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National Transportation Noise Map Documentation

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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 over time.

This document describes the methodology and assumptions included in the National Transportation Noise Map (NTNM) which consists of noise inventory layers for aviation, roadway, and passenger rail transportation sources. Future versions are envisioned to include additional transportation noise sources (e.g. railroad freight, maritime).

2 Intended Use

Data within the National Transportation Noise Map represent potential noise levels across the nation for an average annual day for the specified year. These data are intended to facilitate the tracking of trends in transportation-related noise by mode and collectively over time, as additional maps are released. It can also be used to identify areas for more detailed research.

These maps are based on simplified noise modeling and should not be used to evaluate noise levels in individual locations or at specific times and should not be used for regulatory purposes.

The first release of the National Transportation Noise Map with data from the year 2014 should be considered a prototype and should not be compared to the 2020 release which includes the years 2016 and 2018. The 2018 rail layer should also be considered a prototype.

3 Noise Metric

The national transportation noise map is developed using a 24-hr equivalent A-weighted sound level (denoted by L_{Aeq}) noise metric. The results represent the approximate average noise energy due to transportation noise sources over a 24-hour period at the receptor locations where noise is computed.

4 Aviation Noise

Aviation noise is computed in the Aviation Environmental Design Tool (AEDT) version 3a. See the AEDT documentation[1] for acoustic computation details. The results from the aviation noise inventory are input into the National Transportation Noise Mapping Tool for visualization on the map. The aviation noise modeling inputs and assumptions are described in this section.

Sources

Flight operations[2] 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

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

[2] 2016 aircraft flight operation data are derived from the schedule data in the Traffic Flow Management System (TFMS), while 2018 aircraft flight operation data come from an aircraft movements dataset directly from the Federal Aviation Administration Office of Environment and Energy (FAA AEE). Air traffic counts from the Air Traffic Activity Data System (ATADS) are also considered for both 2016 and 2018. 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, the FAA AEE movements dataset, and air traffic counts from

were excluded; however, military operations at joint-use or commercial airports were included). Helicopter operations are not included in this effort. For the year 2016, this resulted in the modeling of operations at 685 airports. In the year 2018 this resulting in modeling operations at 747 airports.

Receptors

Noise levels are calculated at receptor locations in AEDT. For each airport, the dynamic gridding approach was used to define the receptor set. The starting grid for each airport was a 4 point box, spaced 0.1 nautical miles apart, and centered on the airport reference point. The grid refinement level (using the linear INM approach), varied per airport; the exact refinement level was determined through a manual process of contour review and intensifying the refinement level until a smooth 65 dB contour was produced. For more information on dynamic grids in AEDT, see the AEDT documentation[3].

Assumptions

The following assumptions apply to the aircraft noise modeling used for this effort:

- Weather: NOAA Global Summary of the Day (GSOD) data was used to model yearly-specific meteorological data that was averaged across the year and 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.
- Terrain/Shielding: Not included. Noise levels may be over-predicted in areas with natural shielding features such as mountains.
- Noise level cutoff: Noise level results below 45 dB(A) $L_{Aeq,24}$ are not included.
- Additional assumptions that apply to the AEDT modeling software can be found in the AEDT Technical Manual[3].
- Additional assumptions related to the TFMS dataset can be found in the TFMS Reference Manual[Error! Bookmark not defined.].

AEDT models aviation noise based on measured source data from actual aircraft. The uncertainty in the modeled noise on the ground increases as the noise level decreases due to increasing distance between the aircraft and the receptor. As distance increases, effects not included in the simplified noise modeling used to produce these maps such as shielding, variation in ground type, as well as absorption, refraction and scattering resulting from non-homogenous atmosphere will also increase.

Known discrepancies in source data are described in Section 10, however this should not be considered a fully comprehensive list.

5 Road Noise

Road noise is computed 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.

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the Air Traffic Activity System (ATADS) enable an accurate representation of all Instrument Flight Rules (IFR), Visual Flight Rules (VFR), and local flights in US airspace (note: helicopter operations are not included in this effort). Departure and arrival procedures are determined from detailed radar track data in the terminal area. For 2018, this radar data came directly from the FAA AEE movements dataset; 2016 leveraged the Performance Data Analysis and Reporting System (PDARS).

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

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)[4], which also describes the road types included in the National Transportation Noise Map.

When valid speed information[5] 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 Map are described in Table 1.

Table 1: National Transportation Noise Map 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 Map are described in FHWA's TNM Technical Manual[6] 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[7] and the receptor location.

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

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

[6] FHWA's TNM Technical Manual Chapter 2: https://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v25/tech_manual/

[7] 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.

Assumptions

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

- 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.
- Average Annual Daily Traffic: AADT data are distributed evenly across 24 hours.
- Terrain/Shielding: Not included. Noise levels may be over-predicted in densely-settled urban areas, areas near noise barriers, or areas near natural shielding features such as berms, hills, etc.
- Noise level cutoff: Noise level results below 45 dB(A) $L_{Aeq,24}$ are not included. 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 [4].

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. As distance increases, effects not included in the simplified noise modeling used to produce these maps such as shielding, variation in ground type, as well as absorption, refraction and scattering resulting from non-homogenous atmosphere will also increase.

Since the HPMS dataset is dependent on input from the states, variations in reported data could appear as a change in noise. Known discrepancies in source data are described in Section 10, however this should not be considered a fully comprehensive list.

6 Passenger Rail Noise

Commuter and rapid transit passenger rail noise is computed within the NTNMT using source data described below and computational procedures as outlined in the Federal Transit Administration (FTA) Transit Noise and Vibration Impact Assessment Manual [8] for evaluating moving equipment on conventional passenger rail lines and for horn noise assessment and the Federal Railroad Administration (FRA) High Speed Ground Transportation Noise and Vibration Impact Assessment Manual [9] for high-speed operations (>90 mph). The passenger rail noise modeling inputs and assumptions are described in this section.

Sources

General Transit Feed Specification (GTFS)[10] data are used in conjunction with the North American Rail Network (NARN)[11], and FRA's Highway-Rail Crossing Inventory[12] to obtain operational data, route

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[8] FTA's Transit Noise and Vibration Impact Assessment Manual: https://www.transit.dot.gov/research-innovation/transit-noise-and-vibration-impact-assessment-manual-report-0123

[9] https://www.fra.dot.gov/eLib/Details/L04090

[10] For more information on GTFS, visit: https://gtfs.org/

[11] For more information on the NARN, visit: https://www.bts.dot.gov/newsroom/rail-network-spatial-dataset

[12] https://safetydata.fra.dot.gov/OfficeofSafety/publicsite/DownloadCrossingInventoryData.aspx

information and locations of grade crossings, tunnels[13], and quiet zones. The GTFS data provides information on the representative daily traffic and is obtained by counting the number of trips that each train line makes on a representative weekday in the fall. The traffic count is used in conjunction with train speed to compute the overall rail noise produced by each transit system.

Train speed is determined from operation times with a low speed cutoff of 10 m/s[14] for diesel-powered commuter trains and 0.5 m/s for electrically-powered passenger trains and rapid transit trains. Trains operating at speeds below the low speed cutoffs are assigned a speed of 10 m/s or 0.5 m/s according to train type. Data on the time trains are idling is not available and is not computed. Train speed during acceleration and deceleration periods is accounted for by using a rate of 2 mph/s over the period of time it takes to reach full speed.

The rail noise source types that are included in the NTNMT are as follows:

- Commuter rail mainline[15]
- High-speed electric (90-160 mph)
- LRT and RRT (>25 mph)
- Street cars (<25 mph)[16]
- Commuter rail horns
    - Horn noise is included for track segments within ¼ mile of each grade crossing, unless a quiet zone is identified.

Known discrepancies in source data are described in Section 10, however this should not be considered a fully comprehensive list.

Receptors

Rail noise is calculated at receptor locations. The 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[17] and the receptor location.

Assumptions

The following assumptions apply to the rail noise modeling in the National Transportation Noise Map:

- Weather: Atmospheric effects are not taken into account in rail noise modeling.
- Ground type: Acoustically soft ground effects computed based on general, rule-of-thumb assumptions, which will result in increased uncertainty as source-receptor distance increases. Sound levels for large areas with acoustically hard ground (e.g., water or pavement) may be under-predicted.
- Noise level cutoff: Noise level results below 45 dB(A) $L_{Aeq,24}$ are not included.

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[13] Grade crossings and tunnel locations may be incomplete for Amtrak routes. Grade crossings and tunnel locations that are shared with commuter lines or that are near major metropolitan areas are included.

[14] FRA CREATE Freight Noise and Vibration Model:

[15] Diesel-electric and electric commuter rail mainline trains are represented in one category and use the diesel-electric reference noise level for conservative modeling.

[16] Note that rail systems that have street car components that are included in the GTFS data as light rail systems are included, but systems that are exclusively for streetcars are not currently included.

[17] The source reference location is a point that is 50 feet from the track along a perpendicular line that intersects the midpoint of the track segment.

- Terrain/Shielding: Not included. Noise levels may be over-predicted in densely-settled urban areas, areas near noise barriers, or areas near natural shielding features such as berms, hills, etc.
- Underground sections: The noise contribution from an operation underground is assumed to be 0 dB.
- Idling equipment: Noise from idling time at station stops is not considered.
- Additional assumptions that apply to the acoustical algorithms themselves can be found in FTA's Transit Noise and Vibration Impact Assessment Manual.
- Additional assumptions related to the GTFS and NARN can be found on their respective webpages[10,11].

Noise source reference data is based on measured source data from rail equipment. The uncertainty in the calculated noise increases as the noise level decreases due to increasing distance between the vehicle and the receptor. As distance increases, effects not included in the simplified noise modeling used to produce these maps such as shielding, variation in ground type, as well as absorption, refraction and scattering resulting from non-homogenous atmosphere will also increase.

7 Layers

The transportation noise inventory data are provided as Geographic Information System (GIS) layers for the United States, separated out by geography (Alaska, Hawaii, or CONUS – lower 48 states), for the following years:

- 2018 – Aviation, road, passenger rail* separately and combined
- 2016 – Aviation, road separately and combined
- 2014[18] - Aviation*, road* separately and combined

*Should be considered a prototype

The first release of the National Transportation Noise Map with data from the year 2014 should be considered a prototype and should not be compared to the 2020 release with data from the years 2016 and 2018. The 2018 passenger rail layer should also be considered a prototype.

Aircraft, road and passenger rail noise inventories are provided both separately and as combined GIS layers. The combined aircraft, road, and passenger rail noise inventories are acoustically summed to produce the composite layers.

8 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. These maps include simplified noise modeling and should not be used to evaluate noise levels in individual locations or at specific times.

A summary of the assumptions on aircraft and road noise modeling listed in Sections 4 and 5 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

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

- Aviation: NOAA 30-Year Normals data (1971-2000)Error! Bookmark not defined. 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).
- Rail: No atmospheric absorption is computed.

Ground Type

- Aviation: Acoustically soft ground effects are computed based on SAE AIR5562 methods.
- Road: Acoustically soft ground effects are computed using frequency-based data and procedures outline in the FHWA TNM Technical Manual
- Rail: Acoustically soft ground effects are computed based on a simplified adjustment factor.

In all cases, sound levels for large areas with acoustically hard ground (e.g., water or pavement) may be under-predicted.

Noise Level Cutoff

Noise level results below 45 dB(A) $L_{Aeq,24}$ are not included.

Noise Models

- Road: Pre-calculated TNM results are used as source data in the road noise modeling. The pre-calculated results are based on measured source data from roadway traffic. Additional assumptions that apply to the acoustical algorithms used in road noise modeling can be found in FHWA's TNM Technical Manual on the TNM website or in the National Transportation Library.
- Aviation: AEDT models aviation noise based on measured source data (noise-power-distance) from actual aircraft. Additional assumptions that apply to the AEDT modeling software can be found in the AEDT Technical Manual on the AEDT website or in the National Transportation Library.
- Rail: Noise source reference data is based on measured source data from rail equipment.

In all cases, the uncertainty in the calculated noise increases as the noise level decreases due to increasing distance between the vehicle and the receptor.

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).
- Rail: Operational data, route information, and locations of grade crossings and quiet zones are provided by the General Transit Feed Specification (GTFS), North American Rail Network (NARN), and FRA's Highway-Rail Crossing Inventory.

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.

9 Validation

The National Transportation Noise Map 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 Map.

10 Known Data Discrepancies

The noise levels shown in the National Transportation Noise Map are dependent on the availability of source data. When the same data coverage is not available between years, it could appear as though there has been an increase or decrease in transportation noise that is not real. Known data discrepancies between the years 2016 and 2018 are described in this section.

Note that any discrepancies that are found through this effort are reported to the appropriate agency to inform where gaps exist and encourage more consistent coverage for future years.

10.1 Aviation

The 2016 aviation modeling leveraged the Performance Data Analysis Reporting System (PDARS). PDARS did not provide radar track data for the listed in the table below, therefore these airports were excluded from the 2016 aviation noise modeling.

Table 2: National Transportation Noise Map Excluded Airports in 2016 Aviation Noise Modeling

Airport Code	Airport Name
07FA	Ocean Reef Club
KHII	Lake Havasu City
KHLN	Helena Regional
KIFP	Laughlin/Bullhead International
KMMH	Mammoth Yosemite
PAFA	Fairbanks International
PAJN	Juneau International
PAKT	Ketchikan International
PASI	Sitka Rocky Gutirrez
PHKO	Kona International
PHLI	Lihue
PHOG	Kahului

10.2 Road

The 2018 California HPMS submission did not correctly link to their submitted GIS ARNOLD geometry. Due to this issue, HPMS data from the year 2017 was used for the state of California in the 2018 road layer.

10.3 Rail

There are currently no known data discrepancies for passenger rail.

Appendix A Acronyms

This section defines acronyms commonly used in discussing the NTNM.

Acronym	Definition
AEDT	Aviation Environmental Design Tool
ATADS	Air Traffic Activity Data System
AADT	Average Annual Daily Traffic
dB(A)	A-weighted decibels
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
GSOD	Global Summary of the Day
GTFS	General Transit Feed Specification
HPMS	Highway Performance Monitoring System
$L_{Aeq,24hr}$	24-hour equivalent A-weighted sound level that represents the approximate average noise energy due to transportation sources over a 24-hour period at the receptor locations
LRT	Light Rail Transit
NARN	North American Rail Network
NOAA	National Oceanic and Atmospheric Administration
NTNM	National Transportation Noise Map
PDARS	Performance Data Analysis and Reporting System
RRT	Rapid Rail Transit
TNM	Traffic Noise Model