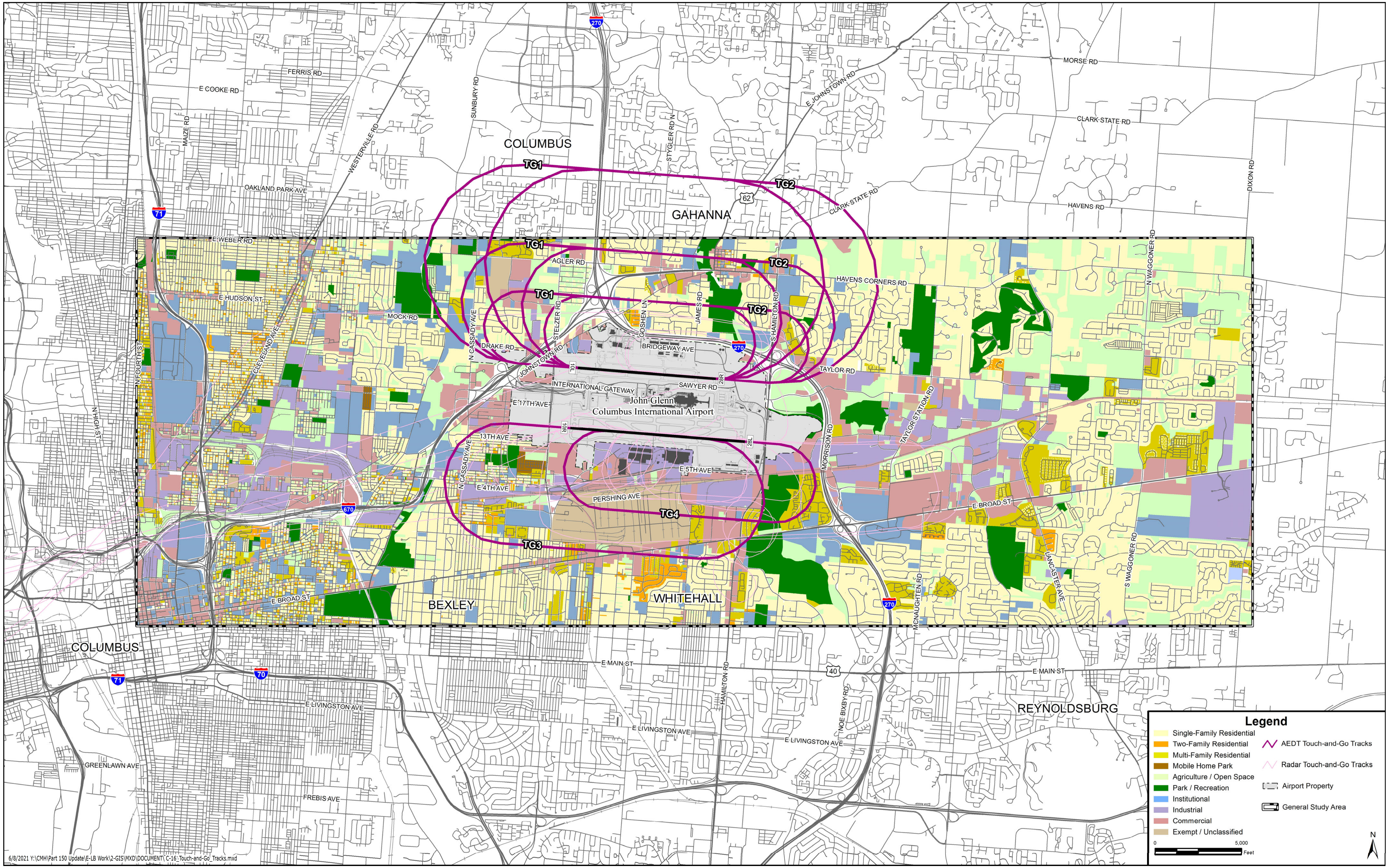

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**Table C-4 Existing (2020) Arrival Flight Track Utilization**

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10L | AJW1 | 3.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJW2 | 0.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJW3 | 5.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJW4 | 0.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APW1 | 0.0% | 0.0% | 0.3% | 0.0% | 1.0% |
| | APW2 | 0.0% | 0.0% | 0.2% | 0.0% | 0.5% |
| | APW3 | 0.0% | 0.0% | 0.3% | 0.0% | 1.0% |
| | APW4 | 0.0% | 0.0% | 0.2% | 0.0% | 0.5% |
| | APW5 | 0.0% | 0.0% | 0.2% | 0.0% | 0.5% |
| | ARW1 | 0.0% | 4.4% | 0.0% | 2.3% | 0.8% |
| | ARW2 | 0.0% | 3.9% | 0.0% | 2.0% | 0.7% |
| | ARW3 | 0.0% | 0.6% | 0.0% | 0.3% | 0.1% |
| | ARW4 | 0.0% | 2.9% | 0.0% | 1.5% | 0.5% |
| 28R | AJZ1 | 12.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ2 | 13.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ3 | 1.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ4 | 0.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ5 | 7.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APZ1 | 0.0% | 0.0% | 1.3% | 0.0% | 3.8% |
| | APZ2 | 0.0% | 0.0% | 0.2% | 0.0% | 0.6% |
| | APZ3 | 0.0% | 0.0% | 0.6% | 0.0% | 1.6% |
| | APZ4 | 0.0% | 0.0% | 0.7% | 0.0% | 1.9% |
| | APZ5 | 0.0% | 0.0% | 0.8% | 0.0% | 2.2% |
| | APZ6 | 0.0% | 0.0% | 0.8% | 0.0% | 2.2% |
| | ARZ1 | 0.0% | 10.5% | 0.0% | 5.5% | 2.8% |
| | ARZ2 | 0.0% | 18.1% | 0.0% | 9.5% | 4.9% |
| | ARZ3 | 0.0% | 0.8% | 0.0% | 0.4% | 0.2% |
| | ARZ4 | 0.0% | 8.1% | 0.0% | 4.3% | 2.2% |
| | ARZ5 | 0.0% | 1.6% | 0.0% | 0.8% | 0.4% |
| | ARZ6 | 0.0% | 0.1% | 0.0% | 0.1% | 0.0% |

**Table C-4 Existing (2020) Arrival Flight Track Utilization, *(Continued)***

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10R | AJS1 | 3.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS2 | 2.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS3 | 5.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS4 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS5 | 1.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APS1 | 0.0% | 0.0% | 0.9% | 0.0% | 0.5% |
| | APS2 | 0.0% | 0.0% | 6.2% | 0.0% | 3.7% |
| | APS3 | 0.0% | 0.0% | 7.1% | 0.0% | 4.2% |
| | APS4 | 0.0% | 0.0% | 5.3% | 0.0% | 3.2% |
| | APS5 | 0.0% | 0.0% | 8.9% | 0.0% | 5.3% |
| | ARS1 | 0.0% | 1.9% | 0.0% | 2.5% | 0.4% |
| | ARS2 | 0.0% | 6.6% | 0.0% | 8.9% | 1.3% |
| | ARS3 | 0.0% | 2.5% | 0.0% | 3.4% | 0.5% |
| | ARS4 | 0.0% | 0.8% | 0.0% | 1.1% | 0.2% |
| 28L | AJT1 | 12.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT2 | 0.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT3 | 19.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT4 | 6.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT5 | 0.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APT1 | 0.0% | 0.0% | 14.5% | 0.0% | 9.4% |
| | APT2 | 0.0% | 0.0% | 8.5% | 0.0% | 5.5% |
| | APT3 | 0.0% | 0.0% | 23.0% | 0.0% | 14.9% |
| | APT4 | 0.0% | 0.0% | 6.1% | 0.0% | 3.9% |
| | APT5 | 0.0% | 0.0% | 13.9% | 0.0% | 9.0% |
| | ART1 | 0.0% | 6.7% | 0.0% | 10.4% | 1.7% |
| | ART2 | 0.0% | 2.6% | 0.0% | 3.9% | 0.6% |
| | ART3 | 0.0% | 10.9% | 0.0% | 16.8% | 2.8% |
| | ART4 | 0.0% | 3.8% | 0.0% | 5.8% | 1.0% |
| | ART5 | 0.0% | 13.3% | 0.0% | 20.5% | 3.4% |
| **Total** | | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

Source: CMH ANOMS data, Landrum & Brown analysis, 2020.

**Table C-5 Existing (2020) Departure Flight Track Utilization**

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10L | DJW1 | 1.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW2 | 3.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW3 | 3.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW4 | 0.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW5 | 2.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW6 | 0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW7 | 0.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPW1 | 0.0% | 0.0% | 0.5% | 0.0% | 0.8% |
| | DPW2 | 0.0% | 0.0% | 0.3% | 0.0% | 0.5% |
| | DPW3 | 0.0% | 0.0% | 0.3% | 0.0% | 0.5% |
| | DPW4 | 0.0% | 0.0% | 0.3% | 0.0% | 0.5% |
| | DRW1 | 0.0% | 3.0% | 0.0% | 1.4% | 0.6% |
| | DRW2 | 0.0% | 5.9% | 0.0% | 2.8% | 1.2% |
| | DRW3 | 0.0% | 1.3% | 0.0% | 0.6% | 0.3% |
| | DRW4 | 0.0% | 1.3% | 0.0% | 0.6% | 0.3% |
| | DRW5 | 0.0% | 0.4% | 0.0% | 0.2% | 0.1% |
| | DRW6 | 0.0% | 0.1% | 0.0% | 0.1% | 0.0% |
| 28R | DJZ1 | 9.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ2 | 13.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ3 | 1.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ4 | 9.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ5 | 5.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ6 | 1.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ7 | 0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPZ1 | 0.0% | 0.0% | 0.9% | 0.0% | 1.9% |
| | DPZ2 | 0.0% | 0.0% | 0.7% | 0.0% | 1.6% |
| | DPZ3 | 0.0% | 0.0% | 1.2% | 0.0% | 2.5% |
| | DPZ4 | 0.0% | 0.0% | 1.0% | 0.0% | 2.1% |
| | DPZ6 | 0.0% | 0.0% | 1.3% | 0.0% | 2.7% |
| | DRZ1 | 0.0% | 0.9% | 0.0% | 0.5% | 0.2% |
| | DRZ2 | 0.0% | 15.0% | 0.0% | 7.6% | 3.3% |
| | DRZ3 | 0.0% | 2.2% | 0.0% | 1.1% | 0.5% |
| | DRZ4 | 0.0% | 8.2% | 0.0% | 4.2% | 1.8% |
| | DRZ5 | 0.0% | 1.9% | 0.0% | 1.0% | 0.4% |
| | DRZ6 | 0.0% | 7.9% | 0.0% | 4.0% | 1.8% |
| | DRZ7 | 0.0% | 5.6% | 0.0% | 2.8% | 1.3% |

### Table C-5 Existing (2020) Arrival Flight Track Utilization, *(Continued)*

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10R | DJS1 | 2.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS2 | 0.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS3 | 1.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS4 | 4.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS5 | 0.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS6 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS7 | 0.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS8 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS9 | 0.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPS1 | 0.0% | 0.0% | 6.3% | 0.0% | 4.5% |
| | DPS2 | 0.0% | 0.0% | 4.4% | 0.0% | 3.2% |
| | DPS3 | 0.0% | 0.0% | 5.1% | 0.0% | 3.6% |
| | DPS4 | 0.0% | 0.0% | 3.2% | 0.0% | 2.3% |
| | DPS5 | 0.0% | 0.0% | 2.5% | 0.0% | 1.8% |
| | DRS1 | 0.0% | 1.2% | 0.0% | 1.7% | 0.3% |
| | DRS2 | 0.0% | 3.4% | 0.0% | 4.9% | 0.9% |
| | DRS3 | 0.0% | 1.3% | 0.0% | 1.9% | 0.3% |
| | DRS4 | 0.0% | 0.7% | 0.0% | 1.1% | 0.2% |
| | DRS5 | 0.0% | 3.8% | 0.0% | 5.5% | 1.0% |
| | DRS6 | 0.0% | 0.7% | 0.0% | 1.1% | 0.2% |
| 28L | DJT1 | 0.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT2 | 1.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT3 | 16.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT4 | 13.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT5 | 3.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT6 | 0.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT7 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPT1 | 0.0% | 0.0% | 13.6% | 0.0% | 8.8% |
| | DPT2 | 0.0% | 0.0% | 12.2% | 0.0% | 7.9% |
| | DPT3 | 0.0% | 0.0% | 25.3% | 0.0% | 16.4% |
| | DPT4 | 0.0% | 0.0% | 19.6% | 0.0% | 12.7% |
| | DPT7 | 0.0% | 0.0% | 1.4% | 0.0% | 0.9% |
| | DRT1 | 0.0% | 1.1% | 0.0% | 1.7% | 0.3% |
| | DRT2 | 0.0% | 6.9% | 0.0% | 11.2% | 2.0% |
| | DRT3 | 0.0% | 9.0% | 0.0% | 14.7% | 2.5% |
| | DRT4 | 0.0% | 14.7% | 0.0% | 24.0% | 4.2% |
| | DRT5 | 0.0% | 3.3% | 0.0% | 5.4% | 0.9% |
| **Total** | | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

Source: CMH ANOMS data, Landrum & Brown analysis, 2020.

## Table C-6 Existing (2020) Touch-and-Go Flight Track Utilization

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10L | TG1 | n/a | | | | 18.0% |
| 28R | TG2 | | | | | 57.0% |
| 10R | TG3 | | | | | 6.0% |
| 28L | TG4 | | | | | 19.0% |

Source: Landrum & Brown, 2020.

**Aircraft Weight and Departure Stage Length:** Aircraft weight upon departure is a factor in the dispersion of noise because it impacts the rate at which an aircraft is able to climb. Generally, heavier aircraft have a slower rate of climb and a wider dispersion of noise along the flight route. Where specific aircraft weights are unknown, the AEDT uses the distance flown to the first stop as a surrogate for the weight, by assuming that the weight has a direct relationship with the fuel load necessary to reach the first destination. The AEDT groups trip lengths into eleven stage categories and assigns standard aircraft weights to each stage category. These categories are:

| Stage Category | Stage Length |
|---|---|
| 1 | 0-500 nautical miles |
| 2 | 501-1000 nautical miles |
| 3 | 1001-1500 nautical miles |
| 4 | 1501-2500 nautical miles |
| 5 | 2501-3500 nautical miles |
| 6 | 3501-4500 nautical miles |
| 7 | 4501-5500 nautical miles |
| 8 | 5501-6500 nautical miles |
| 9 | 6501-7500 nautical miles |
| 10 | 7501-8500 nautical miles |
| 11 | 8500+ nautical miles |

Destinations within a stage length of one include Atlanta, Chicago, Detroit, New York, Philadelphia, and Washington, DC. Destinations within a stage length of two include Boston, Dallas, Houston, Minneapolis, and south Florida. Destinations within a stage length of three include Denver, Phoenix, and Salt Lake City. Destinations within a stage length of four include Las Vegas, Los Angeles, San Francisco, and Seattle. There are no scheduled operations at CMH to destinations with a stage length of five or greater.

The stage lengths modeled for the Existing (2020) Baseline Noise Exposure Contour are based upon a review of existing schedules and typical destinations for current conditions at CMH. **Table C-7** indicates the proportion of the operations that were modeled within each of the nine stage length categories for Existing (2020) Baseline Noise Exposure Contour.

**Table C-7 Existing (2020) Stage Lengths**

| Stage Length Category | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
|---|---|---|---|---|---|
| 1 | 60.9% | 91.1% | 100.0% | 98.9% | 100.0% |
| 2 | 27.2% | 8.9% | 0.0% | 1.1% | 0.0% |
| 3 | 6.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 4 | 5.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| 5 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 6 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 7 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 8 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 9 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 10 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 11 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Total** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

Source: Official Airline Guide (OAG) data, Landrum & Brown analysis, 2020.

**Ground Run-up Noise:** Engine run-ups are primarily performed on regional jet and general aviation jet aircraft for maintenance purposes. These run-ups occur at three locations at CMH described below and shown on **Exhibit C-17**. In order to model noise from aircraft engine run-ups, aircraft run-up locations and times were obtained from run-up logs collected by the CRAA. Standard practices require aircraft operators to log run-ups that occur at night (10:00pm to 6:59am). For modeling purposes, it was assumed an additional percentage of run-ups occur during the daytime. **Table C-8** shows the number, types, and the duration of engine run-ups that were modeled for the Existing (2020) Baseline conditions.

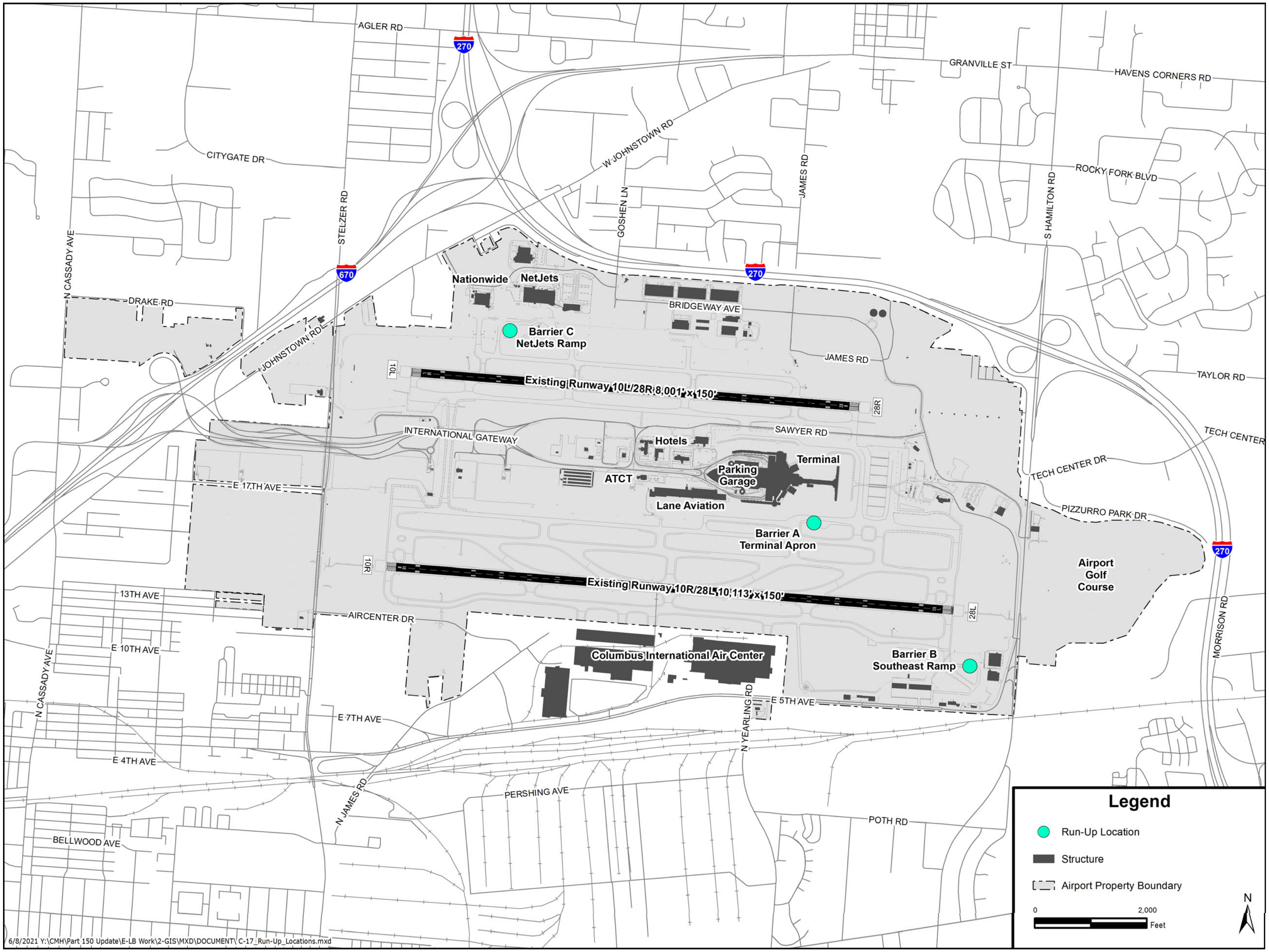
- **Barrier A / Southeast Ramp:** Located just north of the southeast end of Taxiway G. Aircraft face east (preferred) or west between the two sound barrier walls. The majority of run-ups occur here due to the proximity to the Republic Airlines maintenance hangar.
- **Barrier B / Terminal Apron:** Located to the south of Concourse B, along the south edge of the terminal apron. Aircraft face either east or west, parallel to the wall, and are positioned on the north side of the barrier.
- **Barrier C / NetJets Ramp:** Located on the north airfield near the NetJets ramp, north of Runway 10L/28R. Aircraft face either east or west, parallel to the wall, and are positioned on the south side of the barrier.

**Table C-8 Existing (2020) Run-Up Operations**

| Run-Up Location | Aircraft ANP ID | Annual Runups | | | Duration (minutes) | Thrust Setting |
|---|---|---|---|---|---|---|
| | | Daytime | Nighttime | Total | | |
| Southeast Ramp Area | CRJ9-ER | 55 | 18 | 73 | 5:11 | 80% |
| Southeast Ramp Area | EMB145 | 176 | 59 | 235 | 5:00 | 80% |
| NetJets Ramp Area | CNA560U | 29 | 10 | 39 | 6:48 | 80% |
| NetJets Ramp Area | CNA680 | 52 | 17 | 69 | 4:15 | 80% |
| Terminal Apron | EMB145 | 39 | 13 | 52 | 9:27 | 80% |
| Terminal Apron | EMB175 | 21 | 7 | 28 | 4:10 | 80% |
| **Total** | | **372** | **124** | **496** | | |

Source: CRAA Run-Up Logs, Landrum & Brown, 2020.

## Exhibit C-17 Run-Up Locations



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## C.5.2 Future (2025) Baseline Noise Exposure Contour Input Data

The following sections provide the input data for the Future (2025) Baseline Noise Exposure Contour.

**Runway Definition:** The runway layout is not expected to change by 2025 at CMH; therefore, the same runway layout discussed for the Existing (2020) Baseline Noise Exposure Contour will be used to model the Future (2025) Baseline Noise Exposure Contour.

**Number of Operations and Fleet Mix:** The Future (2025) Baseline Noise Exposure Contour operating levels are based upon the Forecast of Aviation Activity prepared for this Part 150 Study Update.[38] The forecast is based upon aviation industry trends and specific airline activity at CMH. The Future (2025) conditions include 150,140 annual operations or 411.5 average-annual day operations, an increase of 11.2 percent from the Existing (2020) Baseline Noise Exposure Contour operating levels. Some differences in fleet mix are expected to occur in 2025, notably the continued reduction in small regional jet flights (40-50 seat jets) and increase in large regional jets (greater that 50 seats) and larger passenger jets. **Table C-9** provides a summary of the average daily operations and fleet mix modeled for the Future (2025) Baseline Noise Exposure Contour, organized by aircraft category, operation type, and time of day.

**Table C-9 Future (2025) Average-Annual Day Operations by Aircraft Type**

| Aircraft Type | AEDT ANP Model ID | Arrivals | | Departures | | Total |
|---|---|---|---|---|---|---|
| | | Day | Night | Day | Night | |
| **Large Passenger Jets** | | | | | | |
| Boeing 737-400 | 737400 | 0.1 | 0.1 | 0.1 | 0.1 | 0.4 |
| Boeing 737-700 | 737700 | 24.8 | 6.9 | 26.0 | 5.8 | 63.5 |
| Boeing 737-800 | 737800 | 11.4 | 6.3 | 14.0 | 3.7 | 35.4 |
| Boeing 737-800 MAX | 737MAX8 | 1.8 | 0.3 | 2.0 | 0.2 | 4.3 |
| Boeing 737-900 | 737800 | 3.9 | 1.1 | 4.0 | 1.0 | 10.0 |
| Airbus A220-100 | 737700 | 1.0 | 0.3 | 1.0 | 0.2 | 2.5 |
| Airbus A319-100 | A319-131 | 4.6 | 2.9 | 5.8 | 1.7 | 15.0 |
| Airbus A320-200 | A320-211 | 1.1 | 0.6 | 1.5 | 0.2 | 3.4 |
| Airbus A320-200 | A320-232 | 3.6 | 2.0 | 4.9 | 0.8 | 11.3 |
| Airbus A320neo | A320-271N | 0.7 | 0.3 | 0.9 | 0.2 | 2.1 |
| Airbus A321-200 | A321-232 | 0.2 | 0.2 | 0.2 | 0.2 | 0.8 |
| Bombardier CRJ-900 | CRJ9-ER | 13.0 | 2.6 | 13.3 | 2.2 | 31.1 |
| Embraer EMB170 | EMB170 | 11.2 | 2.9 | 11.7 | 2.4 | 28.2 |
| Embraer EMB175 | EMB175 | 29.4 | 5.2 | 25.9 | 8.6 | 69.1 |
| Embraer EMB190 | EMB190 | 0.9 | 0.0 | 0.9 | 0.0 | 1.8 |
| **Subtotal** | | **107.7** | **31.7** | **112.2** | **27.3** | **278.9** |

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[38] Aviation Activity Demand Forecast, Prepared for Columbus Regional Airport Authority, January 2020. The FAA Detroit Airports District Office approved the use of this forecast for the Part 150 Noise Compat bility Study Update on March 3, 2020. Additional information on the forecast and impacts of COVID-19 on the aviation industry are included in Section C.5.3 of this Appendix and in Appendix H.

### Table C-9 Future (2025) Average-Annual Day Operations by Aircraft Type *(continued)*

| Aircraft Type | AEDT ANP Model ID | Arrivals | | Departures | | Total |
|---|---|---|---|---|---|---|
| | | Day | Night | Day | Night | |
| **Regional / Air Taxi Jets** | | | | | | |
| Bombardier Global Express | BD-700-1A10 | 0.8 | 0.2 | 0.8 | 0.1 | 1.9 |
| Bombardier CRJ-200 Regional Jet | CL600 | 3.3 | 0.3 | 3.2 | 0.5 | 7.3 |
| Cessna 525C CitationJet | CNA525C | 1.1 | 0.2 | 1.1 | 0.2 | 2.6 |
| Cessna 550 Citation Bravo | CNA55B | 2.2 | 0.2 | 2.2 | 0.2 | 4.8 |
| Cessna 560 Citation Excel | CNA560XL | 3.8 | 0.2 | 3.8 | 0.2 | 8.0 |
| Cessna 680 Citation Sovereign | CNA680 | 3.2 | 0.3 | 3.2 | 0.3 | 7.0 |
| Cessna 750 Citation X | CNA750 | 0.9 | 0.1 | 0.9 | 0.0 | 1.9 |
| Embraer ERJ-145 | EMB145 | 7.4 | 1.3 | 8.1 | 0.7 | 17.5 |
| Gulfstream G5 | GIV | 0.6 | 0.1 | 0.6 | 0.0 | 1.3 |
| Learjet 35 | LEAR35 | 0.6 | 0.0 | 0.6 | 0.1 | 1.3 |
| Mitsubishi MU-3001 | MU3001 | 1.0 | 0.1 | 1.1 | 0.1 | 2.3 |
| **Subtotal** | | **24.9** | **3.0** | **25.6** | **2.4** | **55.9** |
| **Commuter / Air Taxi Props** | | | | | | |
| Beech 58 Baron | BEC58P | 0.4 | 0.5 | 0.4 | 0.5 | 1.8 |
| Cessna 208 Caravan | CNA208 | 1.5 | 0.9 | 2.3 | 0.1 | 4.8 |
| DeHavilland Dash 6 Twin Otter | DHC6 | 1.5 | 0.1 | 1.5 | 0.1 | 3.2 |
| **Subtotal** | | **3.4** | **1.5** | **4.2** | **0.7** | **9.8** |
| **General Aviation Jets** | | | | | | |
| Bombardier Global Express | BD-700-1A10 | 0.9 | 0.2 | 0.9 | 0.1 | 2.1 |
| Bombardier Challenger 300 | CL600 | 6.1 | 0.6 | 5.7 | 0.8 | 13.2 |
| Cessna 525C CitationJet | CNA525C | 4.5 | 0.7 | 4.5 | 0.8 | 10.5 |
| Cessna 550 Citation Bravo | CNA55B | 1.3 | 0.1 | 1.3 | 0.1 | 2.8 |
| Cessna 560 Citation Ultra | CNA560U | 0.7 | 0.1 | 0.7 | 0.1 | 1.6 |
| Cessna 560 Citation Excel | CNA560XL | 0.8 | 0.1 | 0.8 | 0.1 | 1.8 |
| Cessna 680 Citation Sovereign | CNA680 | 0.7 | 0.1 | 0.7 | 0.1 | 1.6 |
| Cessna 750 Citation X | CNA750 | 1.8 | 0.2 | 1.9 | 0.1 | 4.0 |
| Eclipse Aerospace EA500 | ECLIPSE500 | 0.6 | 0.0 | 0.6 | 0.0 | 1.2 |
| Embraer ERJ-145 | EMB145 | 0.9 | 0.2 | 1.0 | 0.1 | 2.2 |
| Falcon 900 | FAL900EX | 0.4 | 0.0 | 0.3 | 0.0 | 0.7 |
| Gulfstream G4 | GIV | 0.7 | 0.1 | 0.7 | 0.0 | 1.5 |
| Learjet 35 | LEAR35 | 3.0 | 0.2 | 2.9 | 0.3 | 6.4 |
| Mitsubishi MU-3000 | MU3001 | 1.1 | 0.1 | 1.2 | 0.1 | 2.5 |
| **Subtotal** | | **23.5** | **2.7** | **23.2** | **2.7** | **52.1** |

**Table C-9 Future (2025) Average-Annual Day Operations by Aircraft Type *(continued)***

| Aircraft Type | AED ANP Model ID | Arrivals | | Departures | | Total |
|---|---|---|---|---|---|---|
| | | Day | Night | Day | Night | |
| **General Aviation Props** | | | | | | |
| Beech 58 Baron | BEC58P | 1.0 | 0.1 | 1.0 | 0.1 | 2.2 |
| Cessna 172 Skyhawk | CNA172 | 1.2 | 0.0 | 1.2 | 0.0 | 2.4 |
| Cessna 182 Skylane | CNA182 | 0.2 | 0.0 | 0.2 | 0.0 | 0.4 |
| Cessna 208 Caravan | CNA208 | 0.7 | 0.4 | 1.1 | 0.1 | 2.3 |
| Cessna 441 Conquest II | CNA441 | 0.7 | 0.1 | 0.8 | 0.0 | 1.6 |
| Single-Engine Prop | COMSEP | 0.5 | 0.0 | 0.5 | 0.0 | 1.0 |
| General Aviation Single Engine Prop | GASEPF | 0.2 | 0.0 | 0.2 | 0.0 | 0.4 |
| General Aviation Single Engine Prop | GASEPV | 1.4 | 0.0 | 1.4 | 0.0 | 2.8 |
| Piper PA28 Cherokee | PA28 | 0.3 | 0.0 | 0.3 | 0.0 | 0.6 |
| Piper PA31 Cherokee Six | PA31 | 0.5 | 0.0 | 0.5 | 0.0 | 1.0 |
| Subtotal | | 6.7 | 0.6 | 7.2 | 0.2 | 14.7 |
| **Grand Total** | | **166.2** | **39.5** | **172.4** | **33.3** | **411.4** |

Notes: Total may not equal sum total due to rounding.
Daytime = 7:00am – 9:59pm, Nighttime = 10:00pm – 6:59am.
Source: Federal Aviation Administration (FAA) Operations Network (OpsNet) data, CRAA Landing Fee Reports, CMH ANOMS data, Landrum & Brown analysis, 2020.

**Runway End Utilization:** Average-annual day runway end utilization in 2025 is expected to remain similar to 2020 conditions; however, ratio between east flow and west flow is expected to more similar to long-term averages which is based on wind conditions that can vary slightly from year-to-year. During the existing baseline period, the ratio was approximately 77.5 percent west flow and 22.5 percent east flow. A review of long-term average runway use based on operating and weather conditions over the past ten years reveals a split of approximately 72.5 percent west flow and 27.5 percent east flow. Therefore, runway end utilization percentages modeled for the Future (2025) conditions were modified to reflect long-term average conditions as shown in **Table C-10**.

**Flight Tracks:** No changes to flight tracks locations are expected to occur within the general study area by 2025.[39] Therefore flight track locations modeled for the Existing (2020) Baseline Noise Exposure Contour, and shown in Exhibits C-11 through C-16, remain the same for the Future (2025) Baseline Noise Exposure Contour modeling. Due to minor changes in runway use percentages, flight track percentages modeled for the Future (2025) Noise Exposure Contour will be expected to vary slightly from those modeled for the Existing (2020) Baseline Noise Exposure Contour. Flight track percentages modeled for the Future (2025) Baseline Noise Exposure Contour are shown in **Table C-11** and **Table C-12**. Touch-and-go flight track percentages are expected to remain similar to those modeled for the Existing (2020) Baseline Noise Exposure Contour shown in Table C-6.

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[39] The Federal Aviation Administration (FAA) is in the process of redesigning and modernization of the National Airspace System through the use of satellite-based navigation. As part of this process, new Performance Based Navigation (PBN) procedures are being developed that will use satellite-based precision to fly more direct routes, saving fuel and time, increasing traffic flow, and resulting in fewer carbon emissions. The FAA is finalizing designs for new Standard Arrival Routes (STARs) at CMH. A review of new RNP procedure flight tracks was conducted which concluded that no changes in flight track locations would occur; and no changes to altitudes or descent gradients would occur, within the General Study Area for this Part 150 Noise Compatibility Study update.

### Table C-10 Future (2025) Runway End Utilization

| Aircraft Category | Runway End | | | | Total |
|---|---|---|---|---|---|
| | 10L | 10R | 28L | 28R | |
| **Daytime Arrivals** | | | | | |
| Large Jets | 14.1% | 13.9% | 34.1% | 37.9% | 100.0% |
| Regional / Air Taxi Jets | 14.2% | 13.8% | 34.2% | 37.8% | 100.0% |
| Commuter / Air Taxi Props | 1.7% | 26.3% | 66.4% | 5.6% | 100.0% |
| General Aviation Jets | 8.2% | 19.8% | 52.3% | 19.7% | 100.0% |
| General Aviation Props | 7.2% | 20.8% | 49.0% | 23.0% | 100.0% |
| **Nighttime Arrivals** | | | | | |
| Large Jets | 8.7% | 19.3% | 50.3% | 21.7% | 100.0% |
| Regional / Air Taxi Jets | 10.9% | 17.1% | 47.3% | 24.7% | 100.0% |
| Commuter / Air Taxi Props | 0.7% | 27.3% | 70.4% | 1.6% | 100.0% |
| General Aviation Jets | 5.1% | 22.9% | 59.5% | 12.5% | 100.0% |
| General Aviation Props | 3.3% | 24.7% | 61.0% | 11.0% | 100.0% |
| **Daytime Departures** | | | | | |
| Large Jets | 13.2% | 13.8% | 33.4% | 39.6% | 100.0% |
| Regional / Air Taxi Jets | 13.9% | 13.1% | 33.7% | 39.3% | 100.0% |
| Commuter / Air Taxi Props | 1.3% | 25.7% | 68.5% | 4.5% | 100.0% |
| General Aviation Jets | 7.4% | 19.6% | 53.0% | 20.0% | 100.0% |
| General Aviation Props | 5.8% | 21.2% | 53.1% | 19.9% | 100.0% |
| **Nighttime Departures** | | | | | |
| Large Cargo Jets | 12.6% | 14.4% | 38.2% | 34.8% | 100.0% |
| Heavy Jets | 13.6% | 13.4% | 36.9% | 36.1% | 100.0% |
| Passenger Jets | 3.2% | 23.8% | 66.3% | 6.7% | 100.0% |
| General Aviation Jets | 5.1% | 21.9% | 56.2% | 16.8% | 100.0% |
| General Aviation Props | 3.7% | 23.3% | 64.8% | 8.2% | 100.0% |

Notes: Daytime = 7:00 a.m. – 9:59 p.m., Nighttime = 10:00 p.m. – 6:59 a.m.
Total may not equal sum total due to rounding.

Source: CMH ANOMS data, Landrum & Brown analysis, 2020.

## Table C-11 Future (2025) Arrival Flight Track Utilization

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10L | AJW1 | 4.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJW2 | 0.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJW3 | 6.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJW4 | 0.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APW1 | 0.0% | 0.0% | 0.4% | 0.0% | 1.7% |
| | APW2 | 0.0% | 0.0% | 0.2% | 0.0% | 0.8% |
| | APW3 | 0.0% | 0.0% | 0.4% | 0.0% | 1.7% |
| | APW4 | 0.0% | 0.0% | 0.2% | 0.0% | 0.8% |
| | APW5 | 0.0% | 0.0% | 0.2% | 0.0% | 0.8% |
| | ARW1 | 0.0% | 5.2% | 0.0% | 2.9% | 0.3% |
| | ARW2 | 0.0% | 4.6% | 0.0% | 2.6% | 0.3% |
| | ARW3 | 0.0% | 0.7% | 0.0% | 0.4% | 0.0% |
| | ARW4 | 0.0% | 3.4% | 0.0% | 1.9% | 0.2% |
| 28R | AJZ1 | 12.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ2 | 12.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ3 | 1.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ4 | 0.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJZ5 | 7.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APZ1 | 0.0% | 0.0% | 1.3% | 0.0% | 5.7% |
| | APZ2 | 0.0% | 0.0% | 0.2% | 0.0% | 0.9% |
| | APZ3 | 0.0% | 0.0% | 0.6% | 0.0% | 2.4% |
| | APZ4 | 0.0% | 0.0% | 0.7% | 0.0% | 2.8% |
| | APZ5 | 0.0% | 0.0% | 0.8% | 0.0% | 3.3% |
| | APZ6 | 0.0% | 0.0% | 0.8% | 0.0% | 3.3% |
| | ARZ1 | 0.0% | 9.7% | 0.0% | 5.1% | 0.7% |
| | ARZ2 | 0.0% | 16.8% | 0.0% | 8.8% | 1.2% |
| | ARZ3 | 0.0% | 0.7% | 0.0% | 0.4% | 0.1% |
| | ARZ4 | 0.0% | 7.5% | 0.0% | 3.9% | 0.6% |
| | ARZ5 | 0.0% | 1.5% | 0.0% | 0.8% | 0.1% |
| | ARZ6 | 0.0% | 0.1% | 0.0% | 0.0% | 0.0% |

### Table C-11 Future (2025) Arrival Flight Track Utilization, *(Continued)*

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10R | AJS1 | 4.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS2 | 2.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS3 | 6.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS4 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJS5 | 1.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APS1 | 0.0% | 0.0% | 0.8% | 0.0% | 0.6% |
| | APS2 | 0.0% | 0.0% | 5.8% | 0.0% | 4.1% |
| | APS3 | 0.0% | 0.0% | 6.7% | 0.0% | 4.7% |
| | APS4 | 0.0% | 0.0% | 5.0% | 0.0% | 3.5% |
| | APS5 | 0.0% | 0.0% | 8.3% | 0.0% | 5.9% |
| | ARS1 | 0.0% | 2.2% | 0.0% | 3.2% | 0.4% |
| | ARS2 | 0.0% | 7.9% | 0.0% | 11.2% | 1.4% |
| | ARS3 | 0.0% | 3.0% | 0.0% | 4.3% | 0.5% |
| | ARS4 | 0.0% | 1.0% | 0.0% | 1.4% | 0.2% |
| 28L | AJT1 | 12.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT2 | 0.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT3 | 18.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT4 | 6.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | AJT5 | 0.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | APT1 | 0.0% | 0.0% | 14.9% | 0.0% | 9.9% |
| | APT2 | 0.0% | 0.0% | 8.7% | 0.0% | 5.8% |
| | APT3 | 0.0% | 0.0% | 23.6% | 0.0% | 15.7% |
| | APT4 | 0.0% | 0.0% | 6.2% | 0.0% | 4.1% |
| | APT5 | 0.0% | 0.0% | 14.3% | 0.0% | 9.5% |
| | ART1 | 0.0% | 6.4% | 0.0% | 9.6% | 1.0% |
| | ART2 | 0.0% | 2.4% | 0.0% | 3.6% | 0.4% |
| | ART3 | 0.0% | 10.4% | 0.0% | 15.5% | 1.7% |
| | ART4 | 0.0% | 3.6% | 0.0% | 5.4% | 0.6% |
| | ART5 | 0.0% | 12.7% | 0.0% | 19.0% | 2.1% |
| **Total** | | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

Source: CMH ANOMS data, Landrum & Brown analysis, 2020.

**Table C-12 Future (2025) Departure Flight Track Utilization**

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10L | DJW1 | 2.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW2 | 4.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW3 | 3.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW4 | 0.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW5 | 2.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW6 | 0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJW7 | 0.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPW1 | 0.0% | 0.0% | 0.5% | 0.0% | 1.7% |
| | DPW2 | 0.0% | 0.0% | 0.3% | 0.0% | 1.1% |
| | DPW3 | 0.0% | 0.0% | 0.3% | 0.0% | 1.1% |
| | DPW4 | 0.0% | 0.0% | 0.3% | 0.0% | 1.1% |
| | DRW1 | 0.0% | 3.5% | 0.0% | 1.8% | 0.2% |
| | DRW2 | 0.0% | 6.8% | 0.0% | 3.5% | 0.3% |
| | DRW3 | 0.0% | 1.5% | 0.0% | 0.8% | 0.1% |
| | DRW4 | 0.0% | 1.5% | 0.0% | 0.8% | 0.1% |
| | DRW5 | 0.0% | 0.4% | 0.0% | 0.2% | 0.0% |
| | DRW6 | 0.0% | 0.1% | 0.0% | 0.1% | 0.0% |
| 28R | DJZ1 | 8.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ2 | 13.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ3 | 1.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ4 | 8.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ5 | 4.9% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ6 | 1.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJZ7 | 0.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPZ1 | 0.0% | 0.0% | 0.9% | 0.0% | 3.0% |
| | DPZ2 | 0.0% | 0.0% | 0.7% | 0.0% | 2.4% |
| | DPZ3 | 0.0% | 0.0% | 1.1% | 0.0% | 3.9% |
| | DPZ4 | 0.0% | 0.0% | 0.9% | 0.0% | 3.3% |
| | DPZ6 | 0.0% | 0.0% | 1.2% | 0.0% | 4.2% |
| | DRZ1 | 0.0% | 0.8% | 0.0% | 0.4% | 0.0% |
| | DRZ2 | 0.0% | 14.0% | 0.0% | 7.1% | 0.8% |
| | DRZ3 | 0.0% | 2.1% | 0.0% | 1.0% | 0.1% |
| | DRZ4 | 0.0% | 7.7% | 0.0% | 3.9% | 0.4% |
| | DRZ5 | 0.0% | 1.8% | 0.0% | 0.9% | 0.1% |
| | DRZ6 | 0.0% | 7.4% | 0.0% | 3.7% | 0.4% |
| | DRZ7 | 0.0% | 5.2% | 0.0% | 2.6% | 0.3% |

**Table C-12 Future (2025) Arrival Flight Track Utilization, *(Continued)***

| Runway End | Track ID | Aircraft Category | | | | |
|---|---|---|---|---|---|---|
| | | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
| 10R | DJS1 | 3.2% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS2 | 0.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS3 | 1.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS4 | 5.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS5 | 0.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS6 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS7 | 1.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS8 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJS9 | 1.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPS1 | 0.0% | 0.0% | 7.5% | 0.0% | 5.5% |
| | DPS2 | 0.0% | 0.0% | 5.2% | 0.0% | 3.9% |
| | DPS3 | 0.0% | 0.0% | 6.0% | 0.0% | 4.4% |
| | DPS4 | 0.0% | 0.0% | 3.7% | 0.0% | 2.8% |
| | DPS5 | 0.0% | 0.0% | 3.0% | 0.0% | 2.2% |
| | DRS1 | 0.0% | 1.4% | 0.0% | 2.1% | 0.3% |
| | DRS2 | 0.0% | 4.0% | 0.0% | 6.0% | 0.8% |
| | DRS3 | 0.0% | 1.6% | 0.0% | 2.4% | 0.3% |
| | DRS4 | 0.0% | 0.9% | 0.0% | 1.3% | 0.2% |
| | DRS5 | 0.0% | 4.5% | 0.0% | 6.8% | 0.9% |
| | DRS6 | 0.0% | 0.9% | 0.0% | 1.3% | 0.2% |
| 28L | DJT1 | 0.5% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT2 | 1.8% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT3 | 15.3% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT4 | 12.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT5 | 3.7% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT6 | 0.4% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DJT7 | 0.1% | 0.0% | 0.0% | 0.0% | 0.0% |
| | DPT1 | 0.0% | 0.0% | 12.8% | 0.0% | 8.9% |
| | DPT2 | 0.0% | 0.0% | 11.5% | 0.0% | 8.0% |
| | DPT3 | 0.0% | 0.0% | 23.9% | 0.0% | 16.6% |
| | DPT4 | 0.0% | 0.0% | 18.6% | 0.0% | 12.9% |
| | DPT7 | 0.0% | 0.0% | 1.3% | 0.0% | 0.9% |
| | DRT1 | 0.0% | 1.0% | 0.0% | 1.6% | 0.2% |
| | DRT2 | 0.0% | 6.7% | 0.0% | 10.5% | 1.3% |
| | DRT3 | 0.0% | 8.7% | 0.0% | 13.7% | 1.6% |
| | DRT4 | 0.0% | 14.3% | 0.0% | 22.4% | 2.7% |
| | DRT5 | 0.0% | 3.2% | 0.0% | 5.0% | 0.6% |
| **Total** | | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

Source: CMH ANOMS data, Landrum & Brown analysis, 2020.

**Aircraft Weight and Departure Stage Length:** The average aircraft departure weights modeled for the Future (2025) Baseline Noise Exposure Contour is based on forecasted departure trip lengths from the forecast of aviation activity prepared for this Part 150 Study Update. There are expected to be no significant changes in the destinations served by airlines from CMH, however changes in the number of operations and fleet mix results in small variations in the departure trip length distributions for the 2025 conditions as shown in **Table C-13**.

### Table C-13 Future (2025) Stage Lengths

| Stage Length Category | Large Jet | Regional / Air Taxi Jet | Commuter / Air Taxi Prop | General Aviation Jet | General Aviation Prop |
|---|---|---|---|---|---|
| 1 | 59.9% | 93.4% | 100.0% | 99.1% | 100.0% |
| 2 | 26.8% | 6.6% | 0.0% | 0.9% | 0.0% |
| 3 | 6.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| 4 | 6.6% | 0.0% | 0.0% | 0.0% | 0.0% |
| 5 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 6 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 7 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 8 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| 9 | 0.0% | 0.0% | 0.0% | 0.0% | 0.0% |
| **Total** | **100.0%** | **100.0%** | **100.0%** | **100.0%** | **100.0%** |

Source: Official Airline Guide (OAG) data, Landrum & Brown analysis, 2020.

**Ground Run-up Noise:** Engine run-up activity was projected for the 2025 conditions based upon the forecast increase in operations at CMH. Estimates of run-up times, durations and locations remained the same as described for the 2020 conditions. The number, types, durations and times of day of engine run-ups that were modeled for the Future (2020) Noise Exposure Contour are shown in **Table C-14**.

### Table C-14 Future (2025) Run-Up Operations

| Run-Up Location | Aircraft ANP ID | Annual Runups | | | Duration (minutes) | Thrust Setting |
|---|---|---|---|---|---|---|
| | | Daytime | Nighttime | Total | | |
| Southeast Ramp Area | CRJ9-ER | 62 | 21 | 82 | 5:11 | 80% |
| Southeast Ramp Area | EMB145 | 199 | 66 | 266 | 5:00 | 80% |
| NetJets Ramp Area | CNA560U | 33 | 11 | 44 | 6:48 | 80% |
| NetJets Ramp Area | CNA680 | 58 | 19 | 78 | 4:15 | 80% |
| Terminal Apron | EMB145 | 44 | 15 | 59 | 9:27 | 80% |
| Terminal Apron | EMB175 | 24 | 8 | 32 | 4:10 | 80% |
| **Total** | | **421** | **140** | **561** | | |

Source: CRAA Run-Up Logs, Landrum & Brown, 2020.

### C.5.3 Comparability of Conditions

The number of annual operations and fleet mix modeled for Existing (2020) Baseline Noise Exposure Contours are based on actual data from September 2018 through August 2019. The operating levels and fleet mix modeled for the Future (2025) Noise Exposure Contour is based upon the Forecast of Aviation Activity prepared for this Part 150 Study Update. The forecast was submitted to the FAA for review in January 2020. The FAA approved this Forecast on March 3, 2020. The forecasts for the CMH Part 150 were prepared and submitted to FAA prior to the COVID-19 public health emergency. It is acknowledged that the current impacts of the COVID-19 public health emergency resulted in a decline in air travel. However, it is anticipated that passenger and airline activity in the short-term will be lower than forecast but will recover with long-term forecast activity. More information about the forecast