Applications of HPMS Data in Traffic Modeling at the Atlanta Regional Commission (ARC)

NATMEC 2002

Purpose Statement, Problem & Issue

- EPA requires HPMS-based forecast of VMT for emissions and air quality analysis, in order to account for off-model travel volume
- Therefore this requires HPMS adjustments to be made to modeled VMT results
- As a result, ARC developed factors to reconcile modeled VMT with HPMS data

Methods & Techniques Used to Accomplish Goal

- ARC adjusted the modeled VMT upwards using HPMS factors.
- ARC developed correlations between model roadway classes and HPMS data specs.
- 4 adjustment factors were developed, based upon ARC's facility types and HPMS data.

ARC Modeling Domain and Background Info

- 13-County Non-Attainment Area
- Population: 3.6 Million + (and still growing)
- ARC's regional traffic model: TRANPLAN / TP+ regional traffic model
- Highway calibration & validation addressed per federal practice: HPMS
- 1990 modeled VMT within 3% of HPMS data

Highway Assignment

- Equilibrium assignments reached within 20 iterations
- Use 4 conical volume delay functions (freeways, expressways & parkways, major arterials & ramps, minor arterials & collectors)
- Toll diversion model (TRANPLAN macro highway update) for the highway network to include toll costs, a logit-based model that computes probability of using toll road

Time of Day model

- % of trips by half hour increments by purpose and mode
- Applied by:
  AM peak (3 hrs, 6:30-9:30)
  PM peak (3 hrs, 4:00-7:00)
  Off peak (rest of day, the remaining 18 hrs)

VMT by V/C ratio (% of total VMT)

LOS	V/C	2000	2025
A-B	(0-0.55)	33.73	28.81
C	(0.55-0.77)	18.83	15.06
D	(0.77-0.93)	15.22	15.23
E	(0.93-1.0)	5.69	7.22
F	(1.0+)	26.52	33.67

HPMS Applications: ARC's Link-Based Emissions

- To establish mobile source emission estimates for conformity analyses, ARC utilizes a traditional link-based procedure as an element of the travel demand model chain.

Time-of-Day Output/ Emission Model Input

Loaded network files from Time-of-Day Model

Spreadsheets for

AM, PM, Off-Peak Periods

- Calculate HPMS-adjusted VMT
- Post-process speeds
- Calculate VOC and NOx emission levels for individual link records

Time Period Assignment

- Input vehicle trips stratified by trucks*, single-occupancy vehicles (SOV), and high occupancy vehicles (HOV)
- Separate auto (SOV+HOV) and truck VMT calculated for each link.

*** Within the ARC model chain the distinction is truck usage, i.e. a vehicle is classified as a truck if it has a commercial use, defined by either commercial registry plates or commercial markings on the vehicle**

Link-Based Emissions Model

For all three time periods, final assigned volumes from assignment

Time-of-Day Model Output

- VMT is HPMS adjusted
- Post processed link speed is calculated
- Link VMT is matched with MOBILE 5b emission factors by link speed
- Emissions are summarized by link for all three time periods

Elements of the Link-Based Model

HPMS Adjustment

- EPA guidance recommends HPMS based forecasts of VMT for emission analyses.
- Equivalency statements used to correlate ARC's assignment group classification with HPMS functional classification.

$$\text{HPMS Adjustment Factor} = \frac{\text{1997 HPMS VMT}}{\text{1997 Modeled VMT}}$$

- HPMS adjustment factor applied to auto and truck VMT for each link based on assignment group classification

Highway Network Specs

- ARC 10 Facility types (TRANPLAN Assignment Group, single digit code 0-9), being expanded to 18:

1. Freeway
2. Expressway
3. Parkway
4. High speed ramps
5. Low speed ramps
6. Class I arterials
7. Class II arterials
8. Class III arterials
9. Class I & II collectors
0. Centroid Connectors

HPMS Functional Class

1. Rural Interstate
2. Rural Principal Arterial
3. Rural Minor Arterial
4. Rural Major Collector
5. Rural Minor Collector
6. Rural Local
7. Urban Interstate
8. Urban Freeway
9. Urban Principal Arterial
10. Urban Minor Arterial
11. Urban Collector
12. Urban Local

Equivalency Statements between ARC and HPMS

ARC Assignment Groups	=	HPMS functional class
1, 2, 3, 4 and 6	=	1, 2, 7, 8 and 9
5, 7 and 8	=	3, 4 and 10
9	=	5 and 11
0	=	6 and 12

4 HPMS Adjustment Factors:

- For freeways, expressways, parkways, high speed ramps and class I arterials: 1.17
- For low speed ramps, class II arterials and class III arterials: 0.9
- For class I and II collectors: 0.69
- For centroid connectors: 1.40

Speed Post-Processor

- Congested Flow Speed = $\frac{\text{link-based VMT}}{\text{link-based VHT}}$

Congested Flow Speed was ***NOT*** used in the emissions calculations. ARC used a **post-processed speed** to calculate link-based VOC and NOx emissions.

Why Was a Post-Processed Speed Used in Emission Calculations?

- The ARC Travel Demand Model has been validated against observed HPMS volume counts and observed times (and by extension, speeds) at the *facility type* level.
- To reconcile speeds to observed conditions on a more refined *link-by-link basis*, a post-processor is applied within the emissions model.

How Was the Speed Post-Processor Applied?

- Built-in lookup table that defines ratios of free flow time to congested flow time as a function of assignment group and v/c ratio.
- Ratios of free flow time to congested time referred to as Speed Functions

Note: TRANPLAN does not store link speed, it stores link time. As such, the speed function is the ratio between free flow and congested time.

How Was the Speed Post-Processor Applied?

- Speed Functions derived from the *same volume-delay functions used in the highway assignment procedure*
- The post-processed speed is calculated by multiplying the free flow speed on a link by the appropriate speed function.

$$\frac{\text{Link Distance}}{\text{Free Flow Time}} * \frac{\text{Free Flow Time}}{\text{Congested Time}} = \frac{\text{Link Distance}}{\text{Congested Time}}$$

Free Flow Speed

Speed Function

Post-Processed (Congested) Speed

Emission Factors

- Within spreadsheets, emission factors for trucks and autos from 2.5 to 65 mph.
- Emission factors calculated using US EPA's MOBILE5b model
- MOBILE5b input files are produced by EPD and shared with ARC - Ensures consistency between ARC's emissions modeling methodology used in conformity analyses and EPD's methodology used to develop the mobile source emissions inventory for the attainment SIP

Off-Model Credits

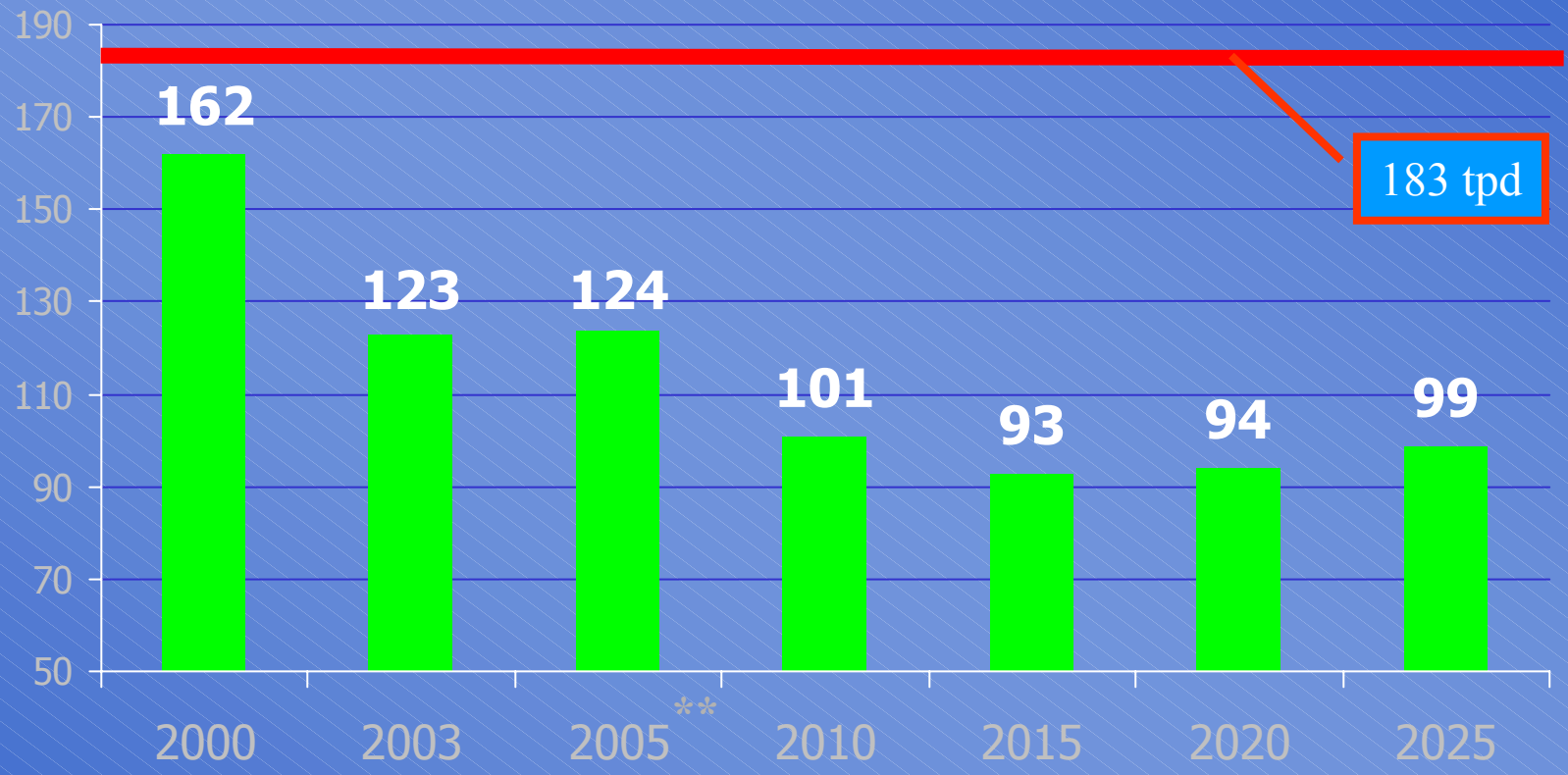
- Additional control measures that could not be modeled with MOBILE5b were calculated as off-model credits.
- Off-model calculations were made following EPA guidance
  - Low Sulfur Georgia Gasoline ☑
  - Partnership for a Smog-free Georgia ☑
  - Senior Citizen I/M Exemption Program ☑

Final Emission Results

- Auto and truck link-based emission results for the AM, PM and Off-Peak periods were aggregated to the daily level to produce a composite emission level for the entire vehicle fleet
- All off-model credits were applied
- Daily emission levels for highway network are calculated

VOC Emissions (in tons/day)

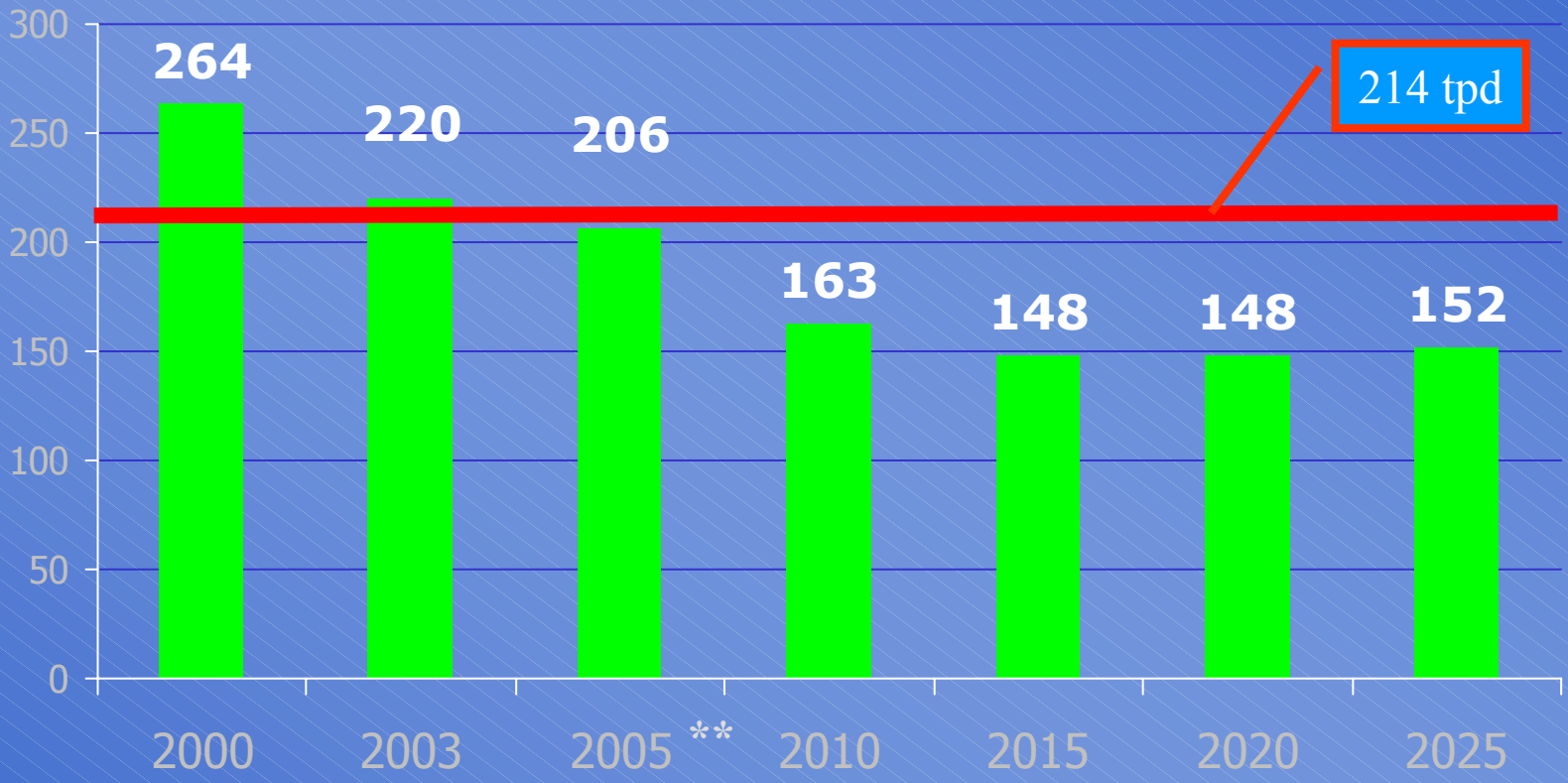
Figures Rounded For Clarity



** - 2005 emissions level conforms to the 9% VOC SIP budget of 183 tpd

NOx Emissions (in tons/day)

Figures Rounded For Clarity



** - 2005 emissions level conform to the 9% NOx SIP budget of 214 tpd

Changes Are Being Made....

- Revised speed post-processor based on speed studies completed in Fall 2000 and Fall 2001
  - Volume-delay curves
  - Free Flow Speeds
- No auto/truck delineation
- Updated emission factors
  - VMT and Registration mix
  - July instead of January
- Revised HPMS adjustment factors
  - 12 unique HPMS adjustments
  - 2000 HPMS counts

Other Enhancements

- New VDF curves, revised free-flow speeds and capacities look-up tables

- New time of day model with 4 time periods

AM peak	(6:00 – 10:00)	4 hrs
Mid day	(10:00 – 3:00)	5 hrs
PM peak	(3:00 – 7:00)	4 hrs
Night time	(7:00 – 6:00)	11hrs

NEW/UPDATED ARC TRAVEL DEMAND MODEL Free flow Speeds

	Facility Type	Central Business District	Urban Very High Density	Urban High Density	Suburban Moderate Density	Suburban Low Density	Exurban	Rural
0	Zone Centroid Connectors	7	11	11	11	11	14	14
1	Interstate / Freeway Off Peak	65	68	68	71	71	73	75
1	Interstate / Freeway Peak	65	68	68	71	71	73	75
2	Parkway	50	55	60	60	62	65	65
3	HOV Buffer Separated	60	63	63	66	66	68	70
4	HOV Barrier Separated	65	68	68	71	71	73	75
5	High Speed Ramp / CD Road	60	60	60	60	60	60	60
6	Medium Speed Ramp	50	50	50	50	50	50	50
7	Low Speed Ramp	40	40	40	40	40	40	40
8	Loop Ramp	30	30	30	30	30	30	30
9	Off Ramp w/ Intersection	25	25	25	25	25	25	25
10	On Ramp w/ Intersection	40	40	40	40	40	40	40
11	Expressway	40	42	45	48	52	55	60
12	Principal Arterial - Class I	26	30	33	36	42	46	55
13	Principal Arterial - Class II	24	27	30	34	40	44	48
14	Minor Arterial - Class I	22	25	28	31	38	42	45
15	Minor Arterial - Class II	20	23	26	29	34	38	42
16	HOV - Arterial (all classes)	20	27	30	33	36	39	42
17	Major Collector	18	22	25	28	31	34	38
18	Minor Collector	15	18	21	24	27	30	35

NEW/UPDATED ARC TRAVEL DEMAND MODEL Capacities

	Facility Type	Central Business District	Urban Very High Density	Urban High Density	Suburban Moderate Density	Suburban Low Density	Exurban	Rural	
0	Zone Centroid Connectors	10000	10000	10000	10000	10000	10000	10000	
1	Interstate / Freeway Off Peak	1800	1850	1900	1950	2000	2000	2000	
1	Interstate / Freeway Peak	1600	1700	1800	1850	1900	1900	1900	
2	Parkway	1800	1800	1800	1900	1900	2000	2000	
3	HOV Buffer Separated	1400	1400	1600	1600	1600	1800	1800	
4	HOV Barrier Separated	2100	2150	2150	2200	2200	2250	2300	
5	High Speed Ramp / CD Road	1800	1800	1800	1800	1800	1800	1800	
6	Medium Speed Ramp	1600	1600	1600	1600	1600	1600	1600	
7	Low Speed Ramp	1400	1400	1400	1400	1400	1400	1400	
8	Loop Ramp	1200	1200	1200	1200	1200	1200	1200	
9	Off Ramp w/ Intersection	1200	1200	1200	1200	1200	1200	1200	-
10	On Ramp w/ Intersection	1200	1200	1200	1200	1200	1200	1200	
11	Expressway	1200	1300	1400	1500	1600	1600	1600	
12	Principal Arterial - Class I	1000	1050	1100	1150	1200	1250	1350	
13	Principal Arterial - Class II	900	900	950	1000	1000	1050	1100	
14	Minor Arterial - Class I	800	800	850	900	900	950	1000	
15	Minor Arterial - Class II	650	700	750	750	800	850	900	
16	HOV - Arterial (all classes)	600	600	650	700	700	750	800	-
17	Major Collector	550	600	600	650	650	700	700	-
18	Minor Collector	400	400	450	450	500	550	600	-

VMT Summarized by HPMS Groups			
	2000 HPMS	2000	Difference in
HPMS Functional Class	VMT	Assigned VMT	VMT
Rural Interstate Principal Arterial	5,882,597	9,580,262	3,697,665
Rural Principal Arterial	3,680,932	3,108,122	-572,810
Rural Minor Arterial	3,929,654	2,343,228	-1,586,426
Rural Major Collector	3,619,184	2,922,776	-696,408
Rural Minor Collector	1,228,002	918,737	-309,265
Rural Local	3,424,895	9,433,189	6,008,294
Urban Interstate Principal Arterial	37,825,822	40,999,220	3,173,398
Urban Freeway and Expressway	5,765,979	2,804,689	-2,961,290
Urban Principal Arterial	10,398,680	12,236,233	1,837,553
Urban Minor Arterial	22,101,606	16,003,606	-6,098,000
Urban Collector	7,466,254	6,397,200	-1,069,054
Urban Local	15,412,042	13,489,783	-1,922,258
	120,735,646	120,243,538	-492,108

Limited access	49,474,398	53,384,171	3,909,773
Major Arterials	14,079,612	15,344,355	1,264,743
Minor arterials	26,031,261	18,346,834	-7,684,426
Collectors	12,313,439	10,238,713	-2,074,726
Local	18,836,936	22,922,972	4,086,036
	120,735,646	120,237,046	-498,600
HPMS Adjustments by Major Groups			
Major Groups	Adjustment (1)_		
Limited access	0.927		
Major Arterials	0.918		
Minor arterials	1.419		
Collectors	1.203		
Local	0.822		

Conclusions

- Modeling for conformity determination is an on-going process, dynamic and fluid (not static), making efficient use of HPMS data.
- Models should be transparent and defensible, and based upon HPMS data.
- Need to adopt modeling facility types to be more in line with HPMS, to avoid disconnect
- Make best use of latest planning assumptions and HPMS data when available
- Re-engineer modeling databases to incorporate HPMS functional classifications

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