INM Version 6.2 Software Update

05/19/2006

Version Information

INM Version 6.2 is a software update to Version 6.1. You must already have INM Version 6.0, 6.0a, 6.0b, 6.0c or 6.1 to use this software update. If you do not have one of these previous versions, you can order a CD-ROM containing INM 6.0 by downloading the INM Order Form from the FAA web site at:

http://www.faa.gov/about/office_org/headquarters_offices/aep/models/inm_model/

After installing INM 6.0, you can download the INM 6.2 software update, which contains all previous updates.

The Version 6.0 User's Guide is the current manual for INM Version 6.2 software. The Version 6.0 Technical Manual is the current technical description of the methods used by INM 6.2 to calculate aircraft noise around airports. Release notes *Inm60a.pdf*, *Inm60b.pdf*, *Inm60c.pdf*, *Inm61.pdf* and this document, *Inm62.pdf*, record the changes to INM since the User's Guide and Technical Manual were published.

Installation Instructions

1. Use MS Windows to make a copy of your existing *INM6.1*directory. Select your *INM6.1* directory and, using the Windows File Manager under the "Edit" menu, select "copy" and then select "paste". This will create a new directory called "*Copy of INM6.1*".

2. Use the right button of your mouse to select the *Copy of INM6.1* directory created in step 1. Select "Rename" and rename the directory *INM6.2*. Make sure that the attributes for the new *INM6.2* directory as well as for all sub-directories and files are <u>not</u> set to "Read-only".

3. Download the *INM62.EXE* file from the FAA Web site. Put it in the new *INM6.2* directory.

4. Double click on the *INM62.EXE* file name to automatically extract the updated files into the new *INM6.2* directory. Select the "Unzip" button. This process will overwrite the old INM 6.1 files and replace them with those required for INM 6.2. The distributed files are presented in Table 1:

Table 1. INM 6.2 Files

File	Date
inm.exe	**05/18/2006**
compute.dll	**05/18/2006**
graph.dll	**05/18/2006**
compu50.dll	**05/18/2006**
winutil.dll	**05/18/2006**
GlobalMapperInterface.dll	**06/10/2004**
GmMpz.dll	**09/05/2003**
NCScnet.dll	**05/18/2003**
NCSEcw.dll	**05/18/2003**
NCSEcwC.dll	**05/18/2003**
NCSUtil.dll	**05/18/2003**
gmdll_regkey.txt	**02/09/2004**
inm60a.pdf	05/19/2000
inm60b.pdf	01/16/2001
inm60c.pdf	09/07/2001
inm61.pdf	02/27/2003
inm62.pdf	**05/19/2006**
helo\HeloExample*.*	**------**
helo\Helicopter.pdf	**05/17/2006**
helo\hnmgrd.cfg	08/27/2002
helo\HnmGrd.exe	05/18/2006
sys_data*.dbf (12 files)	**05/18/2006**
sys_data\acdb60.bin	**05/18/2006**
sys_data\spectra.bin	**05/06/2005**
sys_dbf\pop_conr.dbf	**07/24/2003**
examples\test50.**	------
examples\test50_import.**	------
examples\test411.**	------
Process\census\census2000.cfg	05/07/2002
process\census\Census2000.exe	05/18/2006
process\census\Census2000.pdf	07/24/2002
process\census\fipscode.dat	**03/15/2005**
process\census\fipstate.dat	**03/15/2005**
process\census\shapefile.dbf	11/09/2001
process\census\shapefile.track.dbf	**04/30/2003**
process\census\Tiger2000.exe	**05/18/2006**
process\census\tiger2000.cfg	04/29/2002
process\dxf\CadCvrt.exe	05/18/2006
process\dxf\cadvrt.cfg	08/18/2005
usr_data\sys_aprt.dbf	02/03/2003
usr_data\sys_rwy.dbf	02/03/2003
usr_data\bad_rwy.txt	01/28/2003
usr_data\loc_pts.dbf	01/28/2003
utility\Alaska3CD.exe	05/18/2006
utility\PopConr.exe	05/18/2006
utility\Utility.pdf	**03/30/2006**

File	Date
utility\WriteCpBin.exe	05/18/2006
utility\SpectralcutoffCalculator.exe	**02/01/2006**
utility\spectral_cutoff_cases.txt	**02/15/2005**

Items in bold are new or updated for INM 6.2. Other files are new to INM updates since the release of INM 6.0.

SUMMARY of INM 6.2 Updates

The Federal Aviation Administration, in cooperation with other agencies, has been engaged in research activities designed to improve noise modeling for aviation projects that require environmental noise analysis and disclosure. The majority of this research is performed under the Society of Automotive Engineers Aircraft Noise Committee (SAE A-21). These activities are closely coordinated with similar groups within the European Civil Aviation Conference (ECAC) and the International Civil Aviation Organization (ICAO). INM 6.2 includes several changes related to aircraft noise/performance for commercial aircraft and the modeling of aviation noise over national parks. New acoustic modeling procedures related to audibility have been added to INM 6.2, which are outside the applicability of the core SAE, ECAC and ICAO modeling documents, and are not intended for use in traditional airport and aircraft noise analyses. These capabilities have been developed to address special conditions in national parks that may contain very low level ambient sound level conditions and require the collection of ambient data. Although outside the applicability of the core SAE, ECAC and ICAO modeling documents, the new procedures were recently evaluated under the auspices of the Federal Interagency Committee on Aircraft Noise (FICAN). FICAN specifically studied the performance of INM 6.2 for modeling audibility in Grand Canyon National Park and found INM 6.2 to be the best practice modeling methodology currently available. The full FICAN finding and report[i] are available at http://overflights.faa.gov/.

Commercial Aircraft Noise/Performance Database

Review of the core INM noise and performance database has shown that certain aircraft have grown in maximum allowable takeoff weight, operating range and thrust setting since the database was developed in the late 1980's. This release of INM updates nine aircraft types to better reflect the current "in-service" fleet. The INM **737300**, **7373B2**, **737400**, **737500**, **757PW**, **757RR** and, **777200** have been updated to reflect growth in maximum allowable takeoff weight and engine thrust since data for these aircraft were produced for previous versions of INM. The **747400** and the **737700** data have been re-derived to follow the same rules as used for current aircraft (see ***Appendix A - Updates to INM Noise/Performance Database***). While individual stage weights have been reduced for the **747400**, the overall range of operating weights remains the same and users still retain the capability to model the **747400** over its entire operating range, including the maximum allowable takeoff weight. ***Appendix A*** provides general overview of the guidelines FAA and Eurocontrol have been developing to harmonize model data across manufacturers. In many cases, the aircraft STANDARD procedure has been modified from an "ICAO B"-like procedure to a procedure that has cutback power at 1,000 feet AFE. This may lead to a reduction in contours. The ICAO B procedure is still retained as core standard data and users may directly choose an ICAO B procedure to be consistent with previous studies.

Additional database modifications and updates are presented in the ***National Parks Noise Database Enhancements*** and ***Database Modifications*** sections of this document.

Noise Modeling for National Parks

In 1996, the Federal Aviation Administration began conducting studies to assess Special Flight Rules in the vicinity of Grand Canyon National Park (GCNP). These studies provided noise disclosure assessments under NEPA that required noise models capable of evaluating a broad area for both fixed-wing and helicopter operations, using metrics not contained in the standard release of INM. Since 1996, studies requiring these capabilities have continued with FAA analysis performed using special research or application-specific versions of the INM. The FAA has updated its current release of INM to make these modeling capabilities publicly available. Primary updates to INM to support national parks modeling include an expansion of the noise/performance database to include more general aviation aircraft and the inclusion of supplemental metrics that have been used in analysis of GCNP. Validation studies have highlighted the need to further enhance INM to include more detailed terrain data and the ability to model line-of-sight blockage. A more detailed description of these enhancements is included in the release notes below.

The FAA's immediate use for INM 6.2 is to complete the aircraft overflight noise analysis of GCNP to assess the substantial restoration of natural quiet and to perform noise analyses for air tour management plans in other national parks, as required by US law. The National Park Service (NPS) is particularly interested in the ability to calculate Time Audible for national parks. The FAA has not established a preferred supplemental metric or metrics for national park noise analysis, and these enhanced INM capabilities should not be presumed to constitute an endorsement of these particular metrics over others. Neither should aircraft audibility, when calculated, be presumed to be a measure of an adverse or significant impact. The FAA, in consultation with the NPS, will advise on the use of metrics for national park noise analysis on a case-by-case basis until standardization is achieved based on further technical and scientific review. In accordance with FAA Order 1050.1E, *Environmental Impacts: Policies and Procedures*, offices within the FAA must consult with and receive approval from the FAA Office of Environment and Energy in determining the appropriate supplemental noise analysis for use.

New Noise Metrics

In support of noise modeling for US National Parks, two new noise metrics have been added to this public release of INM: Time Audible (**TAUD**), which is the amount of time that aircraft are audible, and Change in Exposure (delta dose or **DDOSE**), the change in noise exposure associated with aircraft operations (i.e., the arithmetic difference between aircraft noise exposure and ambient sound level). The user also has the ability to calculate the Percentage Time Audible (**%TAUD**) for a specific time period, such as 24 hours, or a shorter period representing a time in which an area may be subjected to aircraft overflights. These metrics have been used in US studies related to national parks and are made publicly available with the INM 6.2 release. As noted above, their inclusion should not be presumed to constitute an endorsement of these particular metrics.

Ambient Noise Levels for National Park Analysis

New metrics, including Time Audible (**TAUD**) and Percent Time Audible (**%TAUD**), require the use of a specialized file that provides representative ambient noise levels for grid locations throughout the park. **TAUD** metrics also require the collection of one-third octave band spectral ambient data. Ambient data files already exist for some national parks. Before initiating ambient data collection, check with the FAA Office of Environment and Energy for existing data. As of May 2006, ambient sound level data have been collected in the following parks:

- 4 national park units in Florida:
    - Biscayne Bay National Park,
    - Everglades National Park,
    - Crocodile Lake National Wildlife Refuge, and
    - Big Cypress National Preserve;
- 6 national park units in Hawaii:
    - Hawaii Volcanoes National Park,
    - Haleakala National Park,
    - Kalaupapa National Historical Park,
    - Kaloko-Honokohau National Historical Park,
    - Pu`ukohola Heiau National Historic Site, and
    - Pu`uhonua o Honaunau National Historical Park;
- Acadia National Park;
- Arches National Park;
- Badlands National Park;
- Bryce Canyon National Park;
- Canyon de Chelly National Monument;
- Canyonlands National Park;
- Denali National Park and Preserve;
- Devils Postpile National Monument;
- Glacier National Park;

- Grand Canyon National Park;
- Grand Teton National Park;
- Great Smoky National Park;
- Hovenweep National Monument;
- Lake Mead National Recreation Area;
- Mount Rushmore National Memorial;
- Muir Woods National Monument;
- Natural Bridges National Monument;
- Navajo National Monument;
- Petrified Forest National Park;
- Point Reyes National Seashore;
- Sequoia & Kings Canyon Parks;
- Whitman Mission National Historic Site;
- Yellowstone National Park;
- Yosemite National Park (on-going);
- Yukon-Charley Rivers National Preserve; and
- Zion National Park

The collection of ambient data is a resource-intensive process and should be performed in consultation with the FAA and the NPS. The FAA and the NPS have worked to develop recommended procedures for collecting ambient data. Users are advised to follow the guidelines given in the Air Tour Management Program (ATMP) ambient guidance for air tour proposals[ii]. A documented example that demonstrates the ambient guidance is provided in the report; *Baseline Ambient Sound Levels in Mount Rushmore National Memorial*[iii]. Follow-up questions on guidance for ambient data collections may be directed to the sources and contacts given in the ambient guidance[ii, iii]. Additional similar guidelines are being developed for ambient data relative to proposals other than air tour management, e.g. airport development.

Table 2 shows the different types of ambient files that are used for each of the special metrics. For legacy purposes, **Time Above** metrics (**TALA**, **TAPNL**, and **TALC**) utilizes either a 2 digit ambient grid file as described in Section 10.1 of the *INM 6.0 User's Guide*, or a new 3 digit version of ambient grid file. **DDOSE** requires the 3 digit ambient grid file, and will not work with the older 2 digit file format. **TAUD** requires a binary ambient file, that is a combination of the 3 digit ambient grid file and an ambient spectral map file, which correlates unique spectra to each ambient sound level specified in the ambient grid file. This binary file merges spectral data with cumulative levels and is produced by error-checking software at FAA. Users requiring use of the **TAUD** metric must submit their ambient data to FAA in accordance with the procedures given in ***Appendix B – Ambient Data Input Files***. FAA will perform a consistency check and return a binary file for use with the project. Once produced, the file may be used indefinitely and transferred as any other publicly available data source.

Table 2. Metric-Specific Ambient Files in INM 6.2

Metric	**Ambient Files**		
	2 Digit Ambient Grid File (*.txt*)	**3 Digit Ambient Grid File (*.txt*)**	**Binary Ambient File (*.bin*), comprised of Ambient Grid and Spectral Map Files**
TALA	**Yes**	**Yes**	*No*
DDOSE	*No*	**Yes**	*No*
TAUD	*No*	*No*	**Yes**

These different ambient files will be discussed in more depth in the following sections and ***Appendix B***.

INM Users should note that the **TAUD** metric cannot be run with the ambient grid file (*.txt*), and **DDOSE** and the **Time Above** metrics cannot be run with the binary ambient file (*.bin*). Furthermore, **Audibility** is not an available option under **Run // Run Options // Run Type** unless the study-specific binary ambient file is referenced in **Setup // File Locations // Ambient Noise File**. To avoid problems with ambient files for a particular INM Study, careful recordkeeping is needed to insure that the correct ambient file is referenced for each metric.

Ambient Screening Analysis

The ambient data collection described in the ambient guidance[ii, iii] may be a costly and resource intensive process. To assist in the determination of the need for ambient data collection, INM provides an ambient screening capability that assumes no ambient noise (i.e., no ambient levels higher than the Equivalent Auditory System Noise (EASN) threshold) for the evaluation of TAUD. The user may utilize this capability to determine if any operations for a given case are audible for the user-specified study area (see ***Appendix C – Calculating Audibility***). If the ambient screening procedure indicates aircraft sound levels are not audible for the entire user-specified study area, and no other ambient-dependent metrics (e.g., TALA and DDOSE) are required in the analysis, ambient sound level measurements are not needed.

Ambient Screening is performed by running an INM case and selecting **Ambient Screening** from the drop down list in **Run // Run Options**, under **Run Type**. Screening should be performed with all run options, including terrain, that would be applicable to the full study. The new terrain options available in INM 6.2 are described later in the release notes. After the selection of Ambient Screening, save the record and exit the Run Options window. To perform the ambient screening go to **Run // Run Start**, and run the noise computations for the case as you would for a normal INM computation. To view the results of the screening analysis, go to **Output // Output Setup**. Under **Metric**, select **SCREEN** (new to INM 6.2) to identify all cases for which the user has selected "Ambient Screening" under **Run Options** above. Exit the window and go to **Output // Output Graphics**. A map will appear that shows up to 2 types of priority zones based on the audibility criteria. Green zones do not have audible aircraft sounds (based on use of the EASN only), whereas red zones do have audible aircraft sounds. As this map is only intended for screening purposes, the minimum size of a priority zone is fixed as a 0.5 nmi square. This map may be exported to a GIS system and used to establish priority for ambient data collection (i.e., ambient data collection is not necessary in green zones, but may be necessary in red zones).

The use of the EASN threshold is considered to be the most conservative modeling assumption and is used for screening purposes only. The EASN threshold is presented in both a figure and in tabular format at the end of ***Appendix C – Calculating Audibility.***

Using TAUD and DDOSE in INM

TAUD and **DDOSE** have been used in research versions and are now merged into the INM 6.2 in a way that does not require modification to the underlying database that contains the inputs to INM studies. No special conversion software is necessary.

The use of **TAUD** requires that a binary ambient file be loaded into INM. **TAUD** will not be available for use without that study-specific binary ambient file. See ***Appendix B*** for instructions in creating and obtaining this file. Once loaded, the **TAUD** option becomes available for use in INM. **TAUD** is calculated using a procedure similar to Ambient Screening defined above. In **Run // Run Options**, under **Run Type**, select **Audibility** from the drop down list.

The **DDOSE** metric may be selected through the Noise Metric drop-down list in the Run-Options window for each INM Case, using **Noise Metric // DDOSE**. It is not available for selection under the Grid section of the Run Options window and therefore grid point values can only be calculated for one of the two new metrics during each CASE run.

In order to run both **TAUD** and **DDOSE** for a particular INM Study, it is necessary to create two separate cases (e.g., BASE_2005_TAUD and BASE_2005_DDOSE) and run each case separately with the appropriate metric-specific ambient file referenced in **Setup // File Locations // Ambient Noise File**.

Upon selecting **TAUD** or **DDOSE**, the user may run INM to produce results using these metrics. **TAUD** and **DDOSE** values can be produced for Standard and/or Detailed Grids. The values will appear in the Metric column of the Standard Grid report. The two metrics will be treated as any other metric in the Detailed Grid report. In summary, **TAUD** and **DDOSE** behave just like ordinary user-defined metrics that have been created to be part of the INM 6.2. The specifics on using **TAUD** and **DDOSE** are given below.

INM - TAUD

Audibility compares aircraft noise against background noise to determine if noise may be detected by a human observer with normal hearing who is actively listening for aircraft noise. The process is based on detectability theory along with research that has assessed human detectability under different environments. ***Appendix C – Calculating Audibility*** provides additional specifics on the theory and background. Audibility requires highly detailed inputs and results may be very sensitive to the quality of input data. Guidance on developing these inputs (i.e. an ambient map file) is still being developed and subject to further scientific review. Accounting for background noise requires an ambient file. The *INM 6.0 User's Guide* as well as ***Appendix B*** of these User's notes address the mechanics of importing an ambient map file.

Users wishing to calculate **TAUD** should first contact the FAA Office of Environment and Energy for guidance on the applicability of a **TAUD** analysis to specific aviation proposals. Given 1) the anticipated process for collecting ambient data, 2) the sensitivity of **TAUD** to ambient data, and 3) the need for consistency between input files, the FAA will provide binary ambient files on a project basis for use in Federal projects.

In order to acquire a special binary ambient file, the user will first need to generate a modified version of the ambient file accompanied by a second file that contains one-third octave spectral information mapped to a cumulative A-weighted sound level. The first file is the 3 digit ambient grid file, a text grid file that assigns a number, often representing the A-weighted ambient sound level, to study area grid points. The second file is the ambient spectral map file, which correlates unique spectra to the ambient sound levels specified in the ambient grid file. The data in these two ambient files are described in ***Appendix B*** and should first meet the criteria specified in the ambient guidance[ii, iii]. After reviewing the two ambient files, the FAA will generate the corresponding, study-specific binary ambient file (*ambient.bin*) and send it to the user. Only by using this FAA generated binary ambient file may **TAUD** be utilized in INM. Once the *ambient.bin* file has been loaded, and the **TAUD** option becomes available for use in INM, the user may select **Relative Threshold** within **Grid Setup** in order to calculate audibility based on spectral ambient data. An ambient file was first introduced in INM 6.0 to support a metric for time above an ambient level (**TALA**) and it is described in Section 10.1 of the *INM 6.0 User's Guide*. While this file may still be used to support **TALA** calculations, the ambient file format has been modified for **TAUD** computations.

Percent Time Audible (**%TAUD**)

The user may calculate the percentage of time that aircraft are audible. This function is enabled by selecting the **Do Percent of Time** check box in the **Grid Setup** window. A time period of 24 hours is used as a default for **%TAUD**, and appears in an input box next to the **Do Percent of Time** check box. However, this value may be changed to a user-specified time period over which to calculate the percentage by changing the value. For example, if the user selects 12 hours, **%TAUD** will be referenced to 12 hours, with 100 **%TAUD** being the equivalent of 12 hours.

It is important to note that when calculating **TAUD**, that the INM audibility calculations do not directly account for overlapping aircraft operations. If all or a portion of the audibility of two unique aircraft overlap in time the model will overpredict audibility. Overprediction is likely in busy operational environments where multiple aircraft are audible simultaneously. For this reason **TAUD** is capped for both **Contour** and **Standard Grid** output at 100% using a default of 24 hours (or 1440 minutes). **TAUD** remains uncapped for **Detailed Grid** output, so it may be utilized as a diagnostic tool (e.g., At grid point X, Aircraft A contributes 1200 minutes TAUD and Aircraft B contributes 670 minutes TAUD, yielding 1870 minutes or 130% TAUD, whereas a capped metric would only yield 1440 minutes or 100% TAUD).

For user-specified time periods other than 24 hours, TAUD will be capped (for **Contour** and **Standard Grid** output) at 100% in accordance with that time period. For example, if the user selects 12 hours, **TAUD** will be referenced to and capped at 12 hours (or 720 minutes). A single input box is provided for inputting a user-specified duration for **TAUD** and **Time Above**. This duration input box is accessed by selecting the **Do Percent of Time** check box in the **Grid Setup** window, and modifying the duration of time over which to calculate **TAUD** and **Time Above**. For time based metrics (TAUD in minutes), the **Do Percent of Time** check box is then unselected after the duration has been modified. Although, unselecting the **Do Percent of Time** check box causes the duration of time input box to disappear, the user-specified time is retained by INM.

Spectral Distance Cutoff Utility for Time Audible

A utility to maximize run-time efficiency in the calculation of **TAUD** has been added to the model. The spectral distance cutoff utility, presented in detail in ***Appendix G – Spectral Distance Cutoff Utility for Time Audible***, allows the user to ensure that time audible calculations are not performed for excessively large slant distances, in particular those for which audibility will not be predicted. The spectral cut-off calculator assumes the most conservative case for propagation (i.e. the case with the minimum attenuation between the source and the receiver, which include the use of the SAE atmosphere and without line-of-sight blockage).

Track Segment Length Considerations

The INM's basic algorithms use energy-based Noise-Power-Distance (NPD) curves to calculate the desired noise metric. The *INM 6.0 Technical Manual* Appendix C describes how the INM uses energy-based NPDs to calculate time-based metrics such as time above. While the INM uses a number of assumptions about how to convert the energy-based data to time-based metrics, comparisons of field-measured and INM-modeled **TAUD** values show good agreement (see the full FICAN finding[i] at http://overflights.faa.gov/). However, note that the INM assumes during the calculation of the time-based metrics that conditions are constant over each of the particular track segments that comprise a flight track. This means that the INM uses the conditions at the closest point in the track segment and applies those conditions to the entire track segment. Users should note that long track segments may introduce errors in time-based metric computations if the conditions over a track segment vary considerably. In particular, track segments of excessive length may lead to over-prediction of the Time-based metrics if the conditions at the closest point lead to a condition above the threshold criteria (such as audibility), while the conditions at the most distant point(s) of the segment do not exceed the criteria. In this case, even though only part of the segment actually met the criteria, INM treats the entire segment as having met the criteria. This issue may be exacerbated when considering line of sight blockage in INM. For instance, if the closest point of approach to an excessively long track segment is not blocked, when considering a specific grid point, then line of sight blockage is not applied for the entire segment. If other points on the same track segment are blocked, line-of-sight blockage would *not* be applied to those points because it is not applied for the entire segment.

Users should consider creating track segments fine enough (i.e. short enough) so that the time the aircraft flies on the segment approximates the desired accuracy of the time-based metric. For example, an aircraft flying 100 knots along a track with segments on the order of 2,000 feet, results in 12-second segment lengths. The maximum error for any one segment would similarly be 12 seconds. Users should consider that run time will increase approximately linearly with the number of segments, so segment size should not be made smaller than that length required to give the desired accuracy. The flight segments in the flight.txt file should be examined to ensure that further sub-segmenting has not occurred.

Time Audible Uncertainties for Overflights of High Altitude Aircraft

In a recent report, the Federal Interagency Committee on Aviation Noise (FICAN) stated, "there is substantial uncertainty with regard to the best approach to represent the noise from commercial high altitude overflights.[i]" This uncertainty has direct implications on the calculation of the time audible (**TAUD**) metric in INM 6.2. Variations in high-altitude aircraft noise (both level and spectra) observed at receivers on the ground in INM may be due to aircraft source noise and performance assumptions (applying low-speed, low-altitude sound pressure level and spectral data for an aircraft to high-speed, high-altitude conditions) and noise propagation effects (variations in propagation conditions, such as scattering due to wind, and attenuation due to varied atmospheric and ground conditions). These changes in aircraft performance and propagation conditions may vary from day-to-day. These effects are especially important when modeling noise from high-altitude aircraft, because of the increased propagation distance, and the use of "average day" conditions in INM modeling. While this variability affects all INM noise metrics, **TAUD** is particularly sensitive, due to its dependence on both sound pressure level and frequency content.

INM - DDOSE

Change in Exposure may be modeled in INM by selecting the **DDOSE** noise metric. **DDOSE** is defined as the arithmetic difference between aircraft noise exposure and ambient sound level, and the user has multiple means for calculating the metric. Specifically, there are several options for selecting the ambient sound level, which is utilized in the calculation of Change in Exposure. Note that, in all cases, computed Change in Exposure values below the specified ambient sound level at a given receiver location will be reported as 0.0 (dB).

Fixed Threshold Change in Exposure

Selecting **Fixed Threshold** within **Grid Setup** allows the user to calculate the Change in Exposure relative to a fixed, user-defined value. Unless normalized to another time period (see below), the metric utilizes a 12-hour equivalent sound level. If the **Fixed Threshold** box is selected, a box appears next to the option labeled **Fixed threshold (dB)** in which the user may enter the actual threshold value. The fixed threshold value is limited to the range 0.0 to 150.0 dB.

Relative Threshold Change in Exposure

Selecting **Relative Threshold** within **Grid Setup** allows the user to calculate Change in Exposure based on user-specified, A-weighted ambient data. The calculation requires the 3 digit ambient grid file highlighted above. Additional information regarding ambient files can be found in ***Appendix B***. Change in Exposure may be calculated in reference to the values in the ambient grid file as is, or with an absolute delta applied to the ambient data. This delta value may be entered into the box labeled **Ambient + Delta (dB)**. Similar to the fixed threshold function, the relative threshold is limited to the range 0.0 to 150.0 dB.

Change in Exposure Normalized to other Time Periods

Using either the **Fixed Threshold** or **Relative Threshold** options outlined above, the user may calculate the Change in Exposure normalized to a time other than 12 hours; this function is enabled by selecting the **Do Percent of Time** check box in the **Grid Setup** window and entering the duration of time over which to calculate the percentage.

National Parks Noise Database Enhancements

Four general aviation aircraft have been added to the INM database: Piper PA28-161 Warrior (**PA28**), Piper PA30 Twin Comanche (**PA30**), Piper PA31-350 Navajo Chieftain (**PA31**), and Maule M-7-235C (**M7235C**). Data for these aircraft have been developed according to procedures outlined in SAE-AIR-1845 that define the aircraft noise source and relate this source to the changing power state of the aircraft.

Data for two helicopters have been added to the *HeloExample* study distributed with the INM. New helicopter data include the Eurocopter EC-130 and Robinson R-22. Data for the four GA aircraft and the two helicopters are derived from a flight test conducted during 2002 at Fitchburg Municipal Airport in Fitchburg, MA.[iv] In addition to the standard Helicopter data used in INM, data for several different airspeeds and approach angles are included for the EC-130 and R-22 in INM 6.2. Updated instructions for the use of helicopter data in INM 6.2 (including the implementation of the additional EC-130 and R-22 data at different airspeeds and approach angles) may be found in the *Helicopter.doc* file, originally disseminated with INM 6.0c and located in the Helo subdirectory of all subsequent versions of the INM.

The above INM database enhancements were included to aide in the modeling of aircraft noise in support of the FAA-NPS Air Tour Management Plan (ATMP) program; in addition to the standard certification procedures flown to derive INM data, data were derived using flight procedures representative of national park operations. The six aircraft were determined based on a review of the database containing Interim Operating Authority (IOA) applications, (Version 3A, dated June 3, 2003), maintained by FAA AWP-4, specific to the Hawaii parks.

Terrain Modeling - Line-of-Sight Blockage

The capability to account for line-of-sight (LOS) blockage has been added to INM Version 6.2. This feature accounts for the attenuation due to LOS blockage from terrain features. LOS blockage may be implemented utilizing the same 3CD terrain data already in use by the model to correct source-to-receiver distance for terrain elevation; it may also be implemented using the additional terrain data types outlined below. The LOS blockage calculation is based on the difference in propagation path length between the direct path and propagation over the top of terrain features. The path length difference is used to compute the Fresnel Number (N_0), which is a dimensionless value used in predicting the attenuation provided by a noise barrier positioned between a source and a receiver. Figure 1 illustrates LOS blockage from a terrain feature. The formulas used by INM to calculate line-of-sight blockage and the Fresnel Number are given in ***Appendix D – Calculating Line-of-Sight Blockage.***

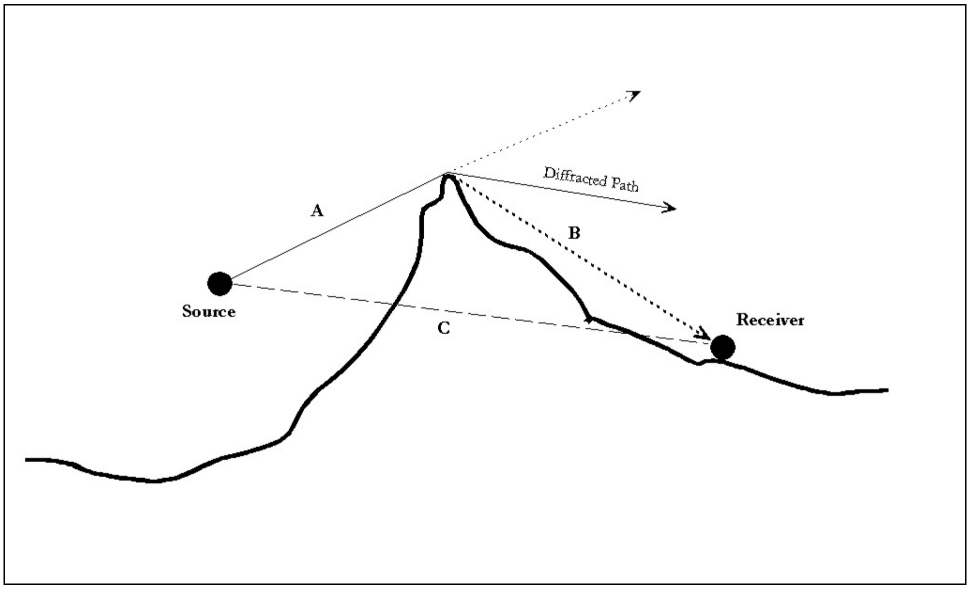

Figure 1. Line-of-Sight (LOS) Blockage Concept

LOS blockage may be invoked by checking the **Do Line-of-Sight Blockage** check box in the **Run Options** window, after having selected the **Do Terrain** option.

In order to calculate LOS blockage, the INM requires terrain data for an area that covers the extent of all of the desired output grid points, as well as the full extent of the calculated flight paths. Standardized terrain data sets often do not contain data for areas extending far out into large bodies of water. Therefore, if any of the calculated flight paths for an INM study extend far out over a large body of water, there may not be enough terrain data available to meet the INM's terrain data coverage requirements for LOS blockage. A process for automatically filling in terrain data in these situations has been developed and may be invoked by checking the **Fill in Missing Terrain** box below the **Do Line-of-Sight Blockage** check box in the **Run Options** window. The user may specify the actual elevation to use in this case; 0 ft/meters mean-sea-level would be appropriate for many coastal areas beside oceans. Non-zero values may be appropriate for other large bodies of water that are at different elevations.

Note that when performing terrain line-of-sight modeling, users should consider the track segment discussion in the above section on the Time Audible metric. In general, segment length should be on the same order as the terrain features being modeled.

Terrain Modeling – Additional Terrain Data Capability

INM 6.2 has been expanded to include the use of multiple terrain data types. Specifically, INM can now utilize higher resolution GridFloat and Digital Elevation Model (DEM) data. Both types of data are maintained as a part of the National Elevation Dataset (NED) by the U.S. Geological Survey (USGS). These data may be downloaded free of charge from the USGS National Map Seamless Data Distribution System (http://seamless.usgs.gov). The data may also be purchased on CDROM media for a nominal fee. When downloading or ordering GridFloat data from this site, a user must specify that the data be saved to the NED GridFloat format. It is recommended that the WGS84 projection be utilized.

Similar to 3CD/3TX terrain data, GridFloat and DEM data may be imported for viewing in the **Output Graphics** window using the Terrain Processor found in **File // Import Data into Study // Terrain Files**. The process for importing the two new terrain formats is the same as the process for importing 3CD/3TX terrain data and is explained in the *INM 6.0 Users' Guide*. The noise calculation program uses the terrain data located in the Terrain Files Directory directly whereas the above import utility creates a special file for viewing in the **Output Graphics** window. As these are different files, it is up to the user to update the terrain data displayed in the **Output Graphics** window to match the terrain data used to calculate the noise levels. INM will not do this automatically.

Imported terrain contours for all three terrain data types are stored under a new file name with a new file format in INM 6.2. The new file name is *_terrain62.bin*, and the new file format allows INM 6.2 to display larger amounts of contour data than was possible with previous versions of the INM. If an older INM study containing terrain contours in the old format is opened with INM 6.2, the data in the old *_terrain.bin* file will automatically be moved to the new *_terrain62.bin* file and the old *_terrain.bin* file will be deleted.

Similar to 3CD/3TX data, all required files must be placed in the directory specified in the **Terrain Files** option of the **File Locations** dialog box. For GridFloat data, this includes files with the *.flt* (terrain elevation data), *.hdr* (metadata including boundaries), and *.prj* (data projection information including datum) file extensions. DEM data must include files with the *.dem* file extensions.

Unlike 3CD/3TX, the GridFloat data format is non-proprietary and stores its data in a latitude-longitude coordinate system that can be used worldwide. GIS systems such as ArcInfo have the option of saving data to this format and there are sources of GridFloat data for areas outside the United States. Note that ArcInfo will not add the *.flt* file extension to the GridFloat file containing the terrain data. If using ArcInfo, filenames will need to be modified by the user to have the *.flt* extension.

Disabling Lateral Attenuation for Propeller Aircraft

Lateral attenuation in INM is based on the draft update to SAE-AIR-1751, Prediction Method for Lateral Attenuation of Airplane Noise During Takeoff and Landing. This document was developed principally for commercial jet aircraft. Military aircraft and helicopters are not addressed by this document. Consequently, INM employs different lateral attenuation equations depending on the class of aircraft. An aircraft's class is determined by its spectral class assignment. A complete description of these assignments is given in ***Appendix F – Excess Lateral Attenuation and Aircraft Spectral Class Assignments***.

SAE A-21 is currently undertaking an update to this AIR. It is anticipated that a future update to the document will incorporate the capability to model propagation over acoustically hard surfaces such as water or rocks. The capability to turn off lateral attenuation for helicopter and propeller aircraft has been added to INM Version 6.2. This can be done by selecting **No-Prop-Attenuation** in the **Lateral Attenuation** drop-down box in the **Run // Run Options** window. This feature simulates propagation over acoustically hard ground. It may be useful for national parks with a significant amount of hard, rock face surfaces.

Level Flyover NPD Curves

Level flyover NPD data have been added for several propeller-driven aircraft in INM 6.2 because level flyover operations constitute a significant amount of the overall operations over national parks. These data can only be accessed by creating user-defined fixed-point profiles for these aircraft. In a fixed-point profile, the data are accessed by specifying the **Flyover/Afb** Operational Mode for each applicable profile step. Doing so will limit the thrust settings available for use with those profile steps to those thrust settings identified in the flyover NPD data sets.

When using the **Flyover/Afb** Operational Mode to access the flyover NPD data, it is important to account for the way the INM handles thrust changes in the different operational modes. For example, when the thrust setting changes between two fixed-point profile steps using the **Approach** or **Depart** Operational Modes, the INM transitions the thrust between the two values over the entire profile segment length. When the thrust level changes between two fixed-point profile steps, and one or both of those steps use the **Flyover/Afb** operational mode, the INM handles the thrust transitions differently. The INM adds a new 100 ft segment to the profile and transitions the thrust between the two values over this short segment. For this reason it is recommended that the flyover NPD data only be used in conjunction with overflight profiles and that those overflight profiles utilize the flyover data throughout the entire profile.

New MapInfo Interchange File Export Function

The INM 6.2 software release contains a new export function that writes MapInfo Data Interchange Format files containing INM graphics output layers. These files can be read by MapInfo Professional and other GIS programs that support the MapInfo Data Interchange format. The **File // Export As MIF/MID** function is available when the **Output Graphics** window is active. Operation of the function is similar to the **File // Export As Shapefile** function.

Output Graphic layers that are enabled (visible) are exported. Data associated with items visible in **Output Graphics**, such as population numbers at population points or noise levels at standard grid points, are also exported. Two pre-named files for each active graphics layer (**.mif* and **.mid*) are written to an existing directory that is selected by the user. For example, noise contours are exported to *Noise-Contours.mif* and *Noise-Contours.mid* files. A prefix can be added to all file names to help differentiate between different sets of MapInfo files. Coordinates can only be exported as latitude/longitude decimal degrees. Table 3 lists the 11 MapInfo Data Interchange files that are available.

Table 3. MapInfo Data Interchange Files

MapInfo Files (.mif, .mid)
*Airport-Drawings.**
*Airport-Runways.**
*Flight-Tracks.**
*Grid-Points.**
*Locations-Points.**
*Noise-Contours.**
*Overlay-Contours.**
*Population-Points.**
*Radar-Tracks.**
*Terrain-Contours.**
*Tiger-Lines.**

Boundary Cutoff Utility

A run-time efficiency utility has been added to INM 6.2, which allows the user to limit acoustic computations to the locations contained within a user-defined geographic boundary. Because contour grids are rectangular, this enables users to restrict contour grid computations to polygonal areas, potentially saving compute time, which may otherwise be devoted to calculating sound levels not of interest to the user. Potential geographic boundaries, which may be used in this utility include, but are not limited to, park, city, county and other boundaries. Note that a geographic boundary may be made up of only a single polygon with no "islands" within the boundary.

The geographic boundary file used by the boundary cutoff utility must be specified in the **Boundary File** dialog box of the **File Locations** window. The file utilizes the same format as the Polyline TXT file described in Section 3.5.2 of the *INM 6.0 User's Guide*. The geographic boundary can be easily imported into INM for viewing in the **Input Graphics** or **Output Graphics** windows using the **Import Polyline TXT file** function, also described in the User's Guide. Note that if any valid polyline TXT file is specified in the **Boundary File** box in the GUI, INM will limit computations to the area within that boundary. It is necessary for the user to remove files from the **Boundary File** box if it is no longer desired to use the Boundary Cutoff Utility.

The percentage of the area defined by the geographic boundary file covered by a given noise contour may also be calculated. The "ACRES" field in the **Contour Area and Population** window has been replaced with a field entitled **% OF BOUNDARY**. This field presents the percentage of the area defined by the geographic boundary file that is covered by the individual contours for contours generated using any noise metric.

Due to the nature of contouring algorithms, in general it is suggested that valid model predictions be undertaken beyond the range of values to be presented graphically. For example, when modeling a 65 dB DNL contour, one might run INM specifying low and high contour level cutoff values of 60 and 70 dB, respectively. Similarly, it is recommended that if accurate area computations are desired within a given boundary, a slightly larger boundary be utilized containing an added buffer. Figure 2 presents an example with an actual boundary in which computations are desired, a buffered boundary used for the model runs, as well as the rectangular contour grid. Various model scenarios using these data illustrate run-time efficiencies of 1.5 to 3 times faster than using only the standard contour grid and evaluating all points within that area. In general it is recommended that buffered boundaries be simplified or smoothed to the extent possible, as INM checks all boundary points in its evaluation of "inside" versus "outside" the boundary. The example illustrated in the figure has almost 3,000 data points in the actual boundary, but less than 200 for the buffered boundary. The use of fewer points will improve run time. See ***Appendix H – Example Boundary Cutoff Data*** for examples of valid and invalid boundary cutoff data files.

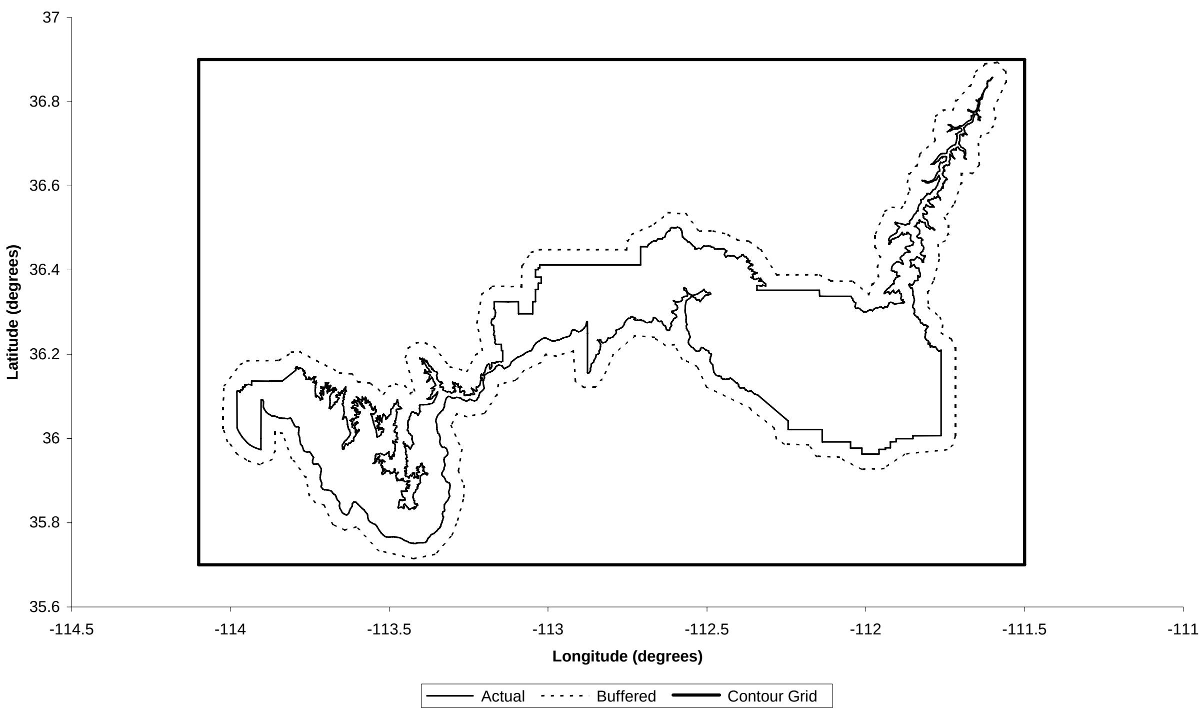

Figure 2. Example Boundary Files used in Boundary Cutoff Utility

Database Modifications

1. Data for the Boeing 757-200 with PW2037 engines has been updated for INM 6.2. The existing INM identifier is **757PW** and the noise identifier is **PW2037**. This aircraft reflects a growth in maximum allowable takeoff weight from 240,000 to 255,000 lbs and new weight-to-stage length rules that are increased from assumptions made in the late 1980's. There are three sets of procedural departure profiles: ICAO_A, ICAO_B, and STANDARD all of which have stage lengths 1 through 7 with weight 7 being the maximum takeoff weight. Noise-Power-Distance data has been updated. Though similar, there are now more curves for approach conditions, and the aircraft now has LAMAX and PNLTMAX curves developed uniquely for this airframe/engine variant. New high temperature jet thrust coefficients have been added for modeling aircraft performance above engine break point temperatures.

2. Data for the Boeing 757-200 with RB211-535E4 engines has been updated for INM 6.2. The existing INM identifier is **757RR** and the noise identifier is **RR535E**. This aircraft reflects a growth in maximum allowable takeoff weight from 220,000 to 255,000 lbs and new weight-to-stage length rules that are increased from assumptions made in the late 1980's. There are three sets of procedural departure profiles: ICAO_A, ICAO_B, and STANDARD all of which have stage lengths 1 through 7 with weight 7 being the maximum takeoff weight. Noise-Power-Distance data has been updated. The NPD for this aircraft was updated for INM 6.1. This release normalized this NPD to an ICAO atmosphere. New high temperature jet thrust coefficients have been added for modeling aircraft performance above engine break point temperatures.

3. Data for the Boeing 737-700 with CFM56-7B engines has been updated for INM 6.2. The existing INM identifier is **737700** and the noise identifier is **CF567B**. The engine type has been updated to CFM56-7B24. This aircraft reflects a growth in maximum allowable landing weight from 138,000 to 129,200 lbs and new weight-to-stage length guidelines that are increased from previous assumptions. There are three sets of procedural departure profiles: ICAO_A, ICAO_B and STANDARD all of which have stage lengths 1 through 6 with 6 being the maximum takeoff weight.

4. Data for the Boeing 737-300 with CFM56-3B-2 engines has been updated for INM 6.2. The existing INM identifier is **7373B2** and the noise identifier is **CFM563**. This aircraft reflects a growth in maximum allowable takeoff weight from 139,000 to 139,500 lbs and new weight-to-stage length guidelines that are increased from previous assumptions. There are three sets of procedural departure profiles: ICAO_A, ICAO_B and STANDARD all of which have stage lengths 1 through 4 and M with M being the maximum takeoff weight.

5. Data for the Boeing 737-300 with CFM56-3B-1 engines has been updated for INM 6.2. The existing INM identifier is **737300** and the noise identifier is **CFM563**. This aircraft reflects new weight-to-stage length guidelines that are increased from previous assumptions. There are three sets of procedural departure profiles: ICAO_A, ICAO_B and STANDARD all of which have stage lengths 1 through 4.

6. Data for the Boeing 737-400 with CFM56-3C-1 engines has been updated for INM 6.2. The existing INM identifier is **737400** and the noise identifier is **CFM563**. This aircraft reflects new weight-to-stage length guidelines that are increased from previous assumptions. There are three sets of procedural departure profiles: ICAO_A, ICAO_B and STANDARD all of which have stage lengths 1 through 4 and M with M being the maximum takeoff weight.

7. Data for the Boeing 737-500 with CFM56-3B-1 engines has been updated for INM 6.2. The existing INM identifier is **737500** and the noise identifier is **CFM563**. The engine type has been updated to CFM56-3C-1. This aircraft reflects a reduction in maximum allowable takeoff weight from 138,500 to 133,500 lbs and new weight-to-stage length guidelines that are increased from previous assumptions. There are three sets of procedural departure profiles: ICAO_A, ICAO_B and STANDARD all of which have stage lengths 1 through 5 and M.

8. Data for the Boeing 777-200 with GE90-90B engines has been updated for INM 6.2. The existing INM identifier is **777200** and the noise identifier has been updated to **GE90**. This aircraft reflects a growth in maximum takeoff weight from 535,000 to 656,000 lbs and available engine thrust from 77,000 to 90,000 lbs. The approach profile has been modified from a 1500 foot level flight segment to a 3,000 foot level flight segment to make it consistent with other INM submissions and reflects a growth in maximum landing weight from 445,000 to 470,000 lbs. There are three sets of procedural departure profiles: ICAO_A, ICAO_B and STANDARD all of which have stage lengths 1 through 9 with 9 being the maximum takeoff weight. The existing jet thrust coefficients have been modified and new high temperature jet thrust coefficients have been added for modeling aircraft performance above engine break point temperatures. The flap identifiers and flap coefficients have also been changed. Existing user-defined flight profiles for the **777200** will need to be updated to make use of the new flap data prior to running any study using these profiles in INM 6.2.

9. Data for the Boeing 747-400 (**747400**) with PW4056 engines has been updated for INM 6.2. There are three sets of procedural departure profiles: ICAO_A, ICAO_B and STANDARD all of which have stage lengths 1 through 9 with 9 being the maximum takeoff weight. Noise-Power-Distance data has been updated to include maximum level metrics. New high temperature jet thrust coefficients have been added for modeling aircraft performance above engine break point temperatures.

10. Data for the Piper PA28-161 Warrior were added to the INM database. The aircraft identifier is **PA28** and the noise identifier is **O320D3**. Noise identifier **O320D3** includes NPD data for three different RPM power settings over three different aircraft

states (approach, departure and level-flyover). The STANDARD approach and departure profiles are both fixed-point profiles. A fixed-point overflight profile identified as LEVEL that uses the **Flyover/Afb** operational mode is also included in the database for this aircraft. Fixed-point profiles are used because research demonstrated that engine RPM provided the best correlation between aircraft state and aircraft noise source.

11. The **PA28WA** substitution is still in the *acft_sub.dbf*, and it is now equated to the new **PA28**. The new **PA28** aircraft should be used in all INM studies, and users should take steps to change references to the PA28WA substitution to the new PA28 standard identifier. A future version of INM will remove the PA28WA record from the *acft_sub.dbf* file, and a study using the PA28WA will have to be manually converted by the user.

12. Data for the Piper PA30 Twin Comanche were added to the INM database. The aircraft identifier is **PA30** and the noise identifier is **IO320B**. Noise identifier **IO320B** includes level flyover NPD data for three different thrust settings. The STANDARD approach and departure profiles are both procedural profiles. A fixed-point overflight profile identified as LEVEL that uses the **Flyover/Afb** operational mode is also included in the database for this aircraft. Because the SAE-AIR-1845 propeller performance equations do not account for the performance decrease with altitude in normally-aspirated piston engines, the INM's two thrust levels (MaxTakeoff and MaxClimb) were used to simulate the performance decrease: MaxTakeoff modeled full available power climb from Sea Level to 3,000 feet and MaxClimb modeled full available power climb from 3,000 feet to 10,000 feet.

13. The **PA30** substitution was removed from the *acft_sub.dbf* file. INM 6.2 automatically converts the **PA30** substitution, if used in a study, into the new **PA30** aircraft.

14. Data for the Piper PA31 Navajo were added to the INM database. The aircraft identifier is **PA31** and the noise identifier is **TIO542**. Noise identifier **TIO542** includes level flyover NPD data for three different thrust settings. The STANDARD approach and departure profiles are both fixed-point profiles. A fixed-point overflight profile identified as LEVEL that uses the **Flyover/Afb** operational mode is also included in the database for this aircraft. The power parameter used in the profile points and the NPD curves is engine RPM.

15. The **PA31** substitution was removed from the *acft_sub.dbf* file. INM 6.2 automatically converts the **PA31** substitution, if used in a study, into the new **PA31** aircraft.

16. Data for the Raytheon Beech 1900D were added to the INM database. The new aircraft identifier is **1900D** and the noise identifier is **PT6A67**. The STANDARD approach and departure profiles are both procedural profiles. This aircraft has two departure stage lengths. Measurements undertaken to derive the data showed that due to high frequency noise components in cruise condition, this aircraft has higher sound levels in cruise than at takeoff. Two departure NPD curves with different power settings, yet identical sound levels, have been added to eliminate possible problems when extrapolating outside the measured NPD range.

17. The **BEC190** substitution is still in the *acft_sub.dbf*, and it is now equated to the new **1900D**. The new **1900D** aircraft should be used in all INM studies, and users should take steps to change references to the **BEC190** substitution to the new **1900D** standard identifier. A future version of INM will remove the **BEC190** record from the *acft_sub.dbf* file, and a study using the **BEC190** will have to be manually converted by the user.

18. Data for the Maule M-7-235C were added to the INM database. The new aircraft identifier is **M7235C** and the noise identifier is **IO540W**. No performance information or standard Approach and Departure profiles for the **M7235C** are included in this release. There is however a fixed-point overflight profile identified as LEVEL that uses the **Flyover/Afb** operational mode included in the database for this aircraft. The Maule NPD data are only intended to model level flyovers, similar to air tours over parklands. As with the Warrior and the Navajo Chieftain, the NPD power parameter is engine RPM. The higher engine RPM NPD represents the Maule's normal airspeed cruise flight. The lower engine RPM NPD represents the Maule's low speed level flight capability, typical of what might be flown over scenic areas within a park. When modeling this aircraft, users should only model overflight operations, as no departure or arrival information is provided.

19. The thrust setting types for all military aircraft have been changed to "other" ("X" in the *nois_grp.dbf* file) in the INM database. Previously some of the thrust setting types were incorrectly set to "percent".

20. Data for the Eurocopter EC-130 are now available for use in the INM. These data have been added to the *npd_curv.dbf* file located in the Helo\HeloExample INM subdirectory. Updated instructions for the use of the EC-130 data (including the implementation of the additional EC-130 data at different airspeeds and approach angles) may be found in the *Helicopter.doc* file, originally disseminated with INM 6.0c and located in the Helo subdirectory of all subsequent versions of the INM.

21. Data for the Robinson R-22 are now available for use in the INM. These data have been added to the *npd_curv.dbf* file located in the Helo\HeloExample INM subdirectory. Updated instructions for the use of the R-22 data (including the implementation of the additional R-22 data at different airspeeds and approach angles) may be found in the *Helicopter.doc* file, originally disseminated with INM 6.0c and located in the Helo subdirectory of all subsequent versions of the INM.

22. Data for the MD600N are now available for use in the INM. These data have been added to the *npd_curv.dbf* file located in the Helo\HeloExample INM subdirectory. It is important to note that only level flyover data is available for the MD600N. Instructions for the use of the MD600N data may be found in the *Helicopter.doc* file, originally disseminated with INM 6.0c and located in the Helo subdirectory of all subsequent versions of the INM.

23. Fixed-point approach profile data for INM aircraft **A30062**, **A310**, **A319**, **A320**, **A32023**, **A32123**, **A330**, **A33034**, **A340**, **737800**, **757300**, **767400**, **777200**, and **777300** were modified, as necessary, to bring them into conformance with the INM method of modeling touchdown and reverse thrust. These aircraft either had their fixed-point approach profiles previously altered for INM version 6.1 or were newly added aircraft for INM 6.1. In all cases the landing ground roll segments were defined as described under item 4 of the Database Modifications section of the INM 6.1 Release Notes. This method as described in the INM 6.1 Release Notes is incorrect. For INM 6.2, the landing ground roll portions of the fixed-point approach profiles for these aircraft have been re-defined using the method described in section 8.7.12 of the INM 6.0 User's Guide.

24. Procedural approach profile data for INM aircraft **737700** were modified, as necessary, to bring them into conformance with the INM method of modeling touchdown and reverse thrust. The landing and decelerate procedure steps have been re-defined using the method described in section 8.7.12 of the INM 6.0 User's Guide.

25. The profile weights of the approach and departure NOISEMAP profiles for the **F16A** aircraft have been changed from 90,000 lbs and 85,000 lbs, respectively, to a more realistic value of 33,000 lbs. This change has no effect on the actual profiles or the output of INM because the **F16A** uses only fixed-point profiles that are calculated independently of aircraft weight.

26. The initial speed for all standard fixed-point departure profiles has been changed from 35 knots to 0 knots in the INM database. This change has no effect on the flight paths or noise levels calculated for these profiles.

27. Duplicate thrust coefficient ID's and corresponding data for the **GIIB** and **GIV** aircraft have been removed from the INM database.

28. Two new noise metric identifiers, **TAUD** (Time Audible) and **DDOSE** (Delta Dose), have been added to the INM database.

29. Weight category assignments have been corrected for four aircraft in the INM database. The weight category assignments for the **CNA55B** and **DOMIN** aircraft have been changed from 'Small' to 'Large'. The weight category assignment for the **767400** aircraft has been changed from 'Large' to 'Heavy', and the assignment for the **VULCAN** aircraft has been changed from 'Heavy' to 'Large'. These changes have no effect on INM studies using these aircraft.

30. The engine type listed for the **F18EF** aircraft has been corrected from the F404-GE-400 engine to the F414-GE-400 engine. This change has no effect on INM studies using this aircraft; the correction only fixes a typo in the database rather than changing the actual engine and thereby changing the aircraft's noise data.

31. The standard fixed-point approach profiles for the **737800** and **757300** have been modified. The length of one of the thrust transition segments has been changed from 0 ft to 100 ft for each profile. These changes should have no significant impact on noise levels calculated for aircraft operations using these profiles.

32. NPD data for many of the military aircraft in the standard database, which were obtained from the U.S. Air Force's NoiseMap noise model, have been modified. Previously many of the NPD curves for a given aircraft, operation type, and metric crossed each other. These crossing NPD curves produced problems for the INM when trying to interpolate/extrapolate noise values for thrust values other than those explicitly given in the NPD curves, and sometimes resulted in unrealistic noise contours. The NPD data have been modified to eliminate all instances of crossing NPD curves.

33. The description field for the **MU3001** aircraft has been updated from MU300-10/JT15D-4 to MU300-10/JT15D-5.

34. The substitution aircraft **BEC400** has been updated to use the **MU3001** instead of the **LEAR35** as its equivalent INM aircraft.

Program Modifications

1. The ability to calculate the time audible (**TAUD**) noise metric has been added to the program. **TAUD** is defined as the time that aircraft are audible to an attentive listener. Calculation of **TAUD** requires source and ambient sound level spectra for a given analysis location. The **TAUD** metric can only be accessed when an FAA-provided binary ambient file is available, as explained above. It is not available for modeling **Multi-Metrics**.

2. The ability to calculate the change in exposure (delta dose or **DDOSE**) noise metric has been added to the program. **DDOSE** has been added to the **Single-Metric** type of noise metrics only; it is not available for modeling **Multi-Metrics**.

3. The ability to disable the use of ground-to-ground lateral attenuation when calculating noise generated by helicopter and propeller-driven aircraft has been added to the program. Lateral attenuation can be turned off for these aircraft by selecting **No-Prop-Attenuation** in the new **Lateral Attenuation** drop-down list located in the **Run // Run Options** window. For INM 6.2, aircraft types are identified by the

departure spectral class assignments its Noise-Power-Distance curves are given in ***Appendix F***.

4. The calculations of the Time Above metrics (**TALA, TAPNL, TALC**) have been modified to include a cap on the maximum value for **Standard Grid** or **Contour** output. Time Above is capped for a user-specified time period (with a default of 24 hours), and Percent Time Above is capped at 100% of that user-specified time period. The **Detailed Grid** output is not capped, so it may be used as a diagnostic tool. This is consistent with the way that **TAUD** is handled in INM 6.2.

5. The ability to calculate the percentage of a given boundary area covered by each contour level and output the percentage in the table produced by the **Output // Contour Area and Population** function has been added to the program. The percentage values replace the contour area values previously displayed in the Acres column. The boundary area is defined by the *boundary.txt* file which must have its location defined in the **Ambient Noise File** dialog box in the **Setup // File Locations** window.

6. The heading of the last column of the *pop_conr.dbf* file has been changed from ACRES to PCT_BOUND. The field specifications for this column have been changed from 1 to 2 decimal places.

7. The ability to perform Ambient Screening analyses has been added to the program. Ambient Screening can be run by selecting "Ambient Screening" from the Run Type drop-down box in the Run // Run Options window. An output record can be set up in order to view Ambient Screening results Output Graphics window by selecting "SCREEN" from the Metric drop-down box in the Output // Output Setup window.

8. The minimum value for the **Do Percent of Time (hr)** field in the **Run // Grid Setup** window has been changed from 0.1 to 0.01.

9. The **Setup // File Locations** window has been changed to allow for the specification of the name and location of a Boundary File. The Boundary File is used to calculate the percentage of a user-specified boundary area covered by individual noise contours as described above.

10. The minimums for the max and min cutoff values in **Run // Run Options** have been changed to –999.9 to accommodate the new **TAUD** and **DDOSE** metrics.

11. An **Optional Export File Name Prefix** field has been added to the **File // Export as Shapefile** window. This field allows the specification of a file name prefix that gets added to the numerous output files created when exporting shapefiles. The prefix will make it easier to distinguish between different sets of shapefiles.

12. The **File // Export as Shapefile** function has been changed to produce a modified *Flight-Tracks.dbf* output file. The new *Flight-Tracks.dbf* file contains operation type,

runway ID, and track ID instead of the previous track ID only. This change enhances the ability to filter track data viewed outside of the INM using ESRI shapefiles.

13. The **File // Export as Shapefile** function has been changed to export more detailed population data. Previously, the Population-Points shapefiles *(*.shp, *.shx,* and **.dbf*) contained Multipoint object types whose feature names were consistent with the population groupings in the **Output // Output Graphics** Census Display control dialog box (i.e. POP <= 300 for the population points that were less than or equal to 300). The new Population-Points shapefiles contain Point type objects whose feature names contain the exact population values at the individual points (i.e. POP_37 indicates a population of 37 at the given point). The new Population-Points shapefiles will be much larger than those generated by INM version 6.1 because each individual population point is now considered an attribute.

14. The **File // Export as Shapefile** function has been changed to export noise data associated with standard grid points, detailed grid points, and location points. Previously, the Grid-Points and Location-Points shapefiles (**.shp, *.shx, and *.dbf*) contained Multipoint object types whose feature names were consistent with the applicable grid names or location point names (i.e. Grid_S01 for all of the grid points in the standard grid named S01). The new shapefiles contain Point type objects whose feature names contain the noise metric values at the individual points (i.e. Grid_S01_67.8DNL). The new shapefiles will be much larger that those generated by INM version 6.1 because each individual grid or location point is now considered an attribute.

15. The **File // Export As MIF/MID** function was added to INM, as explained in the **New MapInfo Interchange File Export Function** section above.

16. The ability to filter radar tracks by runway end when creating INM tracks from radar data in the **Input Graphics** window has been added to the program.

17. A **Previous Zoom** button has been added to the **Input Graphics** and **Output Graphics** windows. The list of items in the **View** menu as well as the **Input Graphics** and **Output Graphics** buttons have been re-ordered to enhance consistency.

18. The default value of the **Refinement** contouring parameter in the **Run // Run Options** window has been changed from 6 to 8. The default value of the **Tolerance** contouring parameter has been changed from 1.00 to 0.25. These new default values will produce a higher-resolution contour grid and more accurate contours as compared to the previous default values.

19. A "000_None" spectral class has been added to the **Acft // Noise Identifiers** window. This change allows aircraft to have no Approach or Departure spectral classes as is the case with the new Maule aircraft added to INM version 6.2. Previously aircraft with no spectral class identified for a given category had their spectral class

automatically assigned to a default value. A noise identifier must have a spectral class other than the "000_None" spectral class assigned for at least one of the three spectral class categories.

20. New terrain options have been added to the **Run // Run Options** window. When the **Do Terrain** box is checked, a new drop-down list appears listing three terrain data formats. A new **Do Line-of-Sight Blockage** box also appears.

21. A **Fill in Missing Terrain** function has been added to the **Run // Run Options** window. This function allows for the creation of constant-elevation terrain data at a user-defined elevation. This terrain data is used to fill in any gaps in the available terrain data when running the INM in Do Line-of-Sight Blockage mode.

22. The "Do Terrain" label has been changed to "Terrain Type" in the "CASE RUN OPTIONS" section of the Case Echo Report. The possible values have also changed to represent the new terrain options available in the **Run // Run Options** window.

23. The values of the "Do Terrain" item in the *flight.txt* file generated by the **Output // Flight Path Report** function have been changed to match the values saved in the "DO_TERRAIN" column of the *case.dbf* file. The possible values in the "DO_TERRAIN" column of *case.dbf* have been expanded to represent the new terrain options available in the **Run // Run Options** window.

24. The Standard Grids window generated by the **Output // Standard Grids** function has been modified. The USER column header has been changed to METRIC to match the column header in the *grid_std.dbf* file.

25. New terrain data checking has been added to **Run // Run Start**. When a Case containing a contour grid is run with the **Do Terrain** box checked and the **Do Line-of-Sight Blockage** box not checked in the **Run // Run Options** window, the INM will determine whether there is enough terrain data available in the Terrain Files directory to cover the entire contour grid. If there is not sufficient terrain data available a *terrain_error.cad* file showing the contour grid boundary and the boundaries of each individual terrain file is written to the Case directory. When any case is run with both the **Do Terrain** box and the **Do Line-of-Sight Blockage** box checked in the **Run // Run Options** window, the INM will determine whether there is enough terrain data available in the Terrain Files directory to cover a rectangle encompassing the contour grid (if applicable for the given Case), all of the applicable location points, population points, standard grid points, and/or detailed grid points, and the extent of all of the calculated flight paths. If there is not sufficient terrain data available a *terrain_error.cad* file showing the required Line-of-Sight Blockage terrain rectangle and the boundaries of each individual terrain file is written to the Case directory. The *terrain_error.cad* file can be viewed in the **Tracks // Input Graphics** window, with red indicating areas of missing terrain data.

26. The ability to import two new terrain data formats, Digital Elevation Model (DEM) data and National Elevation Dataset (NED) GridFloat data, has been added to the Terrain Processor under **File // Import Data** into **Study // Terrain Files**.

27. The Terrain Processor under **File // Import Data** into **Study // Terrain Files** has been modified to add additional terrain elevation grid points to the imported terrain data around the outside edge of the terrain contour rectangle. The additional points are only applied to the data imported for terrain contour viewing in the **Output // Output Graphics** window and have no impact on noise calculations involving terrain data. These additional points help NMPlot to close each of the terrain contours and in some cases help to more sharply define the edge of the terrain contour rectangle when the terrain contours are viewed in **Output // Output Graphics**.

28. The name and format of the binary file used to save imported terrain contours have been changed. The file name has been changed from *_terrain.bin* to *_terrain62.bin*. The new file format allows larger amounts of terrain contour data to be viewed in the **Output // Output Graphics** window. When an older Study is opened in INM 6.2, the INM will automatically move any terrain contour data in the old *_terrain.bin* file to the new *_terrain62.bin* file. The old *_terrain.bin* file will be automatically deleted.

Reported Problems Fixed

1. Fixed a problem with the **View // Fonts** function and label printing from **Output Graphics**. Previously **Output Graphics** labels for **Location Points**, etc. would print out in a font so small they were difficult to see. **View // Fonts** previously would not allow the font properties to be changed in the **Output Graphics** window.

2. Fixed the **Radar Tacks CSV File** import function to accept "0000" as a beacon code. In the User's Guide users are instructed to use "0000" as a default beacon code if they do not have an actual beacon code, and the function previously would not accept "0000".

3. Fixed a minor problem when using terrain data. Previously, for grid locations with altitude lower than airport field elevation (AFE), positive elevation angles (β) were utilized in the calculation of the lateral attenuation adjustment (LAADJ). This resulted in the calculation of air-to-ground attenuation for these receivers. Currently, no air-to-ground attenuation is calculated for any receiver location when the aircraft is on the ground. This change only affects receivers below the airport elevation when Terrain is turned on.

4. Fixed a problem with **Acft // Fixed-Point Profiles** window. Previously, the operational mode combo box was disabled after profiles were initially created and the INM was closed, preventing users from changing the operational modes used by the profiles.

5. Fixed a problem with the **Terrain Processor** when importing terrain data inside a terrain contour rectangle that has one of its corner points at the X,Y coordinates (0,0). Previously such a terrain contour rectangle would cause NMPlot to crash when generating terrain contours. Now the INM will detect if a user-specified terrain contour rectangle has a corner at the point (0,0) and will move that corner away from (0,0) to avoid causing problems for NMPlot.

6. Fixed a problem with an error message that alerts users at run time when there is only one NPD curve for a given metric and operation type. Previously this message incorrectly reported the metric identifier for the single NPD curve.

7. Updated error messages to better inform users when run-time errors occur due to user-specified runways with zero length.

8. Fixed a problem with the **TIGER Processor** that prevented users from being able to view the available counties in West Virginia and the Virgin Islands when trying to import TIGER/Line data into an INM study.

Appendix A – Updates to INM Noise/Performance Database

The core of the INM database consists of noise and performance under certain reference conditions. Aircraft performance profiles represent a full power takeoff for a procedure labeled as STANDARD. For the majority of the commercial transport aircraft, these procedures begin pitch over/acceleration at 1,000 feet. Power cutback occurs either during or at the end of the acceleration. For many aircraft, this resembles what was once designated as ICAO B, though the INM user will note some variation among aircraft. These procedures were developed for different takeoff weights that were related to the operating range of the aircraft. In developing these weights, manufactures make assumptions about load factor and assumed pounds per passenger. Many aircraft developed in the late 1980's for the original INM database assumed a 60% load factor at 200 pounds per passenger and no excess cargo. Recent survey data has been shown to support higher weights per trip length and new aircraft added since 1995 have developed weight-to-stage length assumptions based on "rules" that lead to higher weights. Aircraft have also grown in maximum allowable takeoff weight since the late 1980's. A new aircraft developed today, using the old 60% load factor, would still result in a "heavier" aircraft due to this increase in maximum certification takeoff weight. This release of INM updates 9 aircraft previously developed for INM using a consistent set of takeoff procedure and weight-to-stage length rules. These weights and procedures are more consistent with current submissions, and it is anticipated that FAA in cooperation with NASA and Eurocontrol will continue to sponsor research and development that harmonizes assumptions across all of the aviation industry.

INM Standard Procedures

INM Standard procedures are provided for maximum takeoff power and maximum climb power conditions. Recent research has developed 3 types of procedures for INM. These include a standard procedure that performs engine cutback at 1,000 feet Above Field Elevation (AFE) and ICAO A and ICAO B procedures. These procedures differ in the way flap retraction and power cutback occur.

Present data development of INM will continue to provide three types of procedures. However, recent surveys do not show much use of what are called "ICAO B like" procedures. ICAO A and ICAO B procedures were last defined in *Amendment 10 of the Fourth Addition of the ICAO Procedures for Air Navigation Services, Aircraft Operations, Volume 1 Flight Procedures*. This document is commonly referred to as Volume 1 of ICAO PANS-OPS. Amendment 11 of this document was published on January 11, 2001 and provided new guidance on noise abatement procedures. This document provided procedure guidance rather than specific procedures, and the specific ICAO A and ICAO B procedure definitions were not retained. ICAO A and ICAO B procedures may still be developed under Amendment 11 guidance but the specific procedure definition is not listed in the ICAO Pans OPS. INM provides for the use of these for historical comparisons and will retain them as standard data depending on the needs of the user community.

Survey data of **747400** and **777200ER** weight-to-trip length ratios demonstrates many operations in excess of the 4500 nautical mile upper limit given in previous versions of INM. INM 6.2 adds two new ranges for the distances of 4500-5500 and 5500-6500 nautical miles in order to provide more weights for these longer ranges. Some aircraft such as the **747400** and **777200ER**, also include a 9^{th} weight for the maximum certificated takeoff weight. For new submissions to INM, the last trip length weight will be the maximum certificated weight of the aircraft. Users should select takeoff weights based on the best data available. In the absence of such data, users may select weights based on trip length according to the rules given below.

Takeoff weight for trip length stages:

Stage No.	1	2	3	4	5	6	7	8	9
Trip Length Range (nm X 1,000)	0-.5	.5-1	1.0-1.5	1.5-2.5	2.5-3.5	3.5-4.5	4.5-5.5	5.5-6.5	> 6.5
Representative Range	350	850	1350	2200	3200	4200	5200	6200	
Weight (lb X 1,000)	____	____	_____	_____	_____	_____	_____	_____	_____

In developing takeoff weights for stage lengths, the following guidance has been established to provide common mission planning rules for determining default weights. These "rules" have been shown to correlate with survey data. Airlines do not always purchase aircraft at their maximum certificated weight. INM aircraft are developed based on the maximum certificated weight, with the weight provided as a lower bound on the climb performance of the aircraft.

Parameter	Planning Rule
Representative Trip Length	Min Range + 0.70*(Max Range – Min Range)
Load Factor	65% Total Payload of the Maximum Certificated weight sold to airlines.
Fuel Load	Fuel Required for Representative Trip Length + the average of ATA Domestic and International Reserves As an example, typical domestics reserves include 5% contingency fuel, 200 nm alternate landing with 30 minutes of holding.
Cargo	No additional cargo over and above the assumed payload percentage

INM STANDARD Procedure:

1) Takeoff at Full power
2) Cutback to climb power around 1,000 feet AFE and pitch-over to accelerate
3) Accelerate to clean configuration
4) Climb to 3,000 feet AFE
5) Accelerate to 250 knots
6) Continued climb to 10,000 feet AFE

INM ICAO A Procedure:

1) Takeoff at Full Power
2) Climb to 1,500 feet AFE at full power holding flaps
3) Cutback to Climb Power at 1,500 feet
4) Climb to 3,000 feet AFE at climb power holding flaps
5) Accelerate to clean configuration
6) Accelerate to 250 knots
7) Continued climb to 10,000 feet AFE

INM ICAO B Procedure:

1) Takeoff at Full Power
2) Climb to 1,000 feet and pitch-over to accelerate
3) At full power, accelerate to clean configuration
4) Cutback to climb power
5) Climb to 3,000 feet AFE
6) Accelerate to 250 knots
7) Continued climb to 10,000 feet AFE

Appendix B – Ambient Data Input Files

The supplemental metrics **TAUD**, **TALA** and **DDOSE** require input data files that contain estimates of ambient sound levels. There are two types of data that may be collected and given the expense of ambient data measurements, users analyzing air tour proposals are advised to follow the process given in the ambient guidance[ii, iii]. Additional similar guidelines are being developed for other aviation proposals, e.g., airport development. The first type of data contains representative A-weighted sound levels assigned to a regularly spaced grid and is referred to as the ambient grid file. Ambient grid files are utilized by the **TALA** and **DDOSE** metrics. The other contains representative one-third octave band data that are also assigned to a regularly spaced grid through an indexing convention described below. This is referred to as the ambient spectral map file and it is required for the **TAUD** metric. As mentioned previously, this project-specific pair of ambient grid and ambient spectral map files must then be submitted to the FAA for review, and if approved, the FAA will provide the user with a corresponding binary ambient file. This binary ambient file will activate the **TAUD** run option as described in the release notes. The location and actual filename of the ambient grid files must be specified using the **Setup // File Locations** dialog window (see **Ambient Noise File** box). The binary ambient file must be named ambient.bin and specified in the **Setup // File Locations** dialog window (see **Ambient Noise File** box). Example ambient grid (*ambient.txt*) and ambient spectral map files are included as a part of this Appendix**.**

NOTE: The Ambient Grid File described below was first introduced in INM 6.0 and is documented on page 10-5 of the INM 6.0 Users Guide. The format given in this Appendix now supports ambient data to one decimal place (i.e., 3 total digits) whereas the original format specified only integer values (2 total digits). Files developed in the old format are still supported for backward compatibility for TALA. However, for TALA, INM automatically converts data files to the new 3-digit format. 2-digit data are archived in a file called *ambient_backup.txt* and the new 3-digit data are written to *Ambient.txt*

Ambient Grid File

The purpose of the ambient grid file is to assign a number, representing the A-weighted ambient sound level, to study area grid points. This file is a space-delimited, ASCII text file with format and use illustrated with an example file at the end of this Appendix. The first five rows contain header information that specifies the dimensions of the grid, which is referenced to a geodetic coordinate system. The first two rows, *ncols (Y)* and *nrows (X)*, specify the number of columns and rows of the regular grid. The third and fourth rows specify the Lower Left (ll) or southwest corner of the grid in terms of latitude/longitude in decimal degrees. Row 3 contains the field id “xllcorner” followed by a real number specifying the longitude (x-coordinate of grid) in decimal degrees. Row 4 contains the field id “yllcorner” followed by a real number specifying the latitude (y-coordinate of grid) in decimal degrees. The fifth row contains the field id “cellsize” followed by a real number specifying the spacing between both latitude and longitude points in decimal degrees. The final grid in this example will contain a 15 column by 12 row array of points, evenly spaced 0.1 decimal degrees apart referenced to a lower-left (southwest) corner of -114.03464052 longitude and 35.61089089 latitude.

The sixth row contains the text "NODATA_value" followed by an integer. This value is used to indicate that no ambient grid data are available for one or more locations within the grid. When computing **TAUD** for locations specified as having no data, by default the INM assigns the ISO threshold of human hearing spectral data to those locations. For **TALA** and **DDOSE**, NODATA values are used explicitly as ambient levels, subject to the 0.0 to 150.0 dB threshold limitations. A warning file called *NODATA_warning.txt* file is written to the case directory if any locations have utilized NODATA values for ambient thresholds.

Lines 7 through X+7 each contain Y three-digit integers. The integers represent A-weighted sound levels and are stored as ten times the value they represent (i.e., '347' represents 34.7 dB).

Ambient Spectral Map

The ambient spectral map file is a comma-delimited, ASCII text file, which assigns spectral data to the grid points contained in the ambient grid file outlined above. The first row contains an integer specifying the number of data rows, which follow. Each row contains the following information: (1) first field: index of spectrum, for informational purposes only and not used at this time; (2) second field: spectrum name/site name, for informational purposes only; (3) third field: A-weighted energy sum of spectrum. This value should have a corresponding match in the ambient grid file above; (4) fields four through twenty-seven: sound pressure levels for one-third octave bands 17 (50 Hz) through 40 (10,000 Hz). Note that field 3 above is the value, which is indexed with the ambient grid file for specifying grid-based ambient spectra. For example, a field 3 value of 34.7 will map the one-third octave band spectrum associated with this record to all values of 347 in the ambient grid file. It is useful for documentation purposes for this value to be equivalent to the A-weighted sum of the spectrum, however this is not required and the convention may not hold for the unique case where different spectra have identical A-weighted values. Regardless of convention, the values of column 3 must be unique across all rows. Prior to use of the **TAUD** metric, the FAA will perform a verification check on the data to insure uniqueness of mappings and consistency of spectra to reported A-weighted values.

Ambient.bin file for **TAUD**

The calculation of the **TAUD** metric requires both the A-weighted levels and the ambient spectral map information described above. **TAUD** is based on spectral information; however the ambient mapping design uses the A-weighted level as an index to assign 24 one-third octave band levels to grid locations. Both files must be consistent for use in INM.

Given 1) the anticipated process for collecting ambient data, 2) the sensitivity of **TAUD** to ambient data, and 3) the need for consistency between input files, the FAA will provide binary ambient files for use in Federal projects on a project by project basis. Users wishing to calculate **TAUD** should contact the FAA Office of Environment and Energy before proceeding. Users are encouraged to follow the ambient guidance[ii, iii] during their ambient collection. Once collected, users should again contact the FAA Office of Environment and Energy, who will coordinate the submittal of their ambient grid and ambient spectral map files for a consistency check. For any case in which a user-defined one-third octave band spectral level is below the

Equivalent Auditory System Noise (EASN) threshold, that level will be replaced with the associated EASN level during the consistency check, so as to not predict an unreasonably high audibility level. A file will then be returned to the users, which will active the **TAUD** calculation function for INM. This binary file is publicly available and may be re-used or transferred to any project or any group that requires the use of **TAUD**.

If any errors are uncovered during the generation of the *ambient.bin* file, such as an A-weighted sound level in the ambient grid file which does not have an associated spectrum in the spectral map file or an A-weighted value specified for a given spectrum in the ambient spectral map file does not match the A-weighted sum of the spectral data (within 0.1 dB(A)), then the user will be contacted about revising the submitted ambient grid and spectral map files. Typically, these errors are data anomalies, which would cause INM to abort processing.

Sample Ambient Grid Text File – (*Ambient.txt*)

```
ncols 15
nrows 12
xllcorner -114.03464052
yllcorner  35.61089089
cellsize 0.1
NODATA_value -99
347 347 347 347 347 347 347 347 347 347 347 347 347 347 347
347 347 347 347 347 347 347 347 215 347 347 347 347 347 347
347 347 347 347 347 347 347 347 215 215 215 347 347 347 347
347 347 347 347 347 345 345 345 215 347 347 347 347 215 215
347 345 345 345 345 345 345 345 347 347 347 347 347 215 215
347 345 345 345 345 345 345 347 347 347 347 347 347 215 215
347 347 347 345 347 347 347 347 347 347 347 347 347 347 347
347 347 347 347 347 347 347 347 347 347 347 347 347 347 347
347 347 347 347 347 347 347 347 347 347 228 347 347 347 347
347 347 214 347 347 205 205 205 347 347 347 228 228 228 228
347 347 214 214 347 205 205 205 347 347 347 228 228 228 228
347 347 347 347 205 205 205 347 347 347 347 228 228 228 228
```

Sample Ambient Spectral Map Text File – (*ambi_map.txt*)

```
6
1,3A-1,34.7,45,39.7,35.7,32.7,30.9,30.8,30.8,29.9,29.6,29.6,29.2,28.6,27.8,27.2,26.4,24.6,21.9,19,14.5,9.9,8,7.2,14.8,23.6
2,3A-2,34.5,45,39.5,35.2,32.1,30.3,30.3,30.4,29.5,29.5,29.5,29.2,28.7,28,27.2,26.1,24,21,17.5,12.8,8.7,8,9.4,14.8,23.6
3,3B-2,22.8,44.9,39.2,34.3,30.5,27.7,25.5,23.6,22.2,21,20,18.5,17.5,16,15.2,14.7,13.6,12.3,10.6,8.5,6.7,7,7.2,14.8,23.6
4,3B-2,21.4,44.9,39.1,34.1,29.9,27,24.8,22.7,21.4,20.1,19,17.6,16.5,15.2,14.4,13.9,12.9,11.6,10,8.1,4.6,4.4,7.2,14.8,23.6
5,3D-1,21.5,44.9,39.1,33.9,29.2,25.8,22.6,19.6,17.7,16,14.8,14.3,14.2,14.6,15,15.4,14.9,14.1,12.6,10.1,7.4,4.4,7.2,14.8,23.6
6,3D-2,20.5,44.9,39.1,33.9,29.3,25.9,22.6,19.6,17.6,16,14.7,14.2,14,14.3,14.6,14.9,14.4,13.3,11.6,9.1,4.6,4.4,7.2,14.8,23.6
```

Appendix C – Calculating Audibility

Introduction

Audibility is defined as the ability for an attentive listener to hear aircraft noise. Detectability is based on signal detection theory[v,vi], and depends on both the actual aircraft sound level ("signal") and the ambient sound level (background or "noise"). As such, audibility is based on many factors including the listening environment in which one is located. Conversely, detectability is a theoretical formulation based on a significant body of research. For the purposes of INM modeling the terms "audibility" and "detectability" are used interchangeably. The detectability level (d') calculated in INM is based on the signal-to-noise ratio within one-third octave band spectra for both the signal and noise, using a 10log(d') value of 7 dB.

There are three parts to the calculation of audibility in INM: (1) Calculate the detectability level ($D'L_{band}$) for each one-third octave band of the signal for a single contributing flight path segment; (2) Calculate the detectability level ($D'L_{total}$) for the overall signal for a single contributing flight path segment; and (3) Calculate absolute or percentage of time a signal is audible (detectable by a human) for a flight path (*TAud* or *%TAud*).

Definitions

$L_{signal,band}$	sound level of the signal (aircraft) for a particular frequency band
$L_{noise,band}$	sound level of the background noise (ambient) for a particular frequency band
η_{band}	efficiency of the detector (a scalar value known for each frequency band)
bandwidth	one-third octave bandwidth
$D'L_{band}$	detectability level for a particular frequency band
$D'L_{total}$	total detectability level
d'_{band}	detectability for a particular frequency band
d'_{total}	sum of squares of detectability over all frequency bands
TAud	absolute amount of time a signal is audible by humans
%TAud	percentage of a time period that a signal is audible

Note that values of $L_{signal,band}$ and $L_{noise,band}$ are calculated for each segment-receiver pair and then the total audibility for a given flight track is summed from the individual segments.

Part I of Calculations:

Calculate the detectability level for each one-third octave frequency band, then determine if the signal for that frequency band is detectable.

The theory of detectability level is based on the following equation:

$$D'L_{band} = 10\log\left[\eta_{band}\sqrt{bandwidth}\left(\frac{signal}{noise}\right)\right] \qquad \text{C-1}$$

The following one-third octave band filter characteristics are used in the calculation of detectability:

Table C1. One-Third Octave Band Characteristics

ANSI Band #	Nominal Center Frequency (Hz)	Bandwidth (Hz)	$10\log[\eta_{band}]$
17	50	11	-6.96
18	63	15	-6.26
19	80	19	-5.56
20	100	22	-5.06
21	125	28	-4.66
22	160	40	-4.36
23	200	44	-4.16
24	250	56	-3.96
25	315	75	-3.76
26	400	95	-3.56
27	500	110	-3.56
28	630	150	-3.56
29	800	190	-3.56
30	1000	220	-3.56
31	1250	280	-3.76
32	1600	400	-3.96
33	2000	440	-4.16
34	2500	560	-4.36
35	3150	750	-4.56
36	4000	950	-4.96
37	5000	1100	-5.36
38	6300	1500	-5.76
39	8000	1900	-6.26
40	10000	2200	-6.86

1) Calculate the detectability level for each one-third octave frequency band

$$D'L_{band} = (L_{signal,band} - L_{noise,band}) + \{10\log[\eta_{band}] + 0.5\times 10\log[bandwidth]\} \qquad \text{C-2}$$

Where: $10\log[\eta_{band}]$ is given in the above table; and

$L_{noise,band}$ is the addition of the un-weighted, measured one-third octave band ambient levels and the appropriate EASN level (see below).

Figure C-1 and Table C-2 below present the Equivalent Auditory System Noise (EASN)[vii] levels derived for modeling audibility using one-third octave band data.

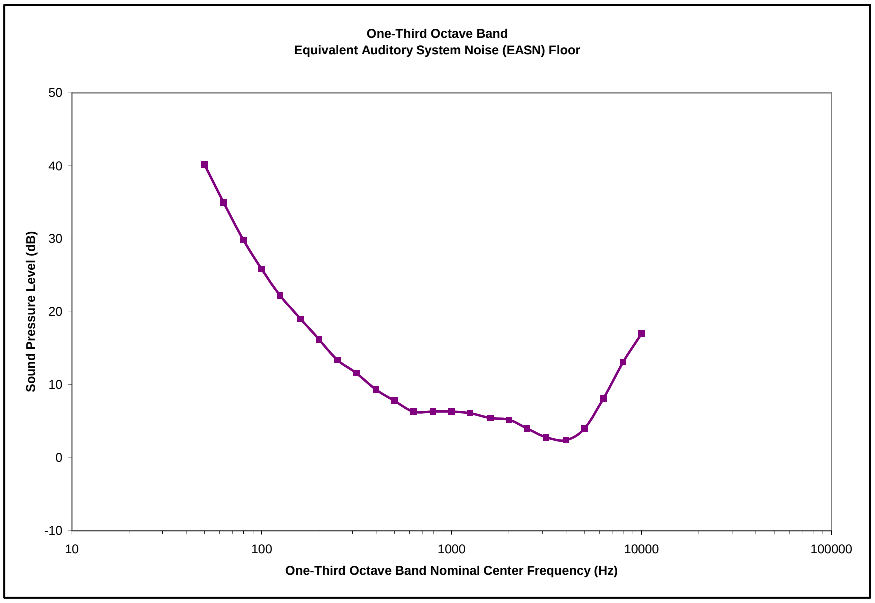

Figure C-1. EASN Threshold

Table C2. EASN Threshold

One-Third Octave Band Nominal Center Frequency (Hz)	EASN Threshold (dB)
50	40.2
63	35.0
80	29.8
100	25.8
125	22.2
160	19.0
200	16.2
250	13.4
315	11.6
400	9.3
500	7.8
630	6.3
800	6.3
1000	6.3
1250	6.1
1600	5.4
2000	5.2
2500	4.0

3150	2.8
4000	2.4
5000	4.0
6300	8.1
8000	13.1
10000	17.0

2) Determine if the signal for that frequency band is detectable

If $D'L_{band} \geq 7$ the signal is flagged as **detectable** for that frequency band

Part II of calculations

Determine if the overall signal is detectable.

1) Calculate the detectability for each one-third octave frequency band using the band detectability levels from Part I

$$d'_{band} = 10^{\frac{D'L_{band}}{10}} \quad \text{C-3}$$

2) Calculate the square root of the sum of squares of detectability over all frequency bands

$$d'_{total} = \sqrt{\left[\sum_{band=17}^{40} \left(d'_{band}\right)^2\right]} \quad \text{C-4}$$

3) Calculate the total detectability level

$$D'L_{total} = 10\log\left[d'_{total}\right] \quad \text{C-5}$$

4) Determine if the overall signal is detectable

If $D'L_{total} \geq 7$ the overall signal is flagged as **detectable**

Part III of calculations:

Calculate the absolute or percentage of time a signal is audible by a human; the time for a single contributing flight path segment is first calculated, then the absolute or percent time is calculated for an overall event or larger period of time (multiple flights for an average day or other time period)

1) Calculate the time audible (in seconds) for a single flight path

seglength	length (in feet) of contributing flight path segment
segspeed	average speed (in feet/second) during contributing flight path segment
segtime	time passed during contributing flight path segment
totaltime	total time of flight for a single event

For each segment, calculate time it takes aircraft to travel through flight path segment

segtime* = (*seglength*/*segspeed*)** x ***# of Operations

If segment is flagged as detectable, then

TAud = TAud + segtime

Then when ***segtime*** is totaled for all segments, a 24 hour percent Time Audible will be:

%TAud = TAud/(24 hours)

2) Calculate the time audible (in minutes) for a time period

TAud = TAud/(60seconds/minute)

Appendix D – Calculating Line-of-Sight Blockage

The adjustment for line-of-sight blockage (LOS_{ADJ}) is based on the theoretical barrier effect (assuming a barrier of infinite length), which is calculated with the following equation:

$$\textit{Barrier Effect} = \begin{cases} 5 + 20 \cdot \log_{10}\left(\dfrac{\sqrt{2\pi |N_0|}}{\tan\left(\sqrt{2\pi |N_0|}\right)} \right) & N_0 < 0 \\ 5 + 20 \cdot \log_{10}\left(\dfrac{\sqrt{2\pi N_0}}{\tanh\left(\sqrt{2\pi N_0}\right)} \right) & N_0 > 0 \end{cases} \qquad \text{[D-1]}$$

where the Fresnel Number is computed as follows:

$$N_0 = \pm 2\left(\frac{\delta_0}{\lambda}\right) = \pm 2\left(\frac{f\delta_0}{c}\right) \qquad \text{[D-2]}$$

where:

N_0 is the Fresnel Number determined along the path defined by a particular source-barrier-receiver geometry;

± is positive in the case where the line of sight between the source and receiver is lower than the diffraction point and negative when the line of sight is higher than the diffraction point;

δ_0 is the path length difference determined along the path defined by a particular source-barrier-receiver geometry, and = (A + B) – C (noted in Figure 1 above);

λ is the wavelength of the sound radiated by the source;

$\boldsymbol{f}$ is the frequency of the sound radiated by the source; and

$\boldsymbol{c}$ is the speed of sound.

Note that in the relationship between the variables in Equation D-2, if the path length difference increases, the Fresnel number and, thus, barrier attenuation increases. If the frequency increases, barrier attenuation increases as well. For illustrative purposes, Figure D1 shows the relationship between barrier attenuation and Fresnel Number for a frequency of 550 Hz.

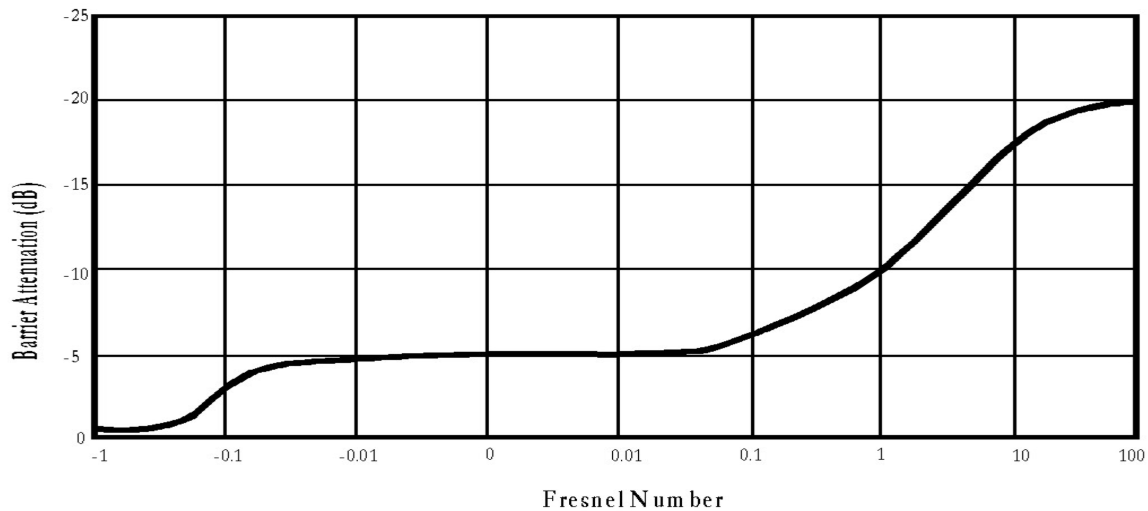

Figure D1. Barrier Attenuation Versus Fresnel Number.

LOS_{ADJ} is then computed by (1) calculating the Barrier Effect for each one-third octave-band, (2) summing the barrier effect acoustic energy in all one-third octave-bands, and (3) converting that sum to decibels. LOS_{ADJ} is then arithmetically subtracted from the NPD data.

If line-of-sight blockage is invoked as a run option, LOS_{ADJ} is compared to lateral attenuation adjustment (LA_{ADJ}) on a point-by-point basis, and the larger of the two values is applied to the calculations. For each segment-receiver-based noise calculation, either LOS_{ADJ} or LA_{ADJ} are implemented, but not both.

Appendix E - INM Technical Manual Update Addendum

INM Version 6.1 modified the lateral attenuation algorithms contained in the model to better correlate modeling predictions with research undertaken recently in both the U.S. and internationally. The lateral attenuation algorithms utilized in the INM are based on SAE-AIR-1751 which specifies an algorithm with two primary components: (1) Overground Attenuation [**G(ℓ)**]; and (2) Long-Range Air-to-Ground Attenuation [**Λ(β)**]. INM 6.1 includes changes only to **Λ(β)** (Long-Rang Attenuation) for Wing-Mounted and propeller aircraft.

Figure E1 below depicts the Long-Range Air-to-Ground Attenuation algorithm. The solid line (designated as "SAE-AIR-1751 (1981, reaffirmed 1991)" represents this equation as specified in SAE-AIR-1845 and used for modeling all aircraft in INM prior to Version 6.1. This curve is identical to Figure 3 in SAE-AIR-1751. The dashed line (designated as "INM Version 6.1") represents the Long-Range Air-to-Ground Attenuation used in Version 6.1 for all aircraft <u>except</u> jet aircraft with tail-mounted engines. INM Version 6.1 still uses the existing SAE-AIR-1751, represented by the solid line for jet aircraft with tail-mounted engines.

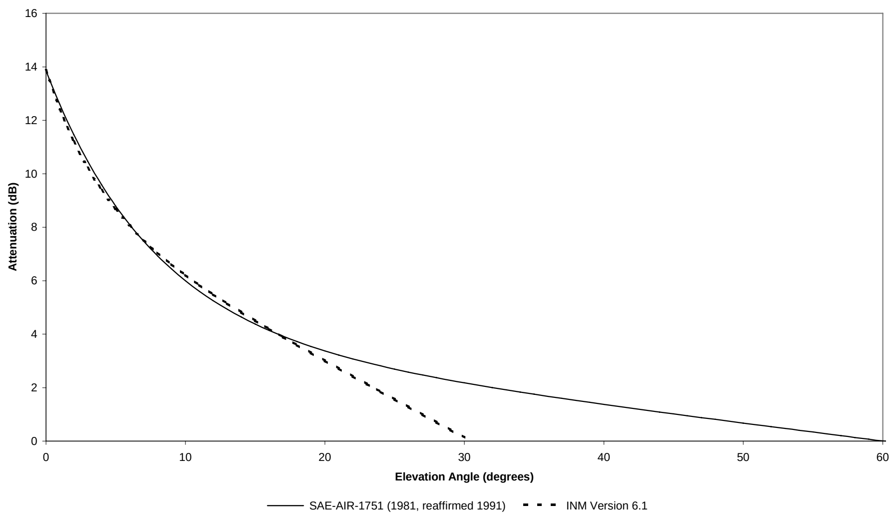

Figure E1. Long-Range Air-to-Ground Attenuation $\Lambda(\beta)$

The Version 6.1 Long-Range Air-to-Ground attenuation algorithm may be represented by the following equation:

$$\Lambda(\beta) = a_1 + a_2\beta + a_3 e^{(a_4\beta)}$$

where: $\boldsymbol{\beta}$ = elevation angle, $0° \leq \boldsymbol{\beta} \leq 30°$

$\mathbf{a_1}$ = 8.66213

$\mathbf{a_2}$ = -0.28436

$\mathbf{a_3}$ = 5.21353

$\mathbf{a_4}$ = -0.25718

Appendix F – Excess Lateral Attenuation and Aircraft Spectral Class Assignments

SAE-AIR-1751 and its draft update provide framework for determining excess lateral attenuation for fixed-wing aircraft. This excess attenuation has been observed from multiple field tests that have been conducted and reported to SAE. In general, these tests focus on commercial jet aircraft. Excess attenuation for military aircraft is determined by equations given in the USAF NOISEMAP program. Table F1 summarizes the excess attenuation effects for INM. Note that the user may disable ground-to-ground attenuation for aircraft designated as props. While SAE-AIR-1751 is not directly applicable to helicopters, Table F1 summarizes the application to helicopters in INM. As noted in the table, the ability to disable ground-to-ground attenuation also applies to helicopters. The "1751 Interim Update" identified in Table F1 refers to the "New Lateral Attenuation Function" introduced in INM Version 6.1.

Table F1. INM 6.2 Lateral Attenuation Algorithm Update

	"All-Soft-Ground"		**"No-Prop-Attenuation"**	
	Air-to Ground	**Ground-to-Ground**	**Air-to Ground**	**Ground-to-Ground**
Wing-Mount Jets	1751 Interim Update	1751	1751 Interim Update	1751
Tail-Mount Jets	1751	1751	1751	1751
Props	1751 Interim Update	1751	1751 Interim Update	*none*
Helis	1751 Interim Update	1751	1751 Interim Update	*none*
Military	NOISEMAP		NOISEMAP	

Users creating user-defined aircraft should be aware of the relationship between NPD curve, spectral class assignment and the excess attenuation modeled in INM. Table F2 presents the classification, by aircraft type, for the assignments of each INM spectral class.

Table F2. Spectral Class Assignments by Aircraft Type

	Spectral Classes		
	Departure	**Approach**	**Flyover / Afterburner**
Wing-Mount Jets	101-108	202-209	N/A
Tail-Mount Jets	113, 132-134	201, 216	N/A
Props	109-112	210-215	112, 213,
Helis	114-120	217-222	301-307
Military	121-131	223-234	121, 125-128, 131

Appendix G – Spectral Distance Cutoff Utility for Time Audible

The INM spectral distance cutoff utility is a pre-processing tool, which enables the user to specify maximum propagation distances (slant distance, source to receiver) over which to calculate time audible (**TAUD**). The utility is intended to minimize the audibility computations for distances, which would not result in audible sound levels, therefore maximizing run-time efficiency. The utility takes as input a user-defined file, which specifies the cases to which it applies, the standard INM *spectra.bin* file, as well as each cases' *flight.pth* file. Note that the use of the *flight.pth* file requires that the case has already been run once prior to the use of the utility. The cutoff distance is calculated by determining the distance at which a given aircraft noise source would no longer be audible, as compared with the EASN threshold and using the SAE-AIR-1845 standard atmosphere.

The spectral distance cutoff utility *SpectralCutoffCalculator.exe* creates a text file named *flight_pth_taud_cutoff.txt* for each INM case pathname specified in the *spectral_cutoff_cases.txt* file. The *flight.pth* file for each case must exist in the specified case directory. The *spectra.bin file* that is in the *sys_data* directory will be used. The *spectral_cutoff_cases.txt* file must exist in the same directory/folder as the *SpectralCutoffCalculator.exe* executable.

The *spectral_cutoff_cases.txt* file is a file generated by the INM user to specify to which study cases the spectral distance cutoff utility should be applied. Each line of the file specifies an INM case directory to which the spectral distance cutoff utility shall be applied. An example file and its format is specified below.

Example *spectral_cutoff_cases.txt* <u>input</u> file:

```
C:\examples\6.2Beta_Test_Study\6.2Beta_Test
C:\examples\6.2Beta_Test_Study\TEST
C:\examples\6.2Beta_Test_Study\6.2Beta_Test_TAUD
```

spectral_cutoff_cases.txt file format specification:

First line: 1st case directory with full path;
:
:
nth line: nth case directory with full path.

The *flight_pth_taud_cutoff.txt* file is the space-delimited, output file for *SpectralCutoffCalculator.exe*. One of these files is created for each case specified in the *spectral_cutoff_cases.txt* input file. An example file and its format are specified below.

Example *flight_pth_taud_cutoff.txt* output file:

```
0 JT3DQ  A   3000.0 A  208   52403.0
1 JT3DQ  A   5000.0 A  208   57670.0
2 JT3DQ  A  11000.0 D  106   70201.0
3 JT3DQ  A  15500.0 D  106  122997.0
4 JT3DQ  P   3000.0 A  208   39769.0
5 JT3DQ  P   5000.0 A  208   40883.0
6 JT3DQ  P  11000.0 D  106   85040.0
7 JT3DQ  P  15500.0 D  106  142957.0
```

flight_pth_taud_cutoff.txt file format specification:

First column: NPD curve counter;
Second column: NPD identifier;
Third column: A-weight or P-weight indicator;
Fourth column: NPD thrust level [units as specified by INM];
Fifth column: NPD curve operation mode [‘A’, ‘D’ or ‘X’];
Sixth column: NPD curve spectral class number;
Seventh column: computed noise cutoff distance for NPD curve [units of feet].

The seventh column may also be modified by the user as desired. For instance, if the user knows calculated audibility levels are not needed beyond *x* feet slant distance from the flight track for a given case, the number *x* may be used in place of the value calculated by the spectral distance cutoff utility. Columns one through five have no function in the INM; they are for the user’s reference only. The *flight_pth_taud_cutoff.txt* file matches the format of the NPD curves found in the *flight.txt* file (which may be created through the INM GUI). When a particular case is run in the INM, the compute module checks that the same number of rows is consistent with what the INM specifies for noise curves. Accordingly, modification of the *flight_pth_taud_cutoff.txt* file must not in any way change the number or order of rows from what is produced by *SpectralCutoffCalculator.exe*.

Once the spectral distance cutoff utility has been run, the user may run the INM without the distance cutoff simply by removing or renaming the *flight_pth_taud_cutoff.txt* file. Each time the spectral cutoff calculator is utilized for a given case a message documenting the date and time of the run is printed to a file named *spectral_cutoff_info.txt* in the case directory.

Appendix H – Example Boundary Cutoff Data

Figure H-1 presents examples of both valid and invalid data used for the boundary cutoff utility. In the diagram, Figure H-1a is an example of valid boundary data and Figure H-1b and H-1c are examples of invalid boundary data. Note that whereas boundary cutoff data may be generated external to the INM, the data in these examples were generated by running an actual INM study using a low refinement and high tolerance setting to produce contour levels lower than are required for the analysis of interest (i.e., 50 dB DNL for a study for which 65 dB DNL is the primary output). The *conr_pts.dbf* file from the 50 dB DNL run was then converted using MS Excel to the polyline txt format required by INM.

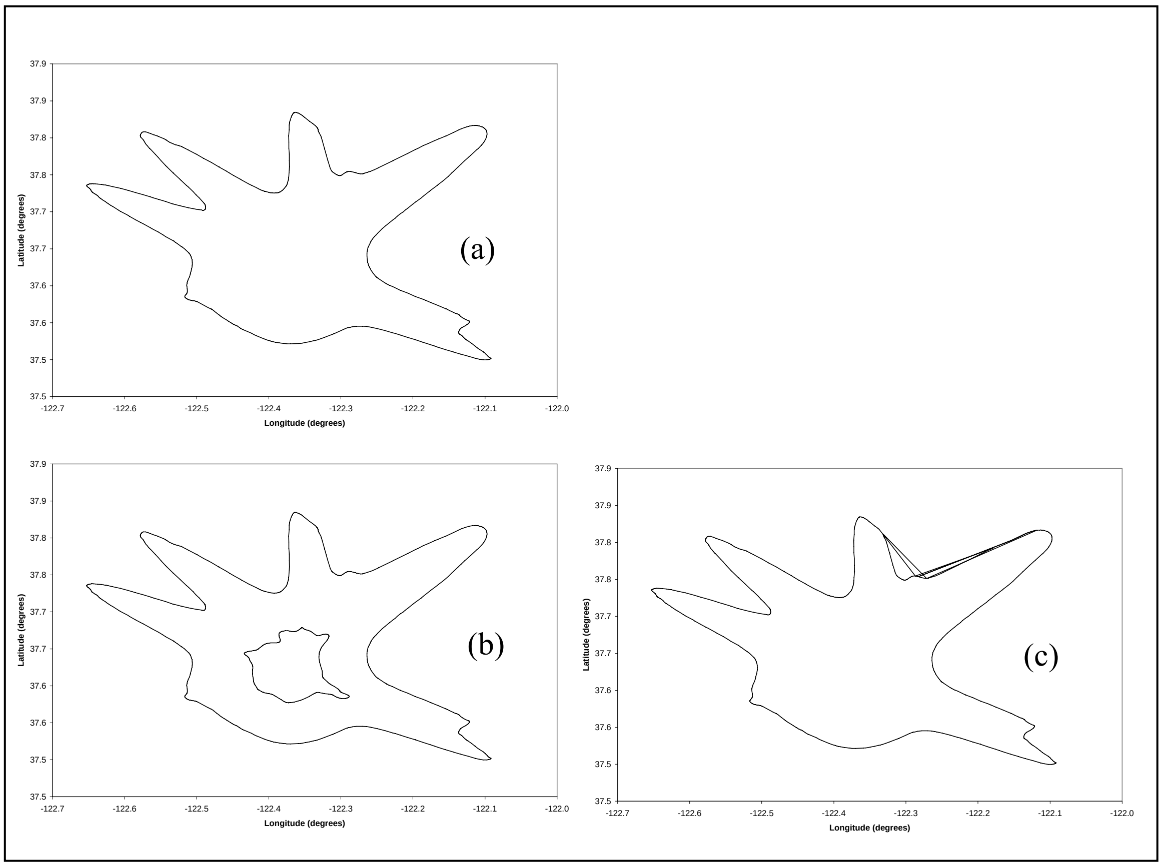

Figure H-1. Example Boundary Cutoff Data

References

[i] Fleming, et. al., Federal Interagency Committee on Aviation Noise: Assessment of Tools for Modeling Aircraft Noise in the National Parks. Cambridge, MA: John A Volpe National Transportations Systems Center Acoustics Facility, and Wyle Laboratories, http://overflights.faa.gov/.

[ii] National Parks Air Tour Management Plan (ATMP) Program Implementation Plan, Cambridge, MA: John A. Volpe National Transportation Systems Center, September 2005.

[iii] Lee, et. al., Baseline Ambient Sound Levels in Mount Rushmore National Memorial, Report No. DOT-VNTSC-FAA-06-11, Cambridge, MA: John A. Volpe National Transportation Systems Center, April 2006.

[iv] Reherman, et. al., DOT-VNTSC-FAA-03-09 Fitchburg Airport Noise Measurement Flight Tests: Summary of Measurements, Data and Analysis. Cambridge, MA: John A Volpe National Transportations Systems Center Acoustics Facility, *to be published*.

[v] Green, David M. and Swets, John A., "Signal Detection Theory and Psychophysics." New York: John Wiley and Sons, Inc, 1966.

[vi] Fidell, et. al., "Predicting Annoyance from Detectability of Low-Level Sounds," Journal of the Acoustical Society of America, 66(5), November 1979, p. 1427 – 1434.

[vii] Horonjeff, Richard D., Comparison of ISO Human Threshold of Hearing Standards: ISO R226:1961 and ISO 389-7:1998, Plus Equivalent Auditory System Noise (EASN) 1/3 Octave Band Spectra Therefrom Derived, Plus Modified FORTRAN Implementation of d' Algorithm Using EASN in Place of Threshold of Hearing, December 7, 2004.