VERTICAL AVIATION INTERNATIONAL

WHITE PAPER

Rotorcraft and Urban Air Mobility Noise Exposure in Communities

A. Introduction

1. Origin and Preparation

This document was prepared during 2020 through June 2022 by the Noise Impact Subcommittee of Vertical Aviation International's Vertical Aviation Operations Industry Advisory Council (formerly, the Helicopter Association International's Fly Neighborly Working Group).

Fly Neighborly
HELICOPTER PILOT TRAINING PROGRAM

2. Purpose

This document provides technical guidance for local planners, other government agencies, and operators in predicting the acoustic environment near new heliports and vertiports. It is intended to provide assistance in preliminary evaluation of the noise compatibility of sites where none exists. It is not intended for the evaluation of existing heliports or those areas where noise is not a potential issue (e.g., offshore oil platforms). It is intended specifically to advise in the definition and siting of new vertiports, which are defined here as vertical takeoff and landing facilities intended for use primarily by "urban air mobility" or "advanced air mobility" aircraft that generally have lower noise emissions than helicopters do. More detailed environmental analysis may be required under Orders 1050.1E and 5050.4B when there is a proposed FAA action relating to establishment of a new facility that makes it subject to NEPA requirements, or where local planning policies impose additional constraints. This document is also intended to guide operational expansion at existing heliports as these facilities are preserved and given additional function as vertiports.

3. Background

FAA Orders 1050.1E and 5050.4B, generally as implemented in 14 CFR Part 150, provide detailed procedures for the environmental assessment of FAA actions under the National Environmental Policy Act (NEPA, P.L. 91-190, 42 USC 4321) and a number of other statutes, regulations and orders. These requirements and procedures are definitive when assessing federal actions and the risk to federal investments in aviation infrastructure. They only apply to heliports when located within the boundaries of an airport subject to NEPA. However, the private sector and local authorities need standardized methods for preliminary evaluation of potential sites for new heliports and vertiports, which may or may not be considered federal

actions under NEPA. This document is intended to fill the need and to give "quick-look" capability without the detailed analysis necessary to a full NEPA assessment.

This document is based on a former FAA Advisory Circular, AC 150-5020-2 from 1983 that gave simplified methods not requiring computer analysis and based on the assumption that the helicopter sound exposure should not exceed the ambient sound level, which could result in a 3 decibel increase in community noise. In this document, a value of 1.5 dB is used, which is defined in Part 150 as the threshold for “significant” change. AC 150-5020-2 (1983) was withdrawn in 1988, and the number reused for a different document, so interested parties are cautioned to find the 1983 version rather than any subsequent document using the same number. A revision of the 1983 AC was drafted as AC 150-5020-2a but was not released by FAA.

While the sense of Part 150 guidance is incorporated in this document, it should be noted that Part 150 is being adapted to a purpose for which it was not originally intended. In general, airport noise guidance is based on predicting shifts in community noise due to changes in airport operation (compared with not making the change) and to assuring that new land development is permitted only in areas with existing or planned airport noise levels considered to be compatible with such use. In this document the intent is the reverse: determining levels of new noise exposure that are compatible with existing land uses. Users of this document are cautioned to consider the whole acoustic environment and make appropriate conclusions based on a balance of factors including potential disruption of activities and utility of the new aviation services provided by the proposed heliport.

4. Overview

A three-step process is suggested to ensure that new facility planning includes effective means for evaluating and minimizing noise impacts. The intent is to identify nearby noise-sensitive locations that can be expected to receive noise levels that might intrude into normal use of the location.

a. The first phase uses estimated noise levels, distances and operation plans to determine whether a proposed facility would meet recommended noise criteria based on traditional land use planning methods applicable to airports. This preliminary step determines whether there are any noise sensitive areas within the day-night noise exposure contour (DNL or CNEL) of the heliport or vertiport, and whether there are any such areas within a maximum single-event noise footprint as recommended by the Federal Interagency Committee on Aviation Noise (FICAN.) This first phase has historically been sufficient for environmental assessment of heliports with low levels of traffic such as hospitals and public safety facilities.

b. The second phase can be used if, based on the phase I estimate, the proposed facility would not clearly meet the recommended noise criteria. Detailed noise readings should then be taken to determine whether the noise levels would constitute a significant change in the ambient noise experienced by people in the vicinity.

c. The third phase focuses on mitigation of noise exposure to refine facility plans to result in acceptable levels of noise exposure. This may include modification of proposed operations or more detailed analysis of, for example, population movement to determine how many people would be affected by heliport noise at various times of the day as population, activity level and ambient noise levels change.

B. Planning Factors

1. General

Helicopters and advanced air mobility vehicles typically operate at low altitudes and, as a result, frequently come within the audible range of people. These aircraft are becoming more widely used in both urban and suburban areas. Therefore, the sound is generated in close proximity to where people live and work. This closeness accentuates the concern associated with the external sound and its acceptability to the communities in which it operates. It is an underlying philosophy of the procedures and recommendations of this guide that each facility siting is a unique situation. Thus, the application of any procedure may not necessarily result in a satisfactory solution for every community and operator. In these regards, individual consideration should be given to such factors as ambient noise, the specific nature of the noise sensitive areas which may be impacted by operations, and seasonal variations in operation.

2. Ambient Noise

People's concerns about aircraft noise are often reflections of the degree to which the aircraft intrudes on existing ambient noise exposure patterns. Ambient noise at a specific location is a composite of sounds from many sources including automobile, truck and bus traffic, motorcycles, construction noise, aircraft, natural sounds etc. The ambient noise level in an area continually varies with time as the result of varying levels of activity. This activity, and hence the resultant ambient noise, changes with time of day, day of the week and the seasons.

3. Sound of Helicopters and Urban Air Mobility (UAM) Vehicles

The noise footprint of vertical takeoff and landing aircraft during approach, landing, takeoff, and departure is considerably smaller than that of many airplanes. The sound is comparable in level to other sounds that are acceptable to the community. That acceptance is often due to familiarity. Heavy trucks and city buses are examples of sounds which are equivalent in sound level to helicopters. The sound generated by a helicopter or UAM, however, is different in character from other forms of transportation. Each mode of flight, takeoff, landing and flyover, can produce different combinations of sound. Often the sound is new to an area. For these reasons, the helicopter or UAM is readily identified and may be singled out for complaint. Newer technology vertical takeoff and landing aircraft such as UAM have unique sounds that may be more or less intrusive than helicopters.

4. Route Planning Considerations

The flight path to and from a proposed facility should take advantage of compatible use corridors, i.e., over freeways and railways, bodies of water, etc. Routes should be selected to avoid noise sensitive facilities such as schools, churches, rest homes, large open-air gatherings of people, etc. Rapid turns as well as other transient maneuvers can give rise to changes in the character and level of the sound. These maneuvers should be avoided whenever practical, particularly near residential areas. The flyover altitude should also be chosen, within reason, to be the highest practicable since doubling the flyover height will decrease the peak sound level heard on the ground by more than 6 decibels. Thus, routes at 1000 to 2000 ft. altitude are preferable to 500 ft. (Advisory Circular 91-36D recommends 2000 ft. minimum altitude over populated areas.) VFR corridors specifically for helicopters have been identified in many cities in order to quantify and reduce public impacts. The FAA also supports the helicopter industry's "Fly Neighborly" program to reduce noise effects.

5. Acoustical Considerations in Site Selection

The FAA's Heliport Design Guide (AC 150/5390-2C) should be consulted in selecting and developing a new site. Where noise impacts are a consideration, it may also be desirable to consider sites in or near high activity areas such as near thoroughfares, freeways, busy streets, railways, etc., since the noise generated by such facilities will tend to mask the sounds generated by the aircraft. Of course, heliports are also compatible in open areas. Except for emergency use, heliports should not be located adjacent to such facilities as schools, churches, and rest homes. Elevated heliports should be considered separately from ground level sites. (See paragraph 15.) Clear zones and helistops or vertistops on rooftops should be encouraged in recognition of the aircraft's demonstrated rescue and evacuation potential in emergency situations, such as fires.

C. Criteria Selection

1. General

Outside noise levels have generally proven to be reliable indicators of community response to sound exposure, and many standards use them exclusively. For this reason, the environmental criteria for heliports have been based on external sound only. However, in some cases, particularly for sites near schools and hospitals, it may be more appropriate to consider indoor sound levels. In these cases, it is not possible to generalize, and each case must be treated on an individual basis depending on applicable building transmission loss values.

2. Sound Level Units

a. Single Event Measure

The Aviation Safety and Noise Abatement Act of 1979 (P.L. 96-193, 49 USC 2101) required that the FAA establish a single system for measuring and evaluating noise impacts for airports,

different from the EPNL measure used for aircraft certification. That system, as incorporated in FAR Part 150 and Order 1050.1E, is the family of units based on the A-weighted sound pressure level. To represent the exposure from a single takeoff or landing event, the FAA chose Sound Exposure Level (SEL), which is a single-event measure combining both the events maximum intensity and its duration. A mathematical explanation of this unit is given in FAR Part 150, Appendix A. Values of SEL for various aircraft may be obtained from measurements using an integrating sound level meter, or listings of sound exposure levels provided by the FAA or aircraft manufacturers. In either case, the individual values of SEL for each takeoff, landing and flyover event, at the distances where the sound is experienced, are combined by the methods contained in this document and compared against the community noise levels.

b. Community Noise Level

So that the relative contributions of the heliport or vertiport and other sound sources in the community can be compared a cumulative noise measure, day-night average sound level (DNL) is specified in FAR Part 150 for evaluating the community noise levels around airports for fixed-wing aircraft. Aviation noise DNL values are obtained by adding logarithmically the single-event SEL values over a 24-hour period, with a 10 dB penalty added for operations between 10 PM and 7 AM. In California, the Community Noise Equivalent Level (CNEL) is used, adding an additional penalty of 3 times the number of operations (equivalent to 4.77 dB) for operations between 7 and 10 PM. In this document, “ambient DNL” is used to denote community noise level as measured by the locally applicable method (DNL or CNEL) while “facility DNL” will be used to denote the noise exposure generated by operations at the heliport.

c. Aircraft Noise Levels

SEL values are obtained for each aircraft type and for each operating condition (takeoff, overflight and landing.) SEL is defined as the sound pressure level lasting one second that contains the same energy as the measured operation for the period during which the level is within 10 dB of its maximum. Standardized measurements are made as part of aircraft type certification, and different processing of the same flight test data results in “NPD” curves (for fixed-wing aircraft, they are noise-power-distance curves; for rotorcraft they are noise-operating condition-distance, but still called NPD.) Appendix xx contains some typical SEL values for helicopters.

3. Normally Compatible Sound Levels

a. Criteria

Public Law 96-193 (cited above) also directs the FAA to identify land uses which are "normally compatible" with various levels of noise from aircraft operations. Because of the size and complexity of many major hub airports and their operations, FAR Part 150 identifies a large number of land uses and their associated noise levels. However, since the operations of most heliports and vertiports tend to be much simpler and the impacts more restricted in area, Part 150 does not apply to heliports off the airport property. Instead, for individual heliports and

vertiports this document recommends the simpler acceptability criteria contained in Table 1. These recommended levels were chosen on the basis of the criteria typically found to be acceptable in areas by type. The community is divided into basic area categories: "residential", "commercial", and "industrial", with ambient DNL levels as shown in Table 1.

Table 1. Recommended Acceptable Levels for Residential, Commercial and Industrial Locations

Location type	*Normally acceptable ambient level, DNL*	*Facility acceptable exposure level, DNL*
Residential	65	61
Commercial	70	66
Industrial	75	71

b. Compatibility

The maximum recommended cumulative sound level (facility DNL) due to the proposed operations of aircraft at a new site should not create more than 1.5 dB increase in the ambient noise level already present in the community at the site of the proposed heliport. This level is chosen based on the FAA's description of "significant" change in noise exposure. This means, the average daily facility DNL should not exceed 4 dB less than the ambient values recommended in Table 1, or the locally measured ambient noise level when it is greater than the normally acceptable level listed in Table 1. (For example, helicopter DNL of 59 dB added to an ambient of 63 dB results in a combined DNL just under 64.5 dB, considered a “just noticeable difference” or a “significant change” when compared with 63 dB.)

Facility DNL can be computed for each aircraft type *a* at operating condition *b* using the relation

$$DNL = SEL_{a,b} + 10log_{10}\left(N_{a,b\ day} + 10N_{a,b\ night}\right) - 49.4\ dB$$

where SEL is that of a single operation at the closest community location of interest, and N_{day} and N_{night} are the number of operations between 7 AM and 10 PM and 10 PM and 7 AM respectively. Individual DNL values from the daily contributions of all aircraft types and operating conditions planned for the heliport or vertiport can be combined using a logarithmic sum of the decibel values

$$DNL_{total} = 10log_{10}(\sum_{i=1}^{n} 10^{(\frac{DNL_i}{10})})$$

In practice, individual takeoff, overflight and landing SEL values are evaluated over an averaged year of operations across a range of aircraft using computer software such as AEDT, AAM or NoiseMap.

In addition to annual average DNL levels, the Federal Interagency Committee on Aviation Noise (FICAN) recommends estimation of the number of awakenings caused by noise. The 1997 FICAN curve estimates this effect as

$$\%\, Awakenings = 0.0087 * \ (SEL_{indoor} - 30)^{1.79}$$

While initially described as a metric to predict awakenings due to individual overflights, the maximum single-event metric has been found to be a good predictor of community response to operations. Setting a maximum target of 5% increase in awakenings yields a maximum indoor SEL of 65 dB. Assuming a building transmission loss of 20 dB, this sets the maximum SEL outside a residence at 85 dB.

SEL values are typically about 10 dB higher than the observed maximum sound pressure level values. A close-by helicopter overflight might be measured with a sound level meter at 75 dB while the SEL value would be 85 due to the duration of the event. It would be 75 SEL if it lasted only one second.

It may be more suitable to perform the analysis on a finer timeline rather than daily. This would use Leqhr values for ambient noise and aircraft sound for each hour, or some group of hours, rather than daily DNL or CNEL values. The result would be more fine-grained analysis, permitting more operations in noisy parts of the day and fewer at night.

c. Ambients

In cases where it is felt that ambient noise levels significantly differ from those given in the table it is recommended that measurements be made. Guidelines for measurement practice can be found in ANSI S12.9 Part 2. If the observed ambient for the area around the site exceeds that listed in Table 1, the maximum recommended DNL noise levels should be increased accordingly. See paragraph 20 for suggestions on measurement techniques.

Community or ambient DNL is computed by measuring average A-weighted sound pressure levels and adding the same offset as for aircraft sounds: 10 dB for noise levels between 10 PM and 7 AM. Measurements using CNEL add 4.77 dB for ambient noise levels between 7 PM and 10 PM.

d. Applications

As outlined in paragraphs 7 and 8, the facility site and related arrival and departure routes should be selected for minimal community noise impact. Examples of this type of preferred route include highways, rail lines, bodies of water, etc. However, it is inevitable that there will be some nearby areas or facilities that may be affected by the helicopter operations. These may include single family residences, apartment complexes, condominiums, schools, churches, and rest homes. One or more of these areas or facilities can be identified from maps and plots for use in determining the noise compatibility of the proposed site. Facilities associated with the operation of the proposed heliport or vertiport itself should not be considered noise sensitive.

D. Noise Calculation Procedures

1. General

The maximum recommended day-night facility noise level is one that does not exceed 4 dB less than the day-night ambient sound levels for the community into which it would be introduced. Three procedures are provided for such assessments. The first of these involves a fixed threshold which, in most cases, will provide sufficient information, particularly where relatively few operations are planned. The second, more detailed procedure requires measurement of ambient sound levels and is tended for those facilites where the first analysis indicates marginal acceptability. The third procedure is used when mitigation is required to avoid exceeding identified acceptability limits.

2. Site/Operational Information

There may be many routes into a heliport or vertiport and all of the potential alternatives should be known in advance of the application and reported. Arrival and departure profiles should also be described. The evaluation should consider the mix of routes and flight profiles which constitute the normal planned operations. If it is known in advance that noise abatement profiles may be needed for particular routes, they should be included in the analysis. All proposed routes should be detailed on a land use map of the area.

Designation of noise sensitive areas and facilities is made by municipal officials from a land use survey of the area surrounding the site. If there are several noise sensitive facilities or areas near the same route, each should be evaluated. Facilities directly associated with the heliport or vertiport operation are excluded.

3. Measurement Method

a. Cumulative noise exposure

The cumulative noise exposure due to aircraft operations is computed for the range of aircraft types and flight profiles proposed using an energy equivalent (integrating) noise metric, DNL. This unit includes the effects of both level and duration of each noise event, the number of events and the increased sensitivity to noise at night. The simplified method allows a tradeoff between the Sound Exposure Level (SEL) and the number of events.

b. Single Aircraft Type and/or Route

Using criteria described above, a recommended maximum number of takeoff and landing events per hour can be developed. The procedure is as follows:

1) Determine the closest point of approach of the aircraft for the nearest flight path (takeoff or approach) to the designated noise sensitive area or facility.

2) Determine the single-event sound exposure level (SEL) by referring to “Report to Congress: Nonmilitary Helicopter Urban Noise Study” https://rosap.ntl.bts.gov/view/dot/9814 or to manufacturers' data for the slant range of the closest point of approach and the appropriate flight condition. If a relationship between noise and slant range is not included in the furnished data, it may be assumed that sound exposure level decreases as ten times the logarithm of the distance ratio $10log_{10}\frac{r}{r_0}$ which is 3 dB per doubling of distance. (Sound pressure level changes by 6 dB per doubling of distance, but sound exposure level is in effect a power measurement summed over time, not a potential measurement.)

3) Confirm that the highest exposure at the closest point of approach does not exceed the 5% awakening value of SEL 85.

4) Derive the average facility DNL value for the proposed number of aircraft operations, as described in paragraph 11. If the facility DNL is at least 4 dB less than the threshold value from Table, the heliport meets the recommended noise criteria.

5) If the analysis indicates marginal acceptability, use of a more detailed method involving comparison with measured ambient noise conditions may be necessary. A proposal may be considered marginal if the proposed number of events is within ten percent of the recommended maximum.

c. Multiple Routes and/or Aircraft Types

If there are several routes and/or a mix of helicopters, the sum of DNL values for all operations can be evaluated for each noise sensitive location as described in paragraph 11.

4. Elevated Facilities

In general, elevated heliports and vertiports, such as those on top of buildings, are evaluated in the same way as grade level facilities. However, care should be taken to use the correct single-event sound exposure levels. The slant range is the direct line-of-sight distance from the noise sensitive location to the aircraft atop the building, not the horizontal distance along the ground.

5. Sound Measurements

While an acoustic measurement program can be undertaken to provide all or part of the data used in the assessment procedures of this document, such programs are often expensive and time consuming. Therefore, they should be undertaken only after all practical analytical assessments have been made. These assessments should have taken into account the many variables affecting the sound level of the aircraft and the peculiarities of the facility application.

Community ambient noise values may be predicted using models of weather and other transportation activity including existing air traffic, but such estimates often fail to capture important local variations and wide area data using the preferred DNL metric is not generally available. An integrating sound level meter meeting the requirements of IEC 61672, Class 1 or

ANSI S1.4, Type 1 is suitable. Class 2 or Type 2 meters can also be used if allowance is made for their increased uncertainty of measurement. ANSI S12.9 Part 4 contains detailed guidance for microphone placement and survey methods.

If helicopter or UAM SEL measurements are deemed necessary, detailed guidance can be found in AC 36-4d and related documents pertaining to aircraft type noise certification, using A-weighted SEL instead of EPNdB. The AC 36 measurements are for specific departure, flyover and approach profiles, which should be changed to the profiles actually proposed for use of the new facility, particularly when new noise abatement procedures are planned.

E. Remedial Actions

1. Alternatives

If analyses or measurements indicate the environmental criteria are not met, the proposal may need to be modified in order to meet them. Such modification may include one or more of the following alternatives:

a) Selection of different arrival and departure routes.

b) Adoption of specific noise abatement piloting techniques. The SEL values provided for standard arrival and departure procedures may result in different levels than with noise abatement techniques. Heliports or vertiports proposing such techniques may find it appropriate to measure the result and use the corresponding SEL values, provided that procedures are in place to assure that routine operations use the identified techniques. This aspect is of particular importance in the case where noise measurements are made during an initial trial demonstration at the proposed site, since the normal operating techniques may not take full advantage of aircraft operational flexibility to further reduce sound levels.

c) Relocation of the heliport/vertiport on the property further away from a noise sensitive facility or area.

d) Construction of a second facility on the site to distribute noise loading between noise sensitive facilities or areas.

e) Erection of barriers to reduce sound propagated into neighboring areas. Noise measurements at noise-sensitive locations may be needed to establish attenuation values different from those assumed in the NPD curves ordinarily used to estimate DNL.

f) Using existing buildings to shield noise from sensitive areas by relocating the facility.

g) Restriction of operating hours to daytime only.

h) Adoption of alternative metrics. The principle of this guidance is that helicopter operations should create not more than a "just noticeable difference" in noise conditions experienced by people nearby. In some cases, the ambient sound or the integrated aircraft sound exposure

over the course of a day cannot be measured accurately using A-weighted DNL metrics. Consideration should be given to partial specific time-varying loudness or other sound-quality metrics that permit accurate assessment of the aircraft sound depending on its ability to blend in with or be prominent in the ambient soundscape.

Other modifications to the heliport or vertiport plan may be possible depending on the particular site, terrain and local conditions. These should be thoroughly studied by all parties involved to arrive at a mutually satisfactory heliport plan. Analyses or measurements should then be repeated with the agreed modifications.

F. References

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