Calgary Airport Authority

Airport Noise Modelling
ACNCC Meeting October 15, 2009

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<td>ACNCC</td>
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<td>DNL or Ldn</td>
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1. Introduction

The purpose of this document is to provide a non-technical reference to the Calgary Airport Authority’s Airport Community Noise Consultative Committee (ACNCC) members in consideration of the noise assessment and modelling elements of the Comprehensive Study Environmental Assessment (EA) for the Calgary International Airport (YYC) Parallel Runway Project (PRP). The noise assessment attempts to predict the long-term impacts through a range of noise descriptors at locations likely to be affected.

In the case of the YYC – PRP development, it is necessary to predict, as accurately as possible, the propagation and distribution of noise and any changes in the propagation and distribution of noise due to the development. Typically these predictions are made using established and tested methods, often derived empirically from real world situations, suitably adapted to reflect the circumstances being considered. This process is known as noise modelling and a number of established modelling software packages are available to do such work.

2. Noise Perception and Metrics

Measured noise levels are rarely steady from one moment to the next, even in quiet situations. Consequently, the science of acoustics has developed a range of different noise metrics that produce single figure values to describe rapidly changing and variable noise conditions, which can be related to the subjective impact of the noise.

2.1 Noise Metrics

Noise metrics, used for the aviation noise assessment, will address the following attributes.

- Capture the absolute or peak noise level of the noise emission source
- Describes the duration the noise is audible at a specific location
- Indicates the degree to which the noise exceeds the ambient noise
- Measure how often the noise occurs
- Accounts for the different impacts of the over flight noise (i.e., in relation to annoyance, sleep and activity disturbance, speech interference, etc.)
- Is easily measured, readily modelled and predicted
- Are readily understood by non-specialists

Currently, there is no single noise metric that has been developed, which can meet all the above requirements. For the purpose of the noise assessment a primary metric will be utilised to address many of the aforementioned attributes. However, those attributes that cannot be addressed by the primary metric, will be addressed using supplementary metrics as described below.
2.2 Core Primary Noise Metric

Day-Night Noise Level (L_{DN} or DNL):
The proposed primary noise index that will be used to assess noise impacts associated with the PRP will be the Day-Night noise level (L_{DN}). This is a 24-hour Continuous Equivalent Noise Level (L_{EQ}) measure with a 10 dBA weighting for any noise events occurring during night-time (2200-0700 hours), when it is considered that peoples’ sensitivity to noise is heightened. This metric can also be used to assess annoyance due to aircraft noise.

2.3 Supplementary Noise Metrics

Supplementary metrics aim to enhance the public’s understanding of aircraft noise impacts. Sole use of a single noise metric may not provide sufficient information for relevant potential noise impacts that need to be adequately assessed or understood by non-technical specialists. Consequently the YYC-PRP study will use a variety of supplementary noise metrics to close these gaps and help explain potential impacts.

The supplementary noise metrics being used are described below.

- **Noise Exposure Forecast (NEF)**
  The NEF descriptor was derived by the USA in the 1960s for use at commercial airports. In Canada, the NEF has been produced to encourage compatible land use planning in the vicinity of airports. The Canadian NEF defines the degree of community annoyance from aircraft noise (and airports) on the basis of various acoustical and operational input data along with a community response survey. It is used to determine acceptable levels for various community and compatible land-use zoning. YYC has existing NEF contours, which were developed in 1979. These contours have been protected under the Municipal Government Act and were reviewed, and supported, in early 2009.

- **Continuous Equivalent Noise Level (L_{EQ})**
  L_{EQ} can be defined as the hypothetical steady sound, which contains the same sound energy as the actual variable sound, over a defined measurement period. L_{EQ} is the most commonly used noise descriptor for all types of noise source, and for aircraft noise its use is widespread across the world. L_{EQ} can be used to assess aircraft noise annoyance, sleep disturbance from overall airport activity at night and impacts on learning.

- **L_{Amax}**
  The maximum instantaneous noise level, or L_{Amax}, created during an aircraft noise event is an indicator of the potential impact on the community since it relates directly, though not uniquely, to the ability of the noise event to interfere with essential human activities, such as speech communication and sleep. The L_{Amax} is the point at which the sound associated with an event reaches its instantaneous maximum intensity in a given period of time. L_{Amax} represents the maximum noise level heard (usually in units of dBA) during a single aircraft event (such as a flyover during an arrival or departure). While the duration of an aircraft noise event near an airport is generally within the 15 to 50 second range, the instantaneous noise level is at or near the L_{Amax} for only a few seconds.
• **Sound Exposure Level (SEL)**

While the most intense instant during an aircraft noise event is defined by its LAmx, to fully describe the event and its potential for noise impact, its duration must also be accounted for. During a typical event, the noise level at a fixed point is constantly changing – gradually rising to its LAmx and then gradually falling. An appropriate descriptor of such a noise event is then one that reflects the total sound energy associated with the noise event. The SEL is a function of both intensity and duration, whereas the LAmx is a function of intensity only. SEL is a noise metric derived from the noise energy dose of a single sound event such as a single vehicle or train compressed to a single second of exposure. As such, the SEL reflects both the maximum sound level and the duration, or length of time, of the sound event. SEL measures the subjective loudness, expressed as the energy of the event, as it would be experienced in a one second interval. As a result, the SEL of a given noise event is greater than its LAmx.

The normalization, to the fictional duration of one second, enables the comparison of noise events with differing true duration and/or maximum level. Additionally, since it is a cumulative measure, a higher SEL can result from either a louder or longer event, or some combination. As SEL combines an event’s overall sound level along with its duration, it allows a direct comparison between noise events because the sound energy is compressed into a single second.

• **Time Above (TA) and Number Above (NA)**

The amount of time that noise levels are greater than a given threshold noise level. TA analysis is expressed as the number of minutes in a certain time period (typically the average annual day) that noise created by aircraft operations exceeds a specified A-weighted decibel level. The TA metric can be applied to any period of the day, such as local school hours. The results of a TA analysis are displayed as an overlay of contour lines.

NA metric shows the average number of events above a specified maximum decibel level, or threshold, for a given period of time. NA is also expressed as contours with each contour line representing the average number of expected events above the specified A-weighted decibel level during the selected time period. The number of events in areas between the contour lines would fall somewhere in the range between the two contour lines.

When TA and NA contours are presented, the public receives an indication of the amount of time airplane noise exceeds the specified level and the number of times each day that noise exceeds the specified level. The threshold levels are flexible and are selected at the discretion of the airport and the community stakeholder groups to meet our EA noise assessment objectives.

2.4 **Noise Levels, Foot Prints, and Contours**

Noise footprints showing the spread of noise from an individual aircraft are useful for comparing how noisy different aircraft are. However, to describe the noise impact over an area, a study needs to take account of all aircraft overflights during a day or night period. This is done by developing noise contours formed from lines joining areas of equal noise level based on aggregating all noise from all aircraft movements during the assessment period.
Noise contours help to quantify the extent of aircraft noise exposure and serve to illustrate its geographical distribution. The total impact is summarised in terms of the area and number of people/households enclosed by noise contours. Contours can be used to compare situations at different times, different places and under different circumstances.

It is important to note that aircraft noise can still be heard outside of a noise contour, or footprint, but at a lower level and less impact than at or within the contour. Figure 1 provides an example of an airport noise contour for a major international airport.

**Figure 1   Example of an Airport Noise Contour**
3. Noise Modelling

Modelling means calculating noise exposure rather than measuring it. The need to determine airport associated noise levels has led to the development of various aircraft noise exposure models. These are computer programs that calculate noise contours around an airport based on the aircraft traffic numbers, the aircraft types and the way in which aircraft are operated.

Modelling aircraft noise involves combining the noise from many individual aircraft movements. All the different types of aircraft and operations have to be taken fully into account, including their specific noise and performance characteristics following different flight paths during arrivals and departures.

Most models calculate noise exposure levels over a matrix of grid points around the airports. Contours are then fitted to these levels by mathematical interpolation between grid points. These models need input information on aircraft performance and noise characteristics. Direct measurements of noise and flight paths are made, but an important source of data is noise measurements collected by aircraft manufacturers as part of the legal certification process.

3.1 Noise Certification of New and Upgraded Aircraft

Because air travel is international in scope, the International Civil Aviation Organization (ICAO) was formed to develop acceptable standards for the aviation industry. Noise certification standards were developed to limit noise at the source – the aircraft.

International standards and operating procedures for aircraft noise certification are developed by working committees of ICAO and referenced in the legislation of the member countries to which Canada is a member state. Civil aircraft using Canadian airports have to meet noise certification requirements agreed by an international treaty contained in ICAO Annex 16.

ICAO Annex 16, Part II classifies jet planes, propeller-driven airplanes and helicopters in terms of their noise certification in several different “chapters” (or stages in the USA), which can be summarised as follows:

- **Unclassified** – the first generation of jet aircraft, which are now banned by international agreement (with rare exceptions). For example the Trident, Comet and Boeing 707;
- **Chapter 2** – the older, noisier aircraft which have been phased out or upgraded. For example the BAC1-11, Boeing 727 and Boeing 737-200;
- **Chapter 3** – the more modern, quieter aircraft. For example the Boeing 757, Boeing 767, Boeing 737-300 and Airbus 310; and
- **Chapter 4** - the modern jet and propeller aircraft. These include the Advanced Turbo Prop and ‘Shorts’ (aircraft with short take off & landing capability).

New noise certification standards are added to Annex 16 as they are developed. The higher the ‘Chapter’ number the lower the certified noise limits. For example, in 2001, ICAO set a new set of standards – called ‘Chapter 4’ which prescribed that from 2006, all new aircraft must meet Chapter 4 standards,
which is more stringent than the then current Chapter 3 standard. Chapter 3 aircraft are themselves again quieter than their predecessor, ‘Chapter 2’, which is now banned in Canada from most operations\(^1\).

### 3.2 Airport Noise Model Methodologies

The objective of noise modeling is to provide a ‘snapshot’ of the potential the noise environment prior to the project development and compare that to impacts post development. A noise model may be thought of as a “black box” which operates on input data, describing the airport and its air traffic, to produce an output in the form of sound levels at discrete points (usually on a calculation grid. Figure 2 below describes the basic elements of the noise modelling system.

**Figure 2  Elements of a Noise Modelling System**

During modelling air traffic is broken down into aircraft types or categories with different noise and performance characteristics which have to be stored in the aircraft database. To minimise computation, individual aircraft types having very similar noise and performance characteristics can be grouped into representative categories.

\(^1\)There are two Chapter 2 aircraft operational in Canada. These aircraft, Boeing 737-200, are operational for the exclusive use on gravel runways in northern Canadian locations.
4. The Integrated Noise Model (INM)

The USA Federal Aviation Authority produces the INM, which is the most commonly used airport noise model in the world. The INM is a computer model that generates data on aircraft noise levels in the vicinity of airports. It uses aircraft operational data e.g. weight, flight paths and profiles to estimate noise levels; accounting for specific airport operation modes, aircraft engine thrust settings, source-to-receiver geometry, acoustic directivity and other environmental factors. The INM can calculate exposure, maximum-level and time-based noise contours, as well as levels at pre-selected locations. The INM contains an extensive database of the noise attributes of aircraft, and is flexible enough to allow data from new aircraft or aircraft types to be inserted.

The INM can be used for:

- Assessing current aircraft noise impacts around a given airport or heliport;
- Assessing changes in noise impact resulting from new or extended runways or runway configurations;
- Assessing changes in noise impact resulting from new traffic demand and fleet mix; and
- Evaluating noise impacts from new operational procedures.

The required inputs to the INM include the following.

1. Airport characteristics (runways, orientation, etc.)
2. Peak planning day
3. Approach and departure profiles
   - Procedural (aerodynamic based profiles)
   - Fixed point profiles
4. Flight tracks
   - Approach
   - Departure
   - Touch-and-go
   - Circling
   - Overflights
5. Flight operations
   - Numbers and types of aircraft assigned to each track
   - Percent aircraft assigned to each track
   - Run-up operations (engine test operations)

The INM is flexible and whilst most inputs have default options within the software, they can be varied to take into account the specific scenarios encountered at a particular airport, for each aircraft type to be included in the assessment.

Outputs from the INM can include:

- Noise contours (contours of equal values of a noise e.g. $L_{DN}$, $L_{max}$, SEL, $L_{eq}$ etc)
- Receptor point calculations (i.e. noise levels at a specific location)
• Population living within a given specific noise metric (i.e. how many people live within the DNL 55 etc. contour)

As with any modelling system the variability of the INM output is strongly dependent on the quality of the input. Consequently, significant effort will be expended in obtaining valid input data relevant to the operations at YYC and ensuring high quality data.

4.1 Noise Model Validation

As well as careful selection and quality assurance of the input data, the validation of an airport noise model is important in order to understand the uncertainty associated with model and to minimise error. For an airport expansion scheme this is usually done by comparison of the preliminary baseline model outputs with monitored noise levels at specific locations. Where the variability between modelled and measured noise levels is unacceptable, the inputs to the model can be changed so that the outputs reflect the measured noise levels. Figure 3 provides a description of how an airport noise model can be validated.

Figure 3  Validation of an Airport Noise Model
5. Airport Operations and Flight Paths

5.1 Airport Characteristics

Figure 4 depicts the Calgary International Airport’s existing Airfield System. The Airport has three intersecting runways:

1. Runway 16/34, 3,863 m (12,675 ft) long
2. Runway 10/28, 2,438 m (8,000 ft) long
3. Runway 07/25, 1,890 m (6,200 ft) long

Runway 16/34 is YYC’s principal runway and is capable of managing all aircraft that operate out of YYC. Runway 10/28 is the secondary runway and is used by most aircraft that operate with the exception of some larger aircraft. Due to Runway 28’s length, larger aircraft types are limited to shorter range or reduced payload operations. Runway 07/25 is used predominantly by smaller general aviation aircraft that typically operate out of the south end of the airport. Runway 07/25 lacks parallel taxiways thus limiting its use as a runway.

In suitable wind conditions, YYC uses Runways 34 and 28 in combination, for arriving and departing aircraft. Normally, aircraft will arrive and depart, in combination, to both Runway 34 and 28. Runway 07/25 is usually used by general aviation aircraft.

The existing airfield has now reached full potential with little capacity improvements available, with the exception of the new parallel runway. To represent this near capacity situation modellers will be using the 90th Percentile Peak Planning Day.
5.2 90th Percentile Peak Planning Day

In order for the study to assess the airport operating close to its busiest, the aircraft data used in predicting noise levels will be derived from the number of air traffic movements and fleet mix for the 90th percentile peak planning day. The projected busy day schedule is shown in Figure 4 and is based on the 90th percentile (36th ranked) busiest day identified from 2008 flight logs provided by NAVCANADA. The peak planning day has been projected to 2015 and 2025 by forecasting daily movements provided by Transport Canada anticipated growth forecast for annual aircraft movements at YYC.
The current schedule is characterised by a morning departures peak starting around 7am and extending to around 9am (with relatively few arrivals). In the afternoon there is an arrivals peak commencing around 4pm, closely followed by an evening departures peak around 7pm. There is a level of overlap between the extended afternoon arrivals peak and the evening departures peak. This same hourly demand pattern is found in the projected schedules for 2015 and 2025, which include the construction and operation of the PRP.

5.3 Aircraft Flight Profiles - Arrivals & Departures

Aircraft flight profiles exist within INM for a number of different aircraft variants. Flight profiles are created in INM by setting up a number of points along a flight path with speed, altitude, and thrust settings of a particular aircraft.

Profiles need only be created for aircraft variants with either a significant amount of movements or those that create a significant amount of noise.

5.4 Aircraft Flight Paths – Lateral Track Dispersion

When aircraft depart an airfield, they are subject to lateral track dispersion – or splay. Track dispersion is the inability of an aircraft, when on departure, to maintain the exact same flight path across the ground below as other aircraft. Track dispersion witnessed by the observer, on the ground, to deem the aircraft off course in comparison to other flights. It is important to understand that aircraft are un-tethered objects and are independent of other motion and are affected by wind conditions.
Track dispersion needs to be accounted for in noise by using the dispersed track function available within INM. This enables the noise model to account for the lateral dispersion across the ground of aircraft tracks about the mean flight track. By incorporating representative real data from the YYC AirScene.com® Flight tracking Environmental Management System, (AirScene.com®) and the potential future flight paths with the PRP in place will enable the noise model to account for lateral dispersion across the ground from a defined the mean flight track.

5.5 Aircraft Types and Variants

The INM database, while extensive, does not contain details on every aircraft variant that use YYC. There were 437 different variants of aircraft used at YYC in 2008, with the most common and noisiest of these aircraft dominating the noise environment from the airport. Consequently, the noise assessment study will focus on creating customized noise data profiles only for aircraft that either creates a significant amount of noise or have a significant number of movements (i.e., the loudest aircraft, and those aircraft with the most movements due to their tendency to dominate noise at airports). The remaining aircraft, that have little influence on overall noise levels, are grouped together under the assumption that these aircraft types are all equivalent to the loudest aircraft type.

5.6 Runway Modal Split Study

The direction in which aircraft arrive and depart from the airport is largely affected by meteorological conditions (e.g., wind). Because aircraft noise levels vary between departure and arrival, the noise from the airport is different depending on the runway mode of use. The runway modal split study will be designed to show how different modes of operation (arrival or departure activities) on existing runways, and the proposed parallel runway, would affect noise levels in the area under varying meteorological conditions.

In addition, the way in which the airport operates each runway can affect noise production, so as a minimum, the study will involve three scenarios for each of the following scenarios.

Departures to the south
Departures to the north

The three scenarios that will be modelled will include the following.

1. Maximum movements on the existing main runway and minimum movements on the proposed parallel runway.
2. An even split of movements on the main runway and the proposed parallel runway, minimum movements on the existing runway and maximum movements on the proposed runway.
3. Maximum movements on the proposed parallel runway and minimum movements on the existing main runway.
5.7 Contour Calculation

INM gives the noise modeller the ability to adjust the way in which noise contours are calculated. This, in turn, affects the accuracy and validity of contours produced. The INM default values can result in noise exposure contours that contain artefacts or unwanted by-products of the calculation process. These artefacts manifest as asymmetries and irregularities in contours.

The best way of avoiding calculation artefacts is to use a finely spaced calculation grid in the model. We will therefore set the model’s parameters so as to optimise the accuracy of the INM output, balanced against the increased calculation times and the amount of data generated.

5.8 Things to Consider

When modelling aircraft noise, models can never be truly accurate in all circumstances. There are always variables for which data is not available or is not possible to input into the INM with absolute precision. It is easy to get lost in the data when these details do not have a noticeable effect on predicted noise levels. The key to creating an appropriate noise model is finding a balance between having a high level of detail for the data with the most significant impact on the model output and averaging the data that is less significant.