Development of On-Road Mobile Source Emission Inventories for Rural Counties

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Vehicle Miles of Travel

- Primary Source is HPMS County-Level Data
- Cross-Classified by Functional Classification and Area Types
- VMT Data is AADT
- HPMS Universe Consists of All Public Roads Within the State

Functional Classifications

- Interstates
- Urban Freeways
- Principal Arterials
- Minor Arterials
- Major Collectors
- Minor Collectors
- Locals

Area Types

- **Rural:** Population 1-4,999
- **Small Urban:** Population 5,000-49,999
- **Urbanized:** Population 50,000-199,999
- **Urbanized:** Population 200,000+

Data

- Centerline Miles
- Vehicle Miles of Travel (VMT)
- Lane Miles

Partial Data for Travis County, Texas

(Urbanized Miles – Population 200,000+)

	Centerline	VMT	Lane Miles
Interstate	28.074	3,577,801	117.623
Urban Freeway	67.903	4,291,218	343.818
Principal Arterial	168.048	3,935,990	631.286
Minor Arterial	109.095	1,127,324	269.340
Major Collector	269.180	1,460,349	587.058
Minor Collector	0.000	0	0.000
Local	313.938	117,397	626.796
Total	955.638	14,510,082	2,635.921

Summer Weekday Adjustment Factors

- Inventories Needed for Average Summer Weekdays
- State DOTs Collect Vehicle Counts Using ATRs
- ATR Counts Used to Develop Seasonal Weekday Adjustment Factors
- ATR Data Not Available for All Rural Counties

Example 1999 Summer Weekday VMT Control Total Calculation

County	AADT VMT	ATR Adjustment Factor	Summer Weekday VMT
Bastrop	1,396,844	1.03472	1,445,342
Caldwell	739,979	1.07689	796,876
Comal	2,390,241	1.07843	2,577,708
Ellis	3,550,288	1.08826	3,863,636
Guadalupe	2,358,496	1.02179	2,409,888
Harrison	2,366,915	1.02179	2,418,490

VMT Forecasts

- Developed From HPMS VMT Data and County Population Statistics and Projections
- VMT Types – Local and Through
- Local VMT Related to Resident Population
- Through VMT Related to Inter-County Travel

VMT Forecasts

- Forecasts Developed for Each County Based on Per Capita VMT
- Forecasts Developed for Each County Based on Regression Analysis of Historic HPMS VMT Data
- Forecasts Combined and Midpoint Calculated
- Midpoint Used as Forecast VMT for Each County

Example 2007 VMT Forecast Calculation

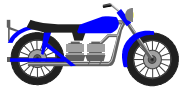
County	Method		
	Regression	Per Capita VMT	Midpoint
Bastrop	1,776,848	1,665,616	1,721,232
Caldwell	883,871	778,101	830,986
Comal	3,302,365	2,503,522	2,902,944
Ellis	4,580,593	3,993,027	4,286,810
Guadalupe	3,015,548	2,533,373	2,774,461
Harrison	2,972,193	2,289,379	2,630,786

VMT Mix

- Estimated Using Weekday Vehicle Classification Data
- Professional Judgment Used to Determine How to Group Counties

FHWA Vehicle Classifications

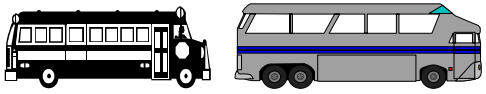
(1) Motorcycles



(2) Passenger Cars (w/ 1 or 2 axle trailers)

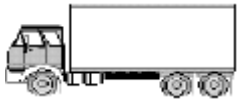
(3) Two Axle, 4 Tire Single Units.
Pickup or Van w/ 1 or 2 axle trailers

(4) Buses

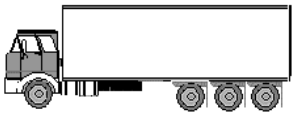


(5) 2D – Two Axle, Six Tire Single Unit
Includes Handicapped Equipped & Mini School Buses.

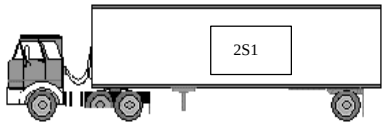
(6) 3 Axles Single Unit

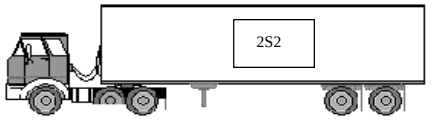


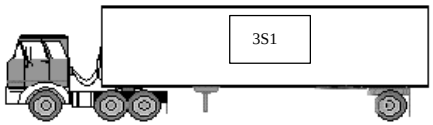
(7) 4, or more, Axles Single Unit



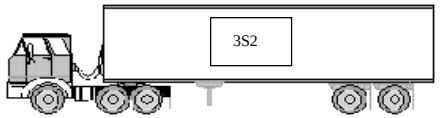
(8) 3-4 Axles, Single Trailer

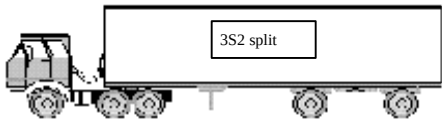




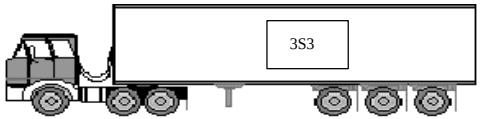


(9) 5 Axles Single Trailer



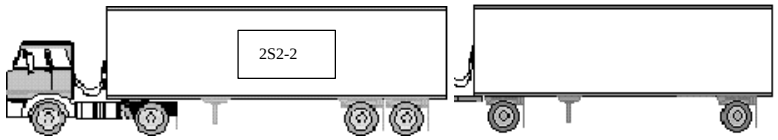


(10) 6, or more, Axles Single Trailer

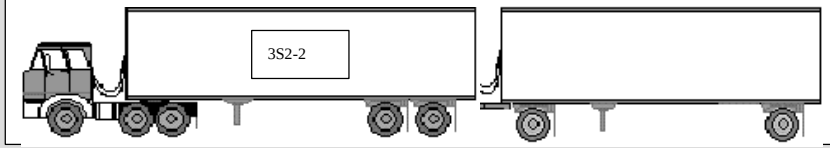


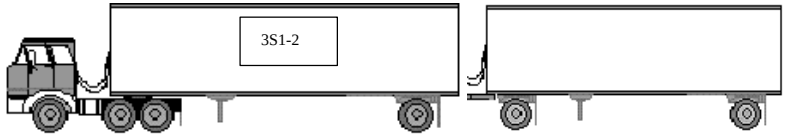
(11) 5, or less, Axles Multi-Trailers

(12) 6 Axles Multi-Trailers



(13) 7, or More, Axles Multi-Trailers





FHWA Vehicle Types

- Motorcycles
- Passenger vehicles
- Two axle four tire single unit trucks
- Buses
- Six tire single unit vehicles
- Three axle single unit vehicles
- Four or more axle single unit vehicles
- Three axle single trailer
- Four axle single trailer
- Five axle single trailer
- Six or more axle single trailer
- Five or less axle multi trailer
- Six axle multi trailer
- Seven or more axle multi trailer

EPA Vehicle Classes

- LDGV - light-duty gasoline vehicles
- LDGT1 - light-duty gasoline trucks up to 6,000 pounds gross vehicle weight rating (GVWR)
- LDGT2 - light-duty gasoline trucks from 6,001 to 8,500 pounds (GVWR)
- HDGV - heavy-duty gasoline vehicles over 8,500 pounds (GVWR)
- LDDT - light-duty diesel trucks
- LDDV - light-duty diesel vehicles
- HDDV - heavy-duty diesel vehicles over 8,500 pounds (GVWR)
- MC - motorcycles

VMT Mix

- Disaggregated Into 8 EPA Vehicle Groups
- MOBILE5 Defaults Used to Separate Light-Duty Vehicles into Gasoline and Diesel Fractions
- County Vehicle Registration Data Used
- Motorcycles Not Counted Directly

VMT Mix

- Procedure Applied Using County-Specific Registration Data
- Classification Count Data May be Aggregated for Several Counties
- Some States May Have Only One VMT Mix Application for All Roadway Classifications

Vehicle Classification Distribution
Aggregated Functional Classifications

Aggregated Functional Classifications	HPMS Functional Classifications
Freeways	Urban Interstate Freeway Urban Other Freeway Rural Interstate Freeway
Arterials	Urban Principal Arterial Urban Minor Arterial Rural Principal Arterial Rural Minor Arterial
Collectors	Urban Major Collector Urban Minor Collector Urban Collector Rural Collector

1999 County Weekday Freeway Vehicle Classification Distributions

County	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
Bastrop	0.718	0.125	0.039	0.039	0.002	0.001	0.075	0.001
Caldwell	0.718	0.125	0.039	0.039	0.002	0.001	0.075	0.001
Comal	0.604	0.143	0.045	0.055	0.002	0.001	0.149	0.001
Ellis	0.724	0.127	0.038	0.039	0.002	0.001	0.069	0.001
Guadalupe	0.613	0.150	0.046	0.091	0.002	0.001	0.097	0.001
Harrison	0.511	0.126	0.040	0.153	0.001	0.001	0.167	0.001

1999 County Weekday Arterial Vehicle Classification Distributions

County	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
Bastrop	0.597	0.215	0.066	0.041	0.002	0.001	0.077	0.001
Caldwell	0.705	0.163	0.050	0.028	0.002	0.001	0.051	0.001
Comal	0.762	0.145	0.042	0.024	0.002	0.001	0.023	0.001
Ellis	0.663	0.157	0.050	0.055	0.002	0.001	0.072	0.001
Guadalupe	0.762	0.145	0.042	0.024	0.002	0.001	0.023	0.001
Harrison	0.597	0.190	0.054	0.075	0.002	0.001	0.082	0.001

1999 County Weekday Collector Vehicle Classification Distributions

County	LDGV	LDGT1	LDGT2	HDGV	LDDV	LDDT	HDDV	MC
Bastrop	0.488	0.310	0.090	0.037	0.001	0.002	0.070	0.001
Caldwell	0.505	0.277	0.082	0.055	0.001	0.002	0.076	0.001
Comal	0.528	0.251	0.077	0.086	0.001	0.002	0.053	0.001
Ellis	0.678	0.183	0.060	0.031	0.002	0.001	0.044	0.001
Guadalupe	0.528	0.251	0.077	0.086	0.001	0.002	0.053	0.001
Harrison	0.624	0.227	0.071	0.039	0.002	0.001	0.036	0.001

Speed Model Overview

- Emissions Are a Function of Vehicle Type and Speed
- Speed Estimates Developed Using Hourly Volumes and Capacities
- Volume/Delay Relationships Based on NCTOG Speed Model
- Speed Estimates Developed Using Total VMT Separated Into Peak and Off-Peak Travel

Speed Model Overview

- HPMS Data Separated Into 3 Area Types: Rural, Small Urban, and Urban

- Also Separated Into 7 Roadway Functional Classifications: Interstate, Freeway, Other Principal Arterial, Minor Arterial, Major Collector, Minor Collector, and Local

Speed Model Overview

- **Total HPMS VMT Allocated Into 4 Time Periods**
  - AM Peak (7:15 a.m. – 8:15 a.m.)
  - Mid-Day (8:15 a.m. – 4:45 p.m.)
  - PM Peak (4:45 p.m. – 5:45 p.m.)
  - Overnight (5:45 p.m. – 7:15 a.m.)
- **Volumes Disaggregated by Directional Split**

Volume/Delay Equation

$$Delay = Min\left[A\,e^{B(\frac{V}{C})}, M \right]$$

Where:

Delay = congestion delay (in minutes/mile)

A & B = volume/delay equation coefficients

M = maximum minutes of delay per mile

V/C = time-of-day directional V/C ratio

Volume/Delay Equation Parameters

Facility Category	A	B	M
High Capacity Facilities (> 3,400 vehicles per hour [VPH], e.g., Interstates and Freeways)	0.015	3.5	5.0
Low Capacity Facilities (≤ 3,400 VPH, e.g., Arterials, Collectors and Locals)	0.050	3.0	10.0

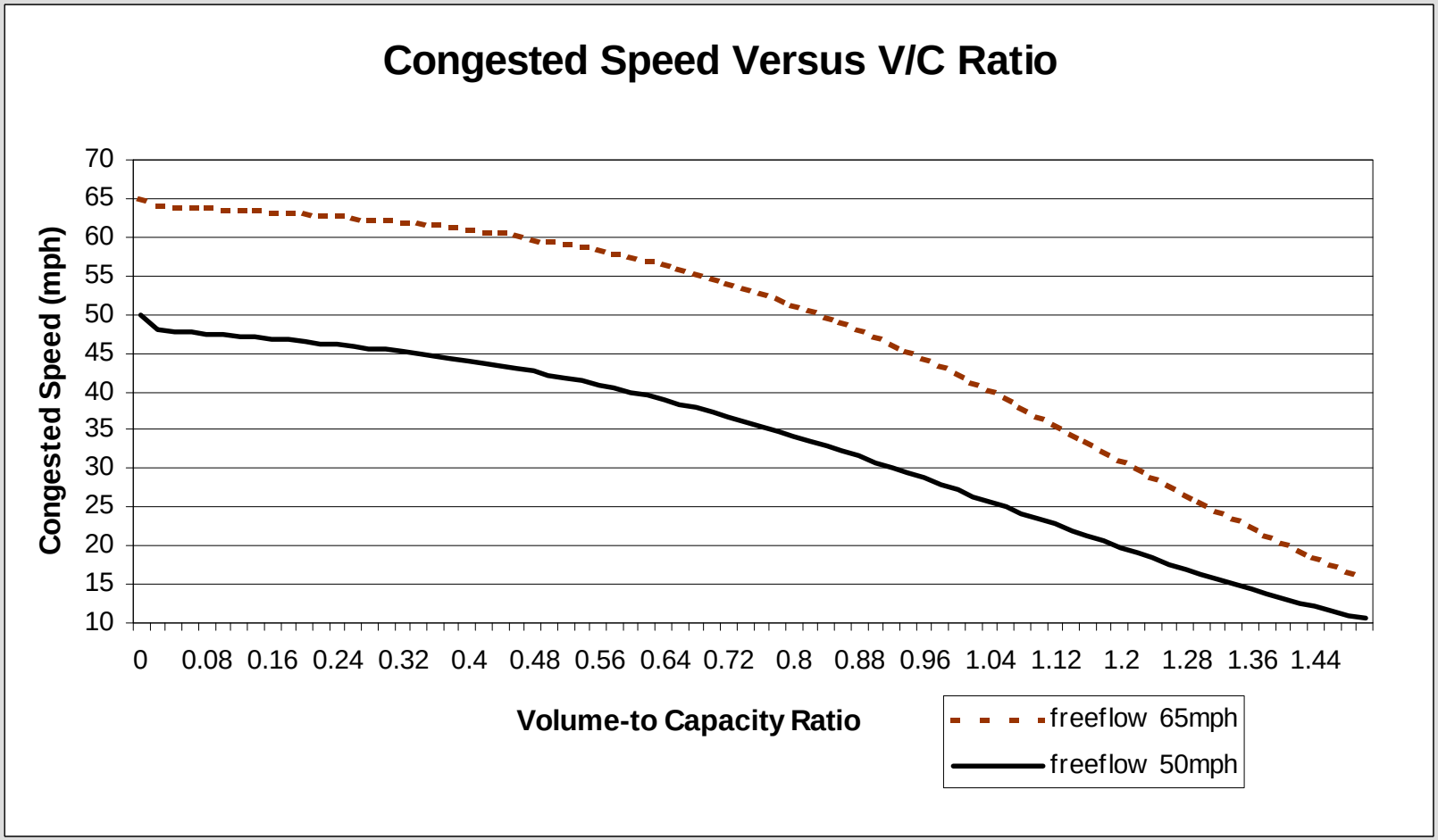
Directional Congested Speed Formula

$$Congested\ speed = \frac{60}{\frac{60}{Freeflow\ speed} + Delay}$$

Speed Model Overview

- Speed Model Applied to Each Area Type/Functional Classification Matrix Cell for Each Time Period by Direction
- Results in 224 Separate Speed Estimates

V/C Ratio Relationship



Capacity and Freeflow Speed

- Capacity is Maximum Flow Past Given Point on Roadway
- Freeflow Speed is the Maximum Speed Traffic Moves Along Roadway if There are no Impediments

Capacity and Freeflow Speed

- Rural and Urban Arterial Freeflow Speeds From HCM
- Freeflow Speed for Other Classifications Decreases From Arterial Speed by 5 mph
- No Freeflow Speed is Below 30 mph

Hourly Lane Capacities (vphpl)

HPMS Area Type	HPMS Roadway Functional Classification						
	Interstate	Freeway	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Local
Rural	2,200	2,100	1,003	920	836	669	502
Small Urban	2,200	2,100	878	805	732	585	439
Urban	2,200	2,100	673	617	561	448	336

Freeflow Speeds (mph)

HPMS Area Type	HPMS Roadway Functional Classification						
	Interstate	Freeway	Other Principal Arterial	Minor Arterial	Major Collector	Minor Collector	Local
Rural	70	65	55	50	40	35	30
Small Urban	70	65	45	40	35	30	30
Urban	70	65	40	35	30	30	30

Capacity and Freeflow Speed

- **V/C Ratios Generated for Each Combination of Time Period, Roadway, Area Type, and Direction**
  - Volume: VMT Multiplied by Each Time Period Factors
  - Capacity: Lane Miles Divided by Centerline Miles to Produce Lanes
  - V/C Ratios: Speed Model Applied to Resulting Volumes and Capacities for Each Classification and Area Type Combination

Future Year Roadway Improvements

- Taken From STIPs
- Defined as Changes to Centerline and Lane Miles
- Added to Most Recent HPMS Data

Emissions Estimation

- MOBILE5 Used to Compute Rural County Mobile Source Emissions
- Applied Using TTI-Developed Emissions Program
- Estimates Emissions for Each Time Period

Time-of-Day Temperature Estimates

- 24-Hour Temperatures and RVP Data Used
- Average Minimum and Maximum Used as Low and High for the Season
- Four Time-of-Day Period Temperatures Obtained by Averaging Temperatures For Same Time Period

MSA Temperature Ranges

MSA	Low	High	Ambient	Future RVP
Austin	74.6	93.6	87.3	7.8
Dallas	74.0	92.3	86.2	7.8
Fort Worth	74.0	92.3	86.2	7.8
Longview	73.0	91.6	85.4	7.8
San Antonio	75.9	93.2	87.5	7.8

MSA Temperatures by Time Period

MSA	Time Period			
	AM Peak	Mid-Day	PM Peak	Overnight
Austin	77.9	88.0	91.3	80.2
Dallas	78.1	88.5	91.2	79.9
Fort Worth	78.1	88.5	91.2	79.9
Longview	78.2	88.1	88.9	77.5
San Antonio	78.0	88.5	92.3	81.1

MOBILE5 Setups

- Emissions Rates Prepared Using Diurnal and Time-of-Day Setups for Each County
- Only Difference in 24-Hour Setups and Time Period for Each Analysis is Temperature
- Best Available Vehicle Age Distribution Used

Emissions Estimates

- Mobile Source Emissions for Each Time Period Computed and Combined With Diurnal Estimates Into 24-Hour Estimate
- MOBILE5 Factors Applied to HPMS and Speed Model Data
- Tier 2 Adjustments Applied Separately Using EPA Guidance

Validation

- Beaumont-Port Arthur Counties Ideal for Comparison
- Includes Rural and Low-Density Urban Counties
- The HPMS-Based Estimation Method and Link-Based Estimation Method Compare Reasonably Well

Comparison of Link- Versus HPMS-Based Emissions Estimates
Beaumont – Port Arthur 3-County Area
1990
(Emissions in Tons Per Day)

Category	VMT	Link-Based Average Speed	Link-Based Emissions	HPMS-Based Average Speed	HPMS-Based Emissions	% Difference
VOC	10,099,149	36.0	29.35	39.6	30.33	3.34%
NOx			42.33		44.54	5.22%

Comparison of Link- Versus HPMS-Based Emissions Estimate Longview Area 1990 (Emissions in Tons Per Day)

Category	VMT	Link-Based Average Speed	Link-Based Emissions	HPMS-Based Average Speed	HPMS-Based Emissions	% Difference
VOC	3,582,793	34.1	10.99	36.2	11.08	0.82%
NOx			13.78		15.00	8.85%

Comparison of Link- Versus HPMS-Based Emissions Estimate Austin Area 1990 (Emissions in Tons Per Day)

Category	VMT	Link-Based Average Speed	Link-Based Emissions	HPMS-Based Average Speed	HPMS-Based Emissions	% Difference
VOC	30,083,310	36.4	89.68	40.4	95.55	6.55%
NOx			101.64		109.78	8.01%

MOBILE6

- Not Available When This Work Was Completed
- Currently No Evaluation of Procedure Using MOBILE6
- TTI Performing Evaluation of Procedure Using MOBILE6 During Summer of 2001
- Contact Authors For Results