United States Department of Transportation

Bureau of Transportation Statistics

National Transportation Noise Mapping Tool

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Notice

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1   Introduction

By most forecasts, the U.S. population is projected to grow by over 100 million by 2050. As demand for transportation increases, transportation-related noise will also change. The Bureau of Transportation Statistics (BTS) has started a national, multi-modal transportation noise mapping initiative to facilitate the tracking of trends in transportation-related noise as changes occur at an unprecedented rate.

This document describes the methodology and assumptions included in the National Transportation Noise Mapping Tool (NTNMT) which produces noise inventory layers for aviation and roadway transportation sources. Future versions of the tool are envisioned to include additional transportation noise sources (e.g. rail, maritime).

2   Noise Metric

The national transportation noise inventory is developed using a 24-hr equivalent sound level (LEQ, denoted by L_{Aeq}) noise metric. The results are A-weighted noise levels that represent the approximate average noise energy due to transportation noise sources over the 24 hour period at the defined receptors. This map includes simplified noise modeling and is intended for the tracking of trends, it should not be used to evaluate noise levels in individual locations and/or at specific times. See Section 6 for more information on intended usage.

3   Aviation Noise

An aviation noise inventory is computed in the Aviation Environmental Design Tool (AEDT) version 2b Service Pack 2. See the AEDT documentation[1] for acoustic computation details. The results from the aviation noise inventory are input into the NTNMT for visualization on the map. The aviation noise modeling inputs and assumptions are described in this section.

Sources

Aircraft flight operation data are derived from the schedule data in the Traffic Flow Management System (TFMS)[2]. By combining data from the Air Traffic Control System Command Center (ATCSCC), the Air Route Traffic Control Centers (ARTCCs), and major Terminal Radar Approach Control (TRACON) facilities, TFMS enables an accurate representation of all Instrument Flight Rules (IFR) flights in US airspace (note: helicopter operations are not included in this effort).

Flight operations are averaged into a single average annual day. Airports with an average of 1 or more jet departures per day are included in the analysis (note: airports with exclusively military operations were excluded; however, military operations at joint-use or commercial airports were included). For the year 2014, this resulted in the modeling of operations at 683 airports.

Departure and arrival procedures are assigned for the annualized day of operations. For the year 2014, detailed track information was available and leveraged for 121 airports, including the dispersion and utilization of each runway and ground track. For the remaining 562 airports, straight-in and straight-out procedures were modeled for all runways.

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[1] AEDT documentation is available on the AEDT Support website: https://aedt.faa.gov/2b_information.aspx

[2] Volpe National Transportation Systems Center, "Traffic Flow Management System (TFMS), Reference Manual TSD Version 8.9," August 2003.

Receptors

Noise levels are calculated at receptors in AEDT. For the aircraft noise inventory, an array of grid points that is large enough to encompass the full 35 dB(A) $L_{Aeq,24}$ exposed area is used. Close in to each airport (as defined by the 55 dB(A) exposed area) an airport-specific receptor resolution is used. The distance between points in the 55 dB(A) exposed area varies between 0.005 and 0.25 nautical miles, depending on the size of the airport and the associated operation count. Beyond the 55 dB(A) exposed area, and out to 35 dB(A), a resolution of 0.25 nautical miles was used.

Assumptions

The following assumptions apply to the aircraft noise modeling used for this effort:
- Weather: NOAA 30-Year Normals data (1971-2000)[3] specific to each airport. Atmospheric absorption is assumed.
- Ground type: Acoustically soft ground. Sound levels for large areas with acoustically hard ground (e.g., water or pavement) may be under-predicted.
- Noise level cutoff: Aircraft noise is calculated out to 35 dB(A) $L_{Aeq,24}$.
- Additional assumptions that apply to the AEDT modeling software can be found in the AEDT Technical Manual[4].
- Additional assumptions related to the TFMS dataset can be found in the TFMS Reference Manual[2].

AEDT models aviation noise based on measured source data from actual aircraft. The uncertainty in the calculated noise on the ground increases as the noise level decreases due to increasing distance between the aircraft and the receptor.

4   Road Noise

Road noise is calculated within the NTNMT using acoustical algorithms from the Federal Highway Administration's (FHWA) Traffic Noise Model (TNM) version 2.5. The road noise modeling inputs and assumptions are described in this section.

Sources

Average Annual Daily Traffic (AADT) values are used in conjunction with vehicle types and speed to compute road noise using TNM's acoustical algorithms. AADTs are obtained from FHWA's Highway Performance Monitoring System (HPMS)[5], which also describes the road types included in the National Transportation Noise Mapping Tool.

When valid speed information[6] is included in the HPMS data, it is used in the road noise modeling. If valid speed information is not included in the HPMS data, average speeds are assigned based on road type and area type (urban or rural). Roads which do not have valid existing speeds, and are also missing road or area type information are assigned a default speed of 35 mph.

The road types and their average speed limits that are included in the National Transportation Noise Mapping Tool are described in Table 1.

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[3] National Climatic Data Center; "U.S. Climate Normals 1971-2000, Products"; 2001; NOAA's National Climatic Data Center, Asheville, NC

[4] FAA's AEDT Technical Manual: https://aedt.faa.gov/2b_information.aspx

[5] For more information on FHWA's HPM, visit: https://www.fhwa.dot.gov/policyinformation/hpms.cfm

[6] Valid speed information is defined as >= 20 mph, or <= 80 mph.

Table 1: National Transportation Mapping Tool Road Types and Average Speeds

Road Type	Area Type	Average Speed (mph)
Interstate	Rural	69
Principal Arterial - Other Freeways and Expressways	Rural	55
Principal Arterial - Other	Rural	55
Minor Arterial	Rural	45
Major Collector	Rural	44
Interstate	Urban	59
Principal Arterial - Other Freeways and Expressways	Urban	61
Principal Arterial - Other	Urban	21
Minor Arterial	Urban	20
Major Collector	Urban	29

The vehicle types that are included in the National Transportation Noise Mapping Tool are described in FHWA's TNM Technical Manual[7] and listed below:

- Automobiles
- Medium trucks
- Heavy trucks

The noise levels are determined using the FHWA's Traffic Noise Model's acoustical algorithms described by equations 1 through 8 in the TNM Technical Manual.

Receptors

Road noise is calculated at receptor locations. The road noise receptors are defined by a uniform grid with a resolution of 98.4 feet (30 m). Each receptor is modeled at a height of 4.92 feet (1.5 m) above ground level. Noise levels are adjusted to account for ground effects and free-field divergence differences between the source reference location[8] and the receptor location.

Assumptions

The following assumptions apply to the road noise modeling in the National Transportation Noise Mapping Tool:

- Weather: Non-homogenous atmospheric effects are not taken into account in road noise modeling and TNM's default temperature and humidity levels are used (68 degrees F, 50% relative humidity).
- Ground type: Acoustically soft ground. Sound levels for large areas with acoustically hard ground (e.g., water or pavement) may be under-predicted.
- Average pavement is used for noise computations. Specific pavements may be quieter or louder depending on the material and texture of the road.
- Noise level cutoff: It is assumed that roadway traffic related noise levels below 35 dB(A) do not significantly contribute to the road noise level. Therefore, computations are cut-off for distances that result in noise levels from a single source to be less than 35 dB(A).
- Average Annual Daily Traffic: AADT data are distributed evenly across 24 hours.

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[7] FHWA's TNM Technical Manual Chapter 2:
https://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v25/tech_manual/
[8] The source reference location is a point that is 50 feet from the road along a perpendicular line that intersects the midpoint of the road segment.

- Attenuation Rate: In this model, noise level attenuation is considered to be due only to ground effects and free-field divergence. Shielding is not considered (i.e. attenuation due to barriers and terrain are not considered). For this reason, noise levels may be over-predicted in areas near highway barriers or natural shielding features such as berms, hills, etc.
- Additional assumptions that apply to the acoustical algorithms themselves can be found in FHWA's TNM Technical Manual.
- Additional assumptions related to the HPMS dataset can be found on the HPMS webpage[5].

Pre-calculated TNM results are used as source data in the road noise modeling. The uncertainty in the calculated noise increases as the noise level decreases due to increasing distance between the vehicle and the receptor.

5   Layers

The aircraft and road noise inventory data for the year 2014[9] are provided as Geographic Information System (GIS) layers for the United States by state. Aircraft and road noise inventories are provided both separately and as combined GIS layers. The combined aircraft and road noise inventories are acoustically summed to produce the composite layers.

The data are organized into of three main directories, Alaska, Hawaii and Continental United States (CONUS), each containing geodatabases for aviation noise, road noise, and combined aviation and road noise. A single raster dataset is contained within each of the Alaska and Hawaii geodatabases while the CONUS directory contains the raster datasets for the 48 contiguous states.

Each state is provided as a separate ArcGIS raster dataset. The 48 contiguous states are contained in one file geodatabase which also includes a single mosaic dataset composed of the individual rasters. Note that the CONUS directory also contains *Overviews* folders. These files are used in the mosaic dataset and allow for quickly viewing lower-resolution copies of raster data when zoomed out. When zooming into an area, the finer resolution data are used.

All layers use variations of the Albers Equal-Area Conic projection[10]. The projection and resolution are modeled after the National Land Cover Database (NLCD 2011)[11].
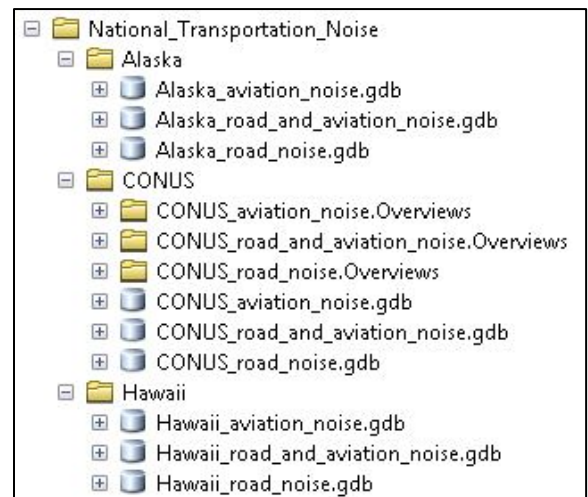

Figure 1: National Transportation Noise Directories

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[9] Data from the year 2013 were used for the state of New York due to HPMS data issues for the year 2014.

[10] Projections used include USA_Contiguous_Albers_Equal_Area_Conic_USGS_version (WKID 102039), NAD_1983_Alaska_Albers (WKID 3338), and Hawaii_Albers_Equal_Area_Conic (WKID 102007).

[11] For more information on the national land cover database 2011, visit: http://www.mrlc.gov/nlcd2011.php.

6   Assumptions Summary

The multi-modal, national transportation noise map is intended to facilitate the tracking of trends in transportation-related noise, by mode and collectively. This maps includes simplified noise modeling and should not be used to evaluate noise levels in individual locations.

A summary of the assumptions on aircraft and road noise modeling listed in Sections 3 and 4 is provided below. In addition, it should be noted that these layers only represent noise from aircraft and road transportation noise sources, non-transportation sources are not reflected in these data.

Weather
- Aviation: NOAA 30-Year Normals data (1971-2000)[3] specific to each airport. Atmospheric absorption is assumed.
- Road: Non-homogenous atmospheric effects are not taken into account in road noise modeling and TNM's default temperature and humidity levels are used (68 degrees F, 50% relative humidity).

Ground Type
Acoustically soft ground is used for both aviation and road noise modeling. Sound levels for large areas with acoustically hard ground (e.g., water or pavement) may be under-predicted.

Noise Level Cutoff
Aviation and road noise is calculated out to 35 dB(A).

Noise Models
- Pre-calculated TNM results are used as source data in the road noise modeling. The uncertainty in the calculated noise increases as the noise level decreases due to increasing distance between the vehicle and the receptor. Additional assumptions that apply to the acoustical algorithms used in road noise modeling can be found in FHWA's TNM Technical Manual.
- AEDT models aviation noise based on measured source data from actual aircraft. The uncertainty in the calculated noise on the ground increases as the noise level decreases due to increasing distance between the aircraft and the receptor. Additional assumptions that apply to the AEDT modeling software can be found in the AEDT Technical Manual.

Data
- Aviation: The source of aircraft flight operation data is the schedule dataset provided by the Traffic Flow Management System (TFMS).
- Road: The source of Average Annual Daily Traffic (AADT) for road noise modeling is provided by FHWA's Highway Performance Monitoring System (HPMS).

Additional Road Noise Assumptions
- Average pavement is used for noise computations. Specific pavements may be quieter or louder depending on the material and texture of the road.
- Average Annual Daily Traffic: AADT are distributed evenly across 24 hours.
- Attenuation Rate: In this model, noise level attenuation is considered to be due only to ground effects and free-field divergence. Shielding is not considered (i.e. attenuation due to barriers and terrain are not considered). For this reason, noise levels may be over-predicted in areas near highway barriers or natural shielding features such as berms, hills, etc.

7 Validation

The National Transportation Noise Mapping Tool is being evaluated in multiple stages. For the first tier, noise levels are evaluated by subject matter experts for confirmation that levels are within a reasonable order of magnitude. Subsequent tiers will increase levels of scrutiny via comparison to existing data sets on regions of overlap. In the future, measured data may be collected by field campaign on major corridors and/or regions of high impact and compared to the output of the National Transportation Noise Mapping Tool.