

MOBILE6 Overview

Workshop #6

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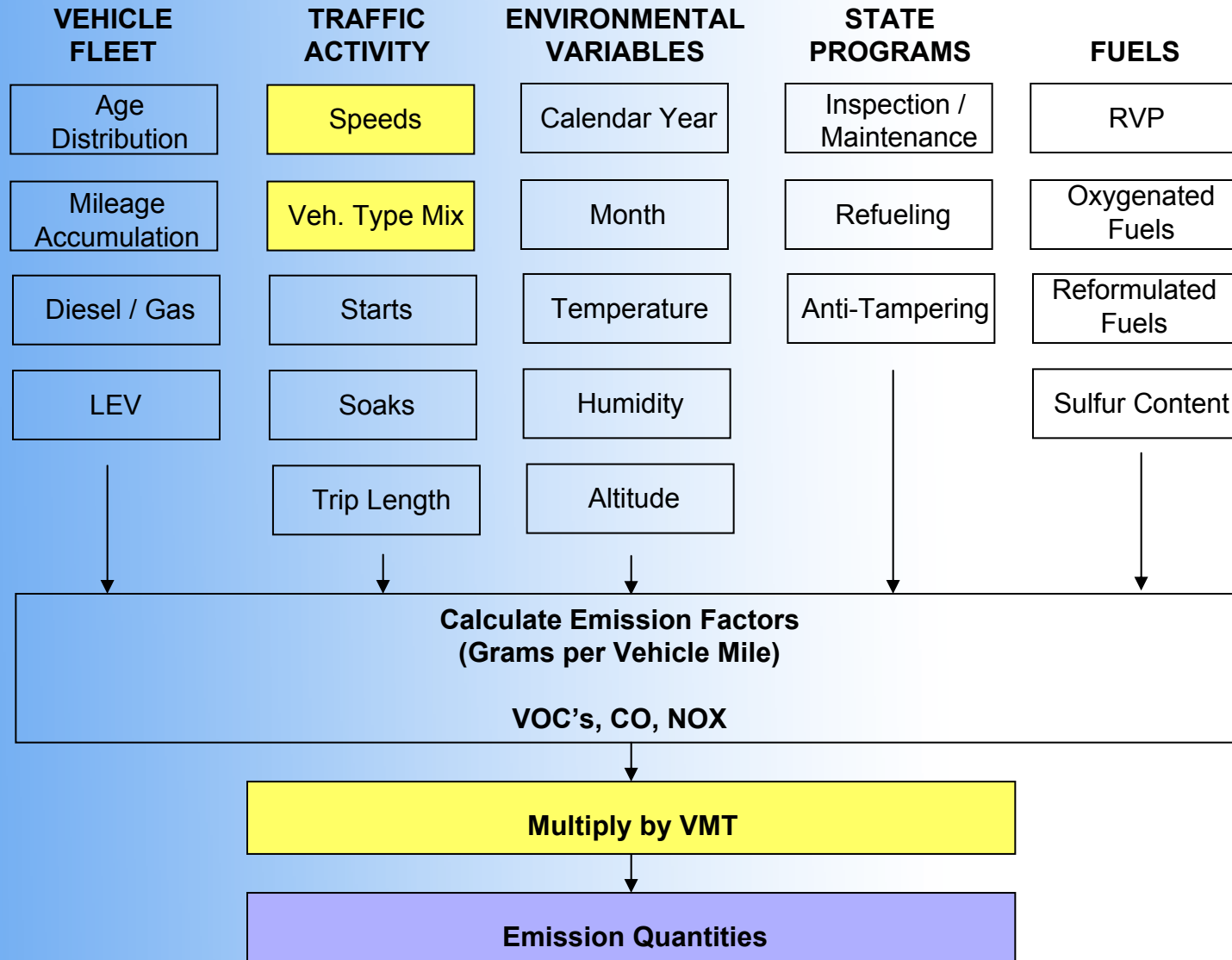
Presentation Topics

1. Overview
2. What's New In MOBILE6?
 - Methods / Data
 - Operation Changes
3. Impacts of Using MOBILE6
 - MOBILE5 vs. MOBILE6
 - Sensitivity to Input Data
 - Impacts on Conformity
4. What goes into MOBILE6?
5. How To Run MOBILE6

What Is MOBILE6?

- MOBILE series of software developed and disseminated by USEPA
 - Calculates emissions factors (gm / veh. mile) for on-highway mobile sources
 - Accounts for factors which affect vehicle operation and emissions
 - Vehicle fleet characteristics (vehicle mix, age)
 - Traffic activity (speed, facility type)
 - Environmental variables (temperature, humidity)
 - Certain Control Measures (I/M, ATP)
 - Fuels (RFG, RVP, oxygenated, etc.)
 - Emission factors must be multiplied by VMT to obtain emission totals

Producing Emissions Using M6



Status of MOBILE6 Releases

- Released: January 29, 2002.
- Who has already used M6?:
 - Serious, Severe and Extreme Ozone Non-Attainment areas – by Jan 29, 2003; new SIPs required.
 - Those needing M6 capabilities to achieve CAA requirements (e.g., Tier II).
 - All Others - Required by Jan 29, 2004 – conformity and future SIPs.
- Ongoing Development
 - Latest Version: MOBILE6.2
 - HC, CO, Nox, PM, Air Toxics
 - www.epa.gov/otaq/m6.htm

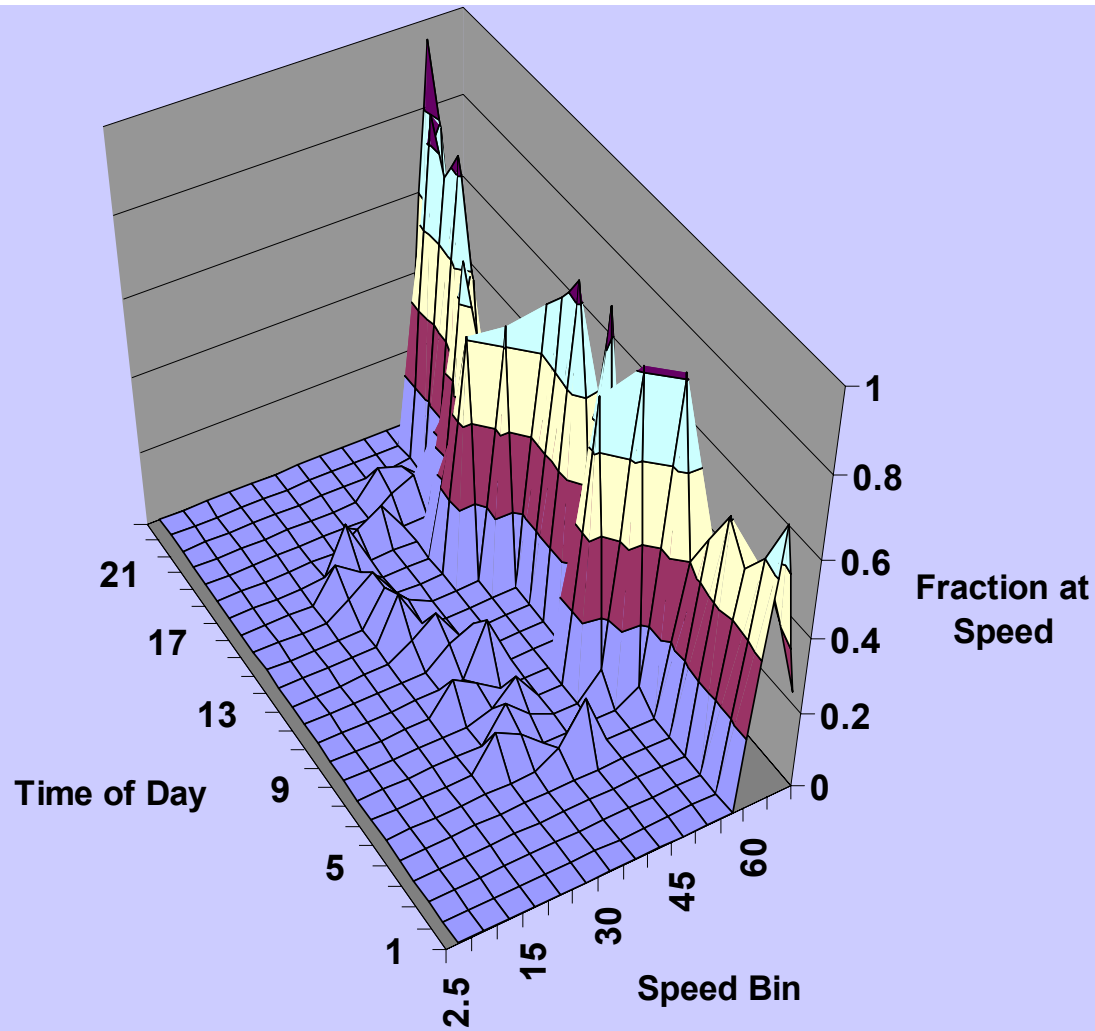
Whats New? – Methods / Data

- New Data / Expanded Analyses in M6
- Weather
 - Humidity (AC effects)
 - Solar effects (default is worst case)
 - Hourly temperatures optional, Min/max ok
- More Activity Data
 - Speeds
 - M5: One average speed for each scenario
 - M6: Speed distribution (14 bins for each hour of day) for each scenario
 - Vehicle Types
 - M5: 8 vehicle types
 - M6: 28 vehicle types
 - Temporal State
 - M5: Cold start / Hot start percentage of VMT
 - M6: Hot soak distributions relating to trip end activity

Whats New? – Methods / Data

- **More Activity Data** (continued)
 - Starts per day and distribution to hours
 - How many engine starts are assumed
 - M5: Spread over drive cycle used to produce gm/mile
 - M6: Handles trip starts separately
 - Facility pattern data
 - M5: Not Considered
 - M6: Freeway, Arterial, Local, Ramp
 - Fraction of VMT by Time-of-day
 - M5: Not Directly Considered
 - M6: Can provide distribution of traffic by hour of the day

Ex. MOBILE6 Enhanced Speed Input



Operation of MOBILE6

- **Benefits:**
 - Newer underlying data more accurate than M5
 - Handles new vehicles, fuels, OBD
 - More flexible input file formats
 - Outputs database file
 - More detailed external data file inputs representing local conditions
 - leads to more accurate emission estimates
- **Negatives:**
 - More efforts to prepare input data files
 - More pre-processing efforts to run county/fc scenarios
 - Some files too detailed for local data inputs (soak)
 - Post processor virtually required for accuracy
 - Control measure impacts change significantly

Operation of MOBILE6

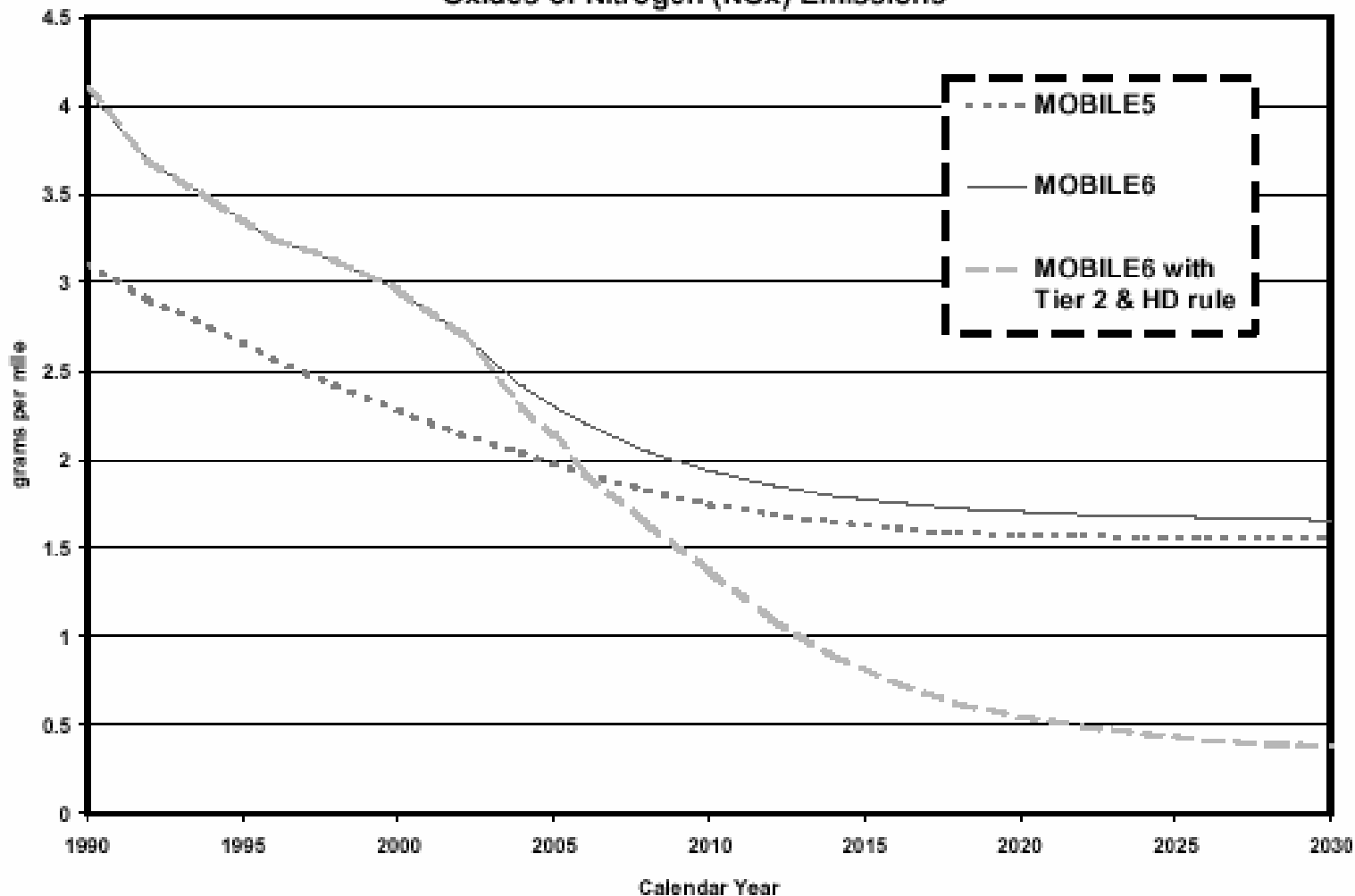
- MOBILE6 is easy to run if use all defaults & one scenario (simplistic)
 - More difficult if use separate scenarios where each scenario has its own speed, hourly distribution, starts per day, vehicle mix (more accurate, stable, replicable)
- Pre Processor may be needed to create the multitude of traffic input data
 - Mix of VMT by Vehicle Class
 - Allocation of VMT to speed bins by hour of the day
 - Starts per day / Distribution to hour
 - Soak distributions
 - Trip length distributions

Impacts of Using MOBILE6

- MOBILE6 Impacts Overview
 - Data & Process
 - Emissions Results:
 - NO_x and VOC curves different
 - Fewer emissions reductions from I/M
 - Local data matters
 - Tier II (vehicles and fuels; 2005 start)
 - Low sulfur diesel
 - (2007 –Northeast / 2008 other start)
 - Vehicle durability assumptions – cleaner, longer

M5 vs M6: NO_x by Year

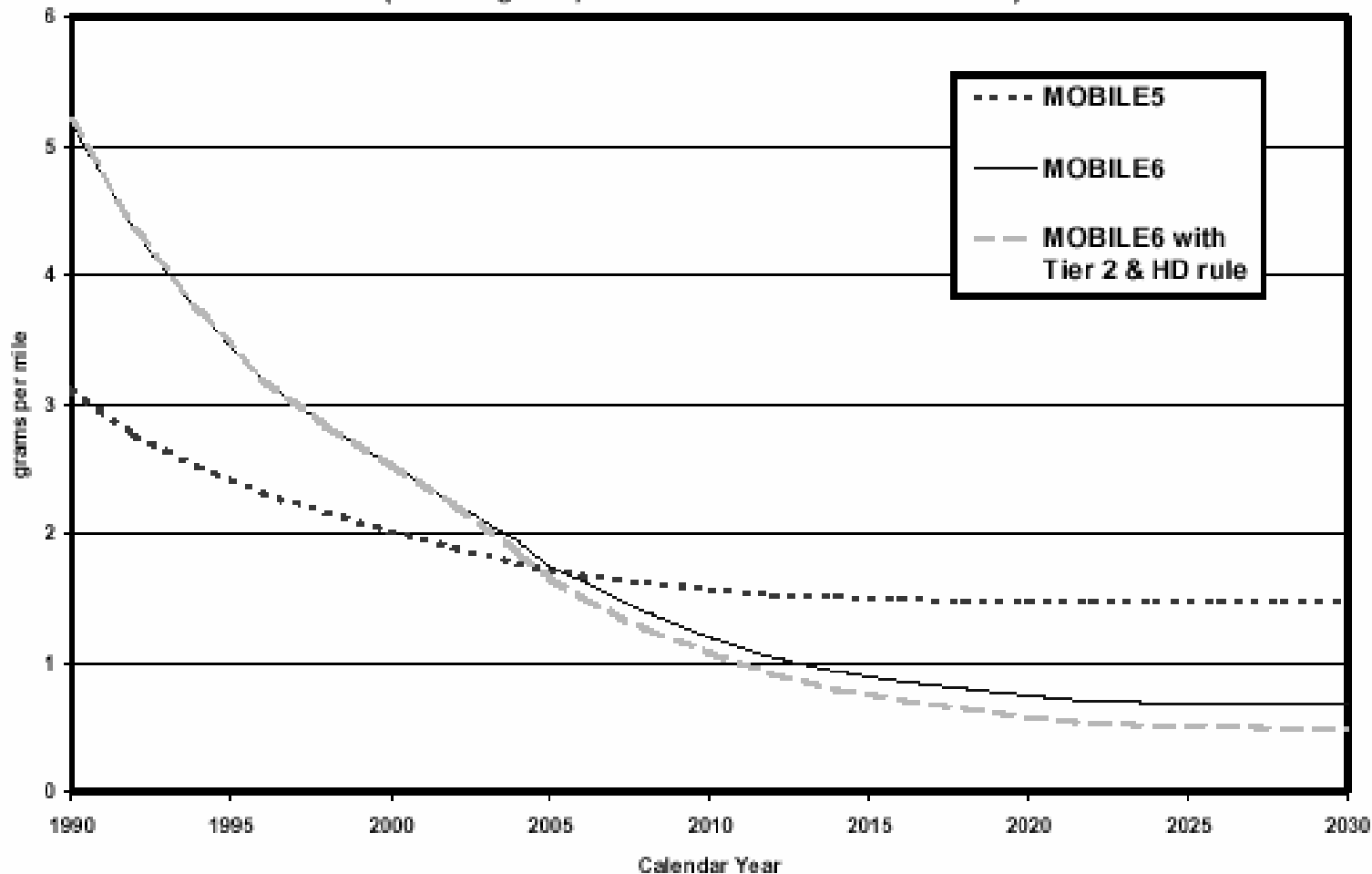
All Highway Vehicles
Oxides of Nitrogen (NO_x) Emissions



M5 vs M6: VOC by Year

All Highway Vehicles

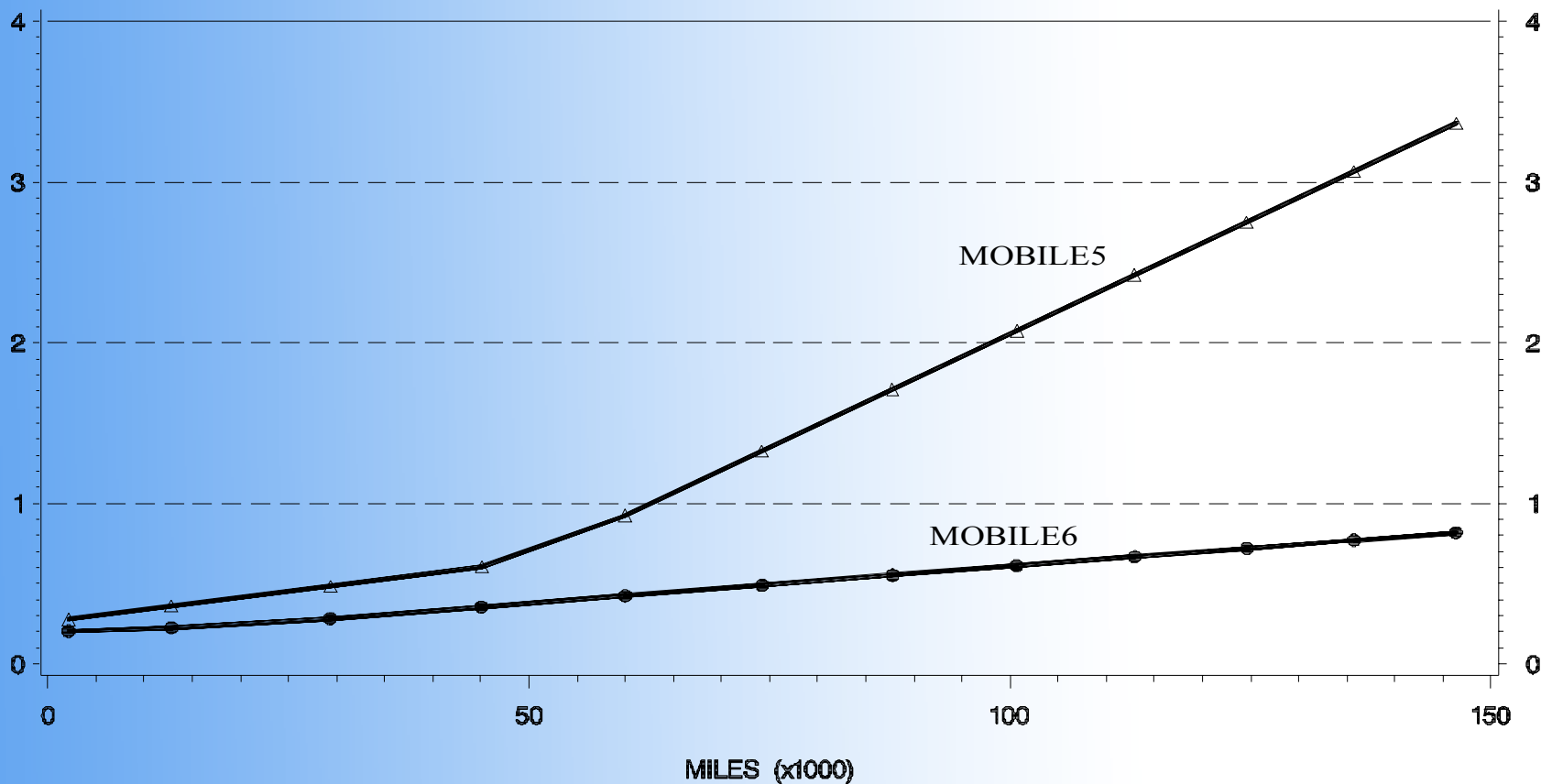
Volatile Organic Compounds (VOC) Emissions
(Including Evaporative and Exhaust Emissions)



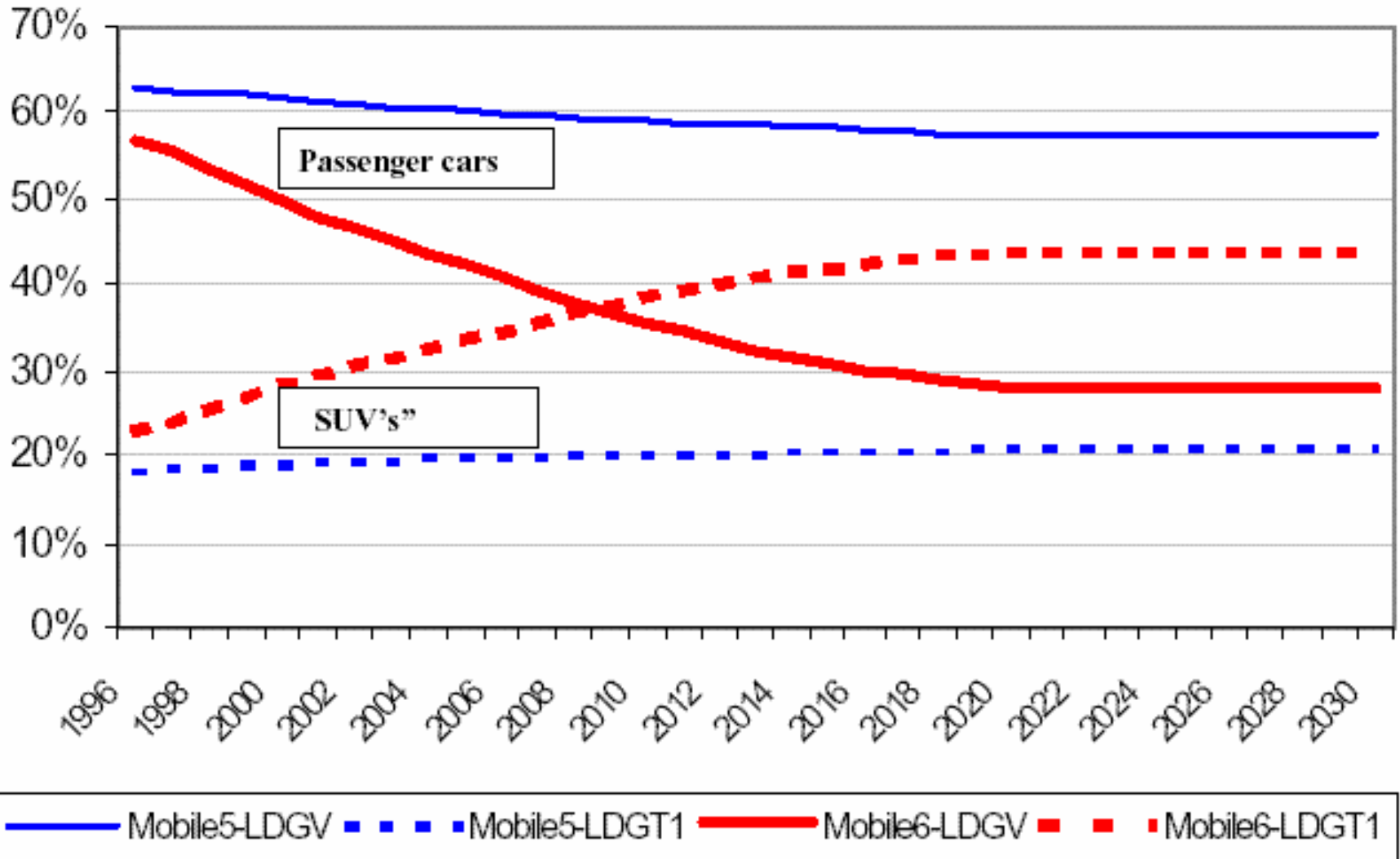
M5 vs M6: Deterioration Rate

FTP COMPARISON OF MOBILE5 and PROPOSED MOBILE6 HC EMISSION FACTORS
1992 MODEL YEAR CARS

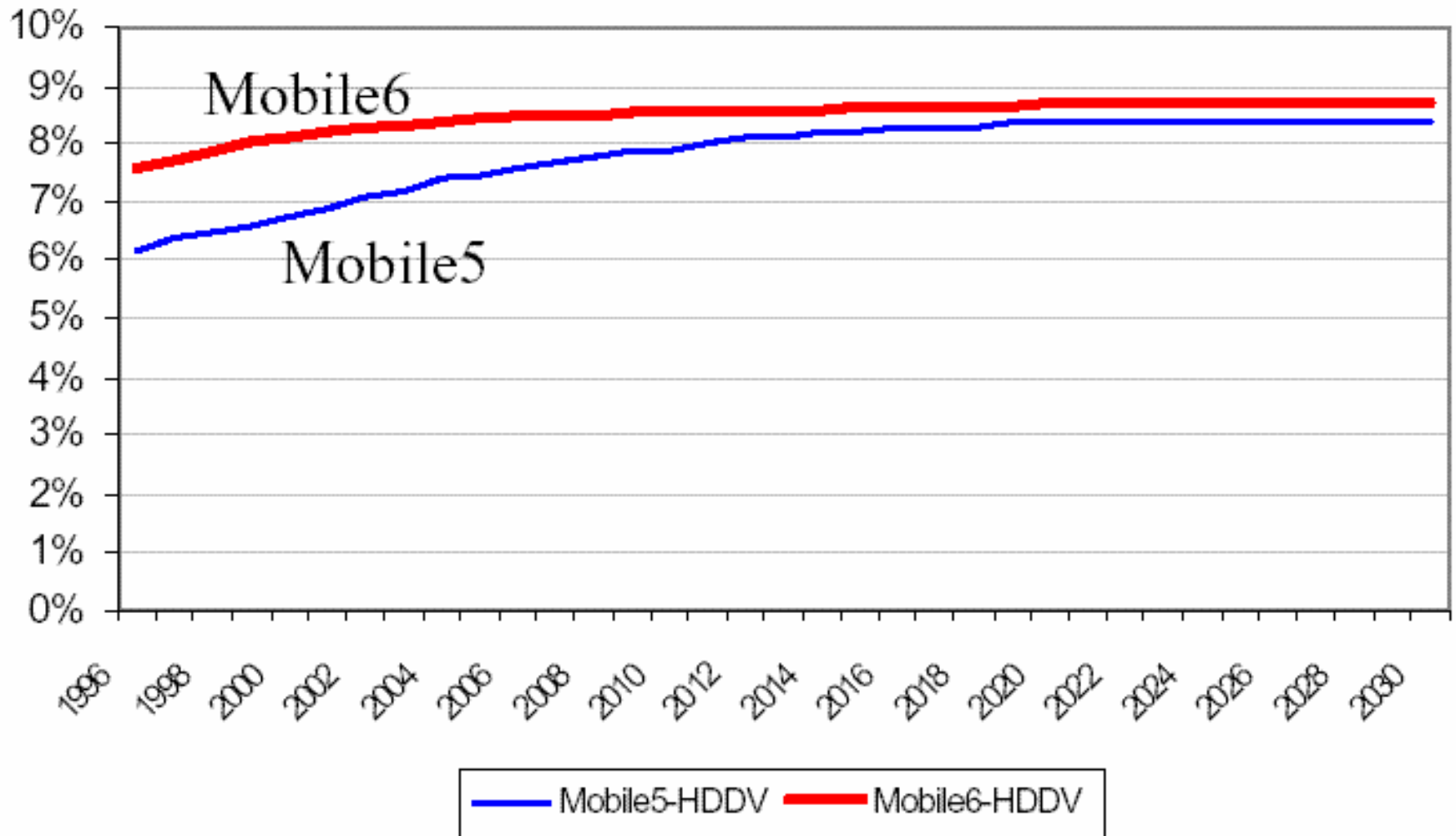
HC (g/mi)



M5 vs M6: Default LDGV, LDGT1



M5 vs M6: Default HDDV



M5 vs M6 – I/M Impacts

MOBILE5B

MOBILE6

I/M Program	Delta VOC	Delta NOx	Delta VOC	Delta NOx
2005 idle+ASM	-72.6 (-45%)	-42.4 (-25%)	-11.5 (-12%)	-12.1 (-8%)
2005 Idle+ ASM+OBD	-84.8 (-53%)	-55.6 (-33%)	-12.6 (-13%)	-12.9 (-8%)
2014 Idle+ASM+OBD	-----	-----	-11.4 (-20%)	-14.8 (-19%)

M5 vs M6 - Why the Difference?

Higher: Past + Present

- Acceleration and AC
- Sulfur on catalysts
- HD NO_x excess
- More older vehicles
- Less oxy CO benefit
- Less I/M credit
- Higher deterioration Rate
- Etc.

Lower: Future

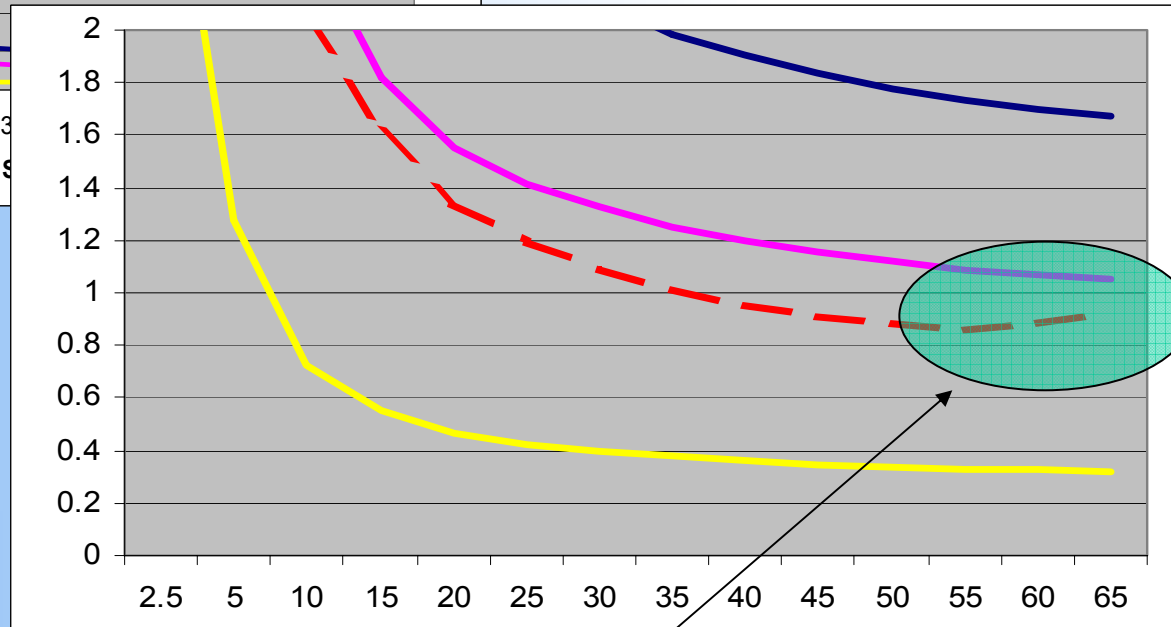
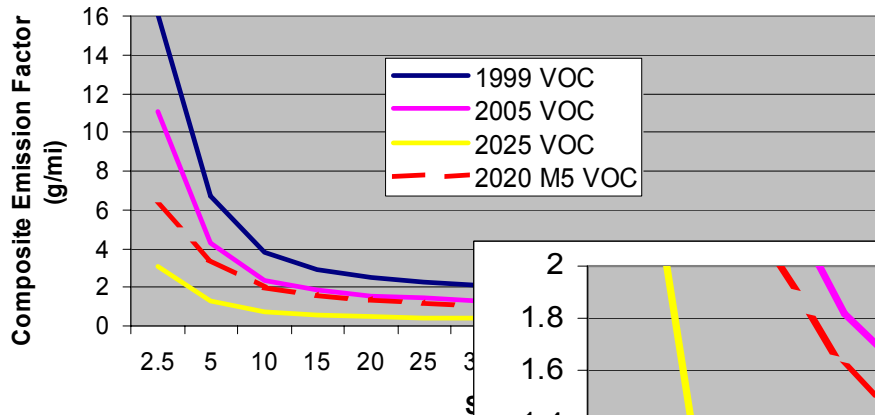
- New FTP rule
- Tier 2 and NLEV
- Low sulfur gas (final)
- HD NO_x consent decree
- Better durability of control technology
- HD 2007 rule
- Low sulfur diesel
- Etc.

Differences Affecting Conformity

- General curve shapes similar to MOBILE5
- What are the differences?
 - Speed: M6 VOC & NOx curves less sensitive than M5
 - Facility Type: Impacts M6 (not dramatic)
 - Both especially true beyond 2020 for NOx
- Potentially impacts a project's influence on emissions:
 - Future project emission impacts much lower due to low emission rates
 - New capacity may not be as detrimental (as far as speed).
 - Lower emissions reductions from speed adjustments
 - Higher value of reducing trips, VMT

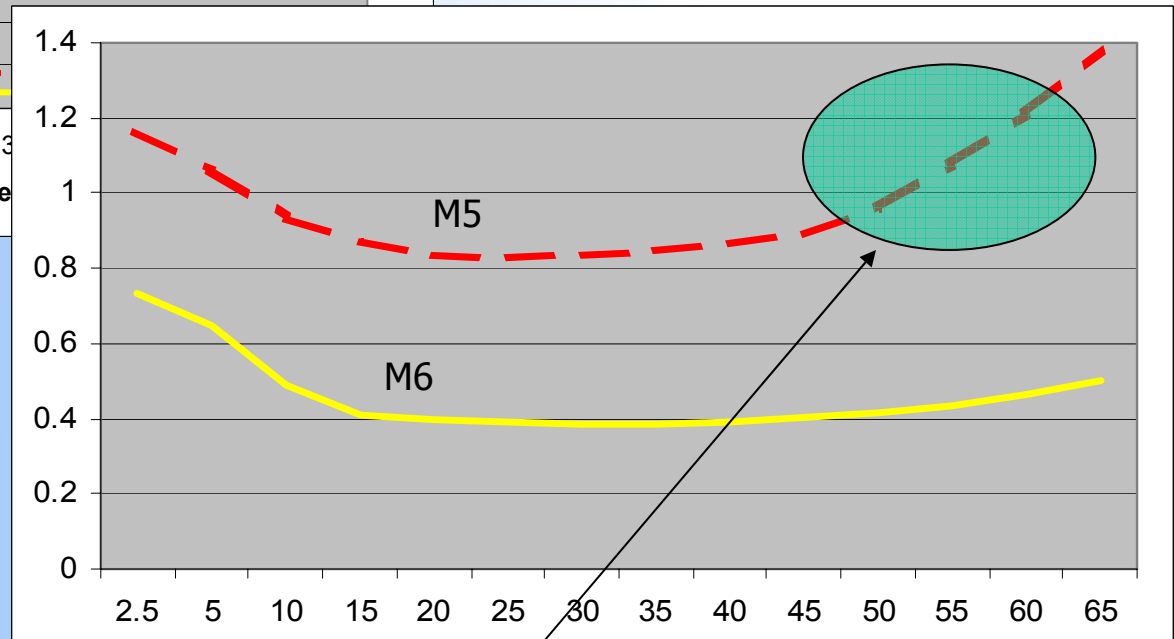
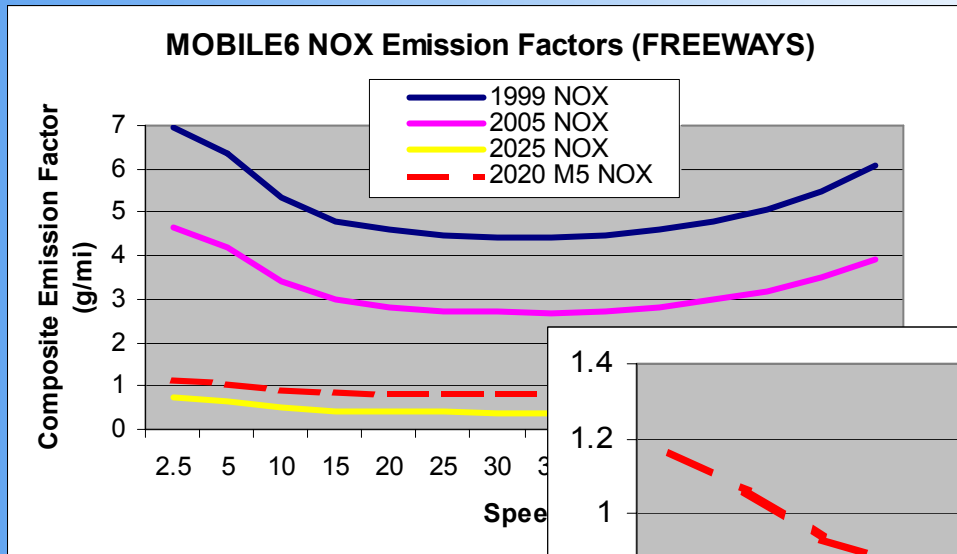
M5 vs M6: VOC / Speed Relationship

MOBILE6 VOC Emission Factors (FREEWAYS)



No longer increase at high speeds

M5 vs M6: NO_x / Speed Relationship



M6 not as steep as M5

Other Sensitivity Comparisons

- Other research and studies available from EPA and FHWA
 - EPA Report “Sensitivity Analysis of MOBILE6.0:
 - FHWA Resource Center Document by same name
- Presents impacts on input data’s influence on emission factors
- Affected EPA recommendations for local data inputs
 - Low Impact = Local Data not required

Input Data to MOBILE6

Required Local Data	Recommended Local Data	Optional Local Data	Recommended <i>Default</i> Data
Regional Temperatures	Registration (vehicle age) data	Diesel Sales Fractions	Other Air-Conditioning related inputs
I/M Assumptions	Absolute Humidity	Vehicle Trip Length Durations	Annual Mileage Accumulation Rates
Special Fuel Characteristics (RFG, RVP)	VMT Fractions by vehicle class	Hourly VMT Pattern Data	Vehicle Engine Starts Per Day
Calendar Year of Evaluation	VMT by Facility Class		Vehicle Soak Times (3 types)
Altitude	VMT Fraction by Speed	Status May Change in Future	

MOBILE6 Documentation

- Available documentation to assist with input data preparation
- **User's Guide to MOBILE6**
 - New keyword structure
 - Description of data input formats
 - Converting M5 inputs to M6
- **Technical Guidance on the Use of MOBILE6**
 - How to use MOBILE6 for SIP/Conformity
 - Local data requirements & recommendations

How To Run MOBILE6

- Can be run from a DOS Prompt:
D:\ > MOBILE6 <ENTER>
- Must supply a MOBILE6 input file
 - Input file contains all the settings and inputs needed to produce a run
 - Input file sections: Header, Run Data, Scenario
- A run may require other M6 related files (*.D files) to be in the same directory
 - IM Credits, Phase-In schedules, etc.

MOBILE6 Input File - Header

- The Header Section contains controls over file output settings

```
MOBILE6 INPUT FILE ← Designates Start of MOBILE6 Input File

REPORT FILE          : m6output.out REPLACE ← ASCII Output File

DATABASE OUTPUT     :
WITH FIELDNAMES     :
EMISSIONS TABLE    : M6OUTPUT.TB1 REPLACE
POLLUTANTS          : HC CO NOX
AGGREGATED OUTPUT   :
```

Database Output File Options

Pollutants to Include in Database Outputs

How will database file be aggregated – This option will output daily emission factors by each of M6 28 Vehicle Types for each RUN and SCENARIO

MOBILE6 Input File – Run Data

- The Run Data Section contains settings which apply to all scenarios within the run. If running different counties, the user may want different run sections for each (does input data vary?)

```
RUN DATA : ←————— Designates Start of New Run Section
MIN/MAX TEMPERATURE: 63.6 92.4 ←———— Temperature data for this run
FUEL RVP : 8.7 ←———— Reid Vapor Pressure
EXPRESS HC AS VOC : ←———— HC Species assumed for analysis
EXPAND EXHAUST : ←———— Affects ASCII Output Report
EXPAND EVAPORATIVE : ←———— (shows emissions by all types)
NO REFUELING : ←———— Refueling Emissions will not be included
REG DISTRIBUTION : LEHI99ag.dat ←———— Vehicle age data in different file
I/M PROGRAM : 1 1984 1999 1 TRC IDLE ←———— IM Program
I/M MODEL YEARS : 1 1968 2050
I/M VEHICLES : 1 22222 11111111 1
I/M STRINGENCY : 1 17.8
I/M COMPLIANCE : 1 94.0
I/M WAIVER RATES : 1 2.0 1.1
I/M EFFECTIVENES : 0.50 0.50 0.50
NO I/M TTC CREDITS : 1
```

MOBILE6 Input File - Scenario

- The Scenario Section indicates to MOBILE that an emission run is to be produced. It uses data specified in the RUN section and any data items in the SCENARIO section. Often scenarios are used for each Facility Group if data varies (fleet mix, speeds, hourly patterns, etc.)

```

SCENARIO RECORD      :[0391 01 Factype] 1
CALENDAR YEAR        :1999
EVALUATION MONTH     : 7
VMT FRACTIONS        : .478 .058 .192 .059 .027 .059 .006 .004
                     : .003 .013 .015 .017 .059 .003 .001 .006
VMT BY FACILITY      :V039101F.def
VMT BY HOUR          :V039101H.def
SPEED VMT            :V039101S.def

SCENARIO RECORD      :[0391 02 Factype] 2
CALENDAR YEAR        :1999
EVALUATION MONTH     : 7
VMT FRACTIONS        : .546 .066 .219 .068 .031 .021 .002 .002
                     : .001 .004 .005 .006 .021 .001 .000 .007
VMT BY FACILITY      :V039102F.def
VMT BY HOUR          :V039102H.def
SPEED VMT            :V039102S

```

Designates Start of New Scenario Run ← (points to the '1' in the first scenario record)

Reference external files ← (points to the .def file names in the first scenario)

Data specific to this scenario ← (bracketed group around the VMT FRACTIONS and VMT BY FACILITY/HOUR data for the first scenario)

Fleet Mix to 16 M6 Vtypes ← (points to the VMT FRACTIONS data for the second scenario)

Mix of VMT among Freeway, Arterial, Ramp, Local ← (points to V039102F.def)

Percentage of VMT in each hour of the day ← (points to V039102H.def)

Distribution of speeds for links in this scenario ← (points to V039102S)

MOBILE6 Descriptive Output

Vehicle Type:	LDGV	LDGT12	LDGT34	LDGT	HdGV	LDDV	LDDT	HDDV	MC	All Veh
GVWR:	-----	<6000	>6000	(All)	-----	-----	-----	-----	-----	-----
VMT Distribution:	0.4775	0.2360	0.0840		0.0563	0.0005	0.0159	0.1237	0.0060	1.0000

Composite Emission Factors (g/mi):										
Composite VOC :	1.50	2.45	2.12	2.36	1.86	0.41	0.38	0.55	6.68	1.692
Composite CO :	22.89	38.03	34.81	37.19	41.47	1.21	0.84	3.66	31.23	25.823
Composite NOX :	1.47	1.82	1.77	1.81	6.49	2.12	1.71	30.36	1.79	5.439

Exhaust emissions (g/mi):										
VOC Start:	0.46	0.90	0.75	0.86	No TRK Start Emissions	0.17	0.14	No TRK Start Emissions	1.25	
VOC Running:	0.44	0.72	0.68	0.71		0.24	0.24		2.53	
VOC Total Exhaust:	0.90	1.62	1.43	1.57	0.73	0.41	0.38	0.55	3.78	1.069
CO Start:	4.85	13.21	12.39	13.00		0.54	0.31		6.54	
CO Running:	18.04	24.82	22.42	24.19		0.67	0.53		24.69	
CO Total Exhaust:	22.89	38.03	34.81	37.19	41.47	1.21	0.84	3.66	31.23	25.823
NOx Start:	0.31	0.42	0.35	0.40		0.05	0.03		0.54	
NOx Running:	1.16	1.41	1.41	1.41		2.07	1.69		1.25	
NOx Total Exhaust:	1.47	1.82	1.77	1.81	6.49	2.12	1.71	30.36	1.79	5.439

Non-Exhaust Emissions (g/mi):										
Hot Soak Loss:	0.229	0.311	0.273	0.301	0.451				0.418	
Diurnal Loss:	0.076	0.112	0.083	0.104	0.152				0.999	
Resting Loss:	0.152	0.230	0.180	0.217	0.320				1.462	
Running Loss:	0.138	0.164	0.132	0.156	0.183					
Crankcase Loss:	0.009	0.015	0.014	0.015	0.017				0.016	
Refueling Loss:	0.000	0.000	0.000	0.000	0.000					
Total Non-Exhaust:	0.604	0.832	0.683	0.792	1.123	0.000	0.000	0.000	2.896	0.623

Similar to MOBILE5 Output
Produces Emission factors in Grams/Mile
This report outputs by MOBILE5 vehicle types

MOBILE6 Database Output

FILE	RUN	SCEN	CAL_YEAR	POL	VTYPE	GM_MILE	GM_DAY	STARTS	ENDS	MILES	MPG	VMT
1	1	1	1999	1	1	1.7701	49.455	7.28	5.3799	27.9392	23.56	0.460548
1	1	1	1999	1	2	2.724	78.058	8.06	5.7548	28.6556	19.93	0.05395
1	1	1	1999	1	3	2.7435	78.616	8.06	5.7548	28.6556	19.93	0.178229
1	1	1	1999	1	4	2.5905	87.188	8.06	5.7548	33.6568	14.1	0.055668
1	1	1	1999	1	5	2.6092	87.816	8.06	5.7548	33.6568	14.1	0.025392
1	1	1	1999	1	6	1.3916	48.452	6.88	4.9123	34.8162	9.73	0.049693
1	1	1	1999	1	7	3.2073	89.333	6.88	4.9123	27.8534	8.78	0.001807
1	1	1	1999	1	8	3.801	83.091	6.88	4.9123	21.8602	8.53	0.00152
1	1	1	1999	1	9	2.332	65.551	6.88	4.9123	28.1094	7.76	0.002605
1	1	1	1999	1	10	2.7691	73.921	6.88	4.9123	26.6951	7.64	0.005494
1	1	1	1999	1	11	4.4427	98.182	6.88	4.9123	22.0998	7.02	0.002733
1	1	1	1999	1	12	7.2403	120.002	6.88	4.9123	16.5742	6.49	0.000014
1	1	1	1999	1	13	0	0	0	0	0	0	0
1	1	1	1999	1	14	0.405	10.414	7.28	5.1979	25.7157	34.91	0.000452
1	1	1	1999	1	15	0.4875	18.758	8.06	5.7548	38.4758	22.05	0.008821
1	1	1	1999	1	16	0.1834	9.128	6.65	4.7481	49.7816	12.66	0.018307
1	1	1	1999	1	17	0.207	11.317	6.65	4.7481	54.6863	11.44	0.005193
1	1	1	1999	1	18	0.2283	15.163	6.65	4.7481	66.4199	10.09	0.00348
1	1	1	1999	1	19	0.23	15.975	6.65	4.7481	69.4632	9.79	0.001395
1	1	1	1999	1	20	0.379	25.896	6.65	4.7481	68.3226	8.58	0.009506
1	1	1	1999	1	21	0.4799	31.134	6.65	4.7481	64.8753	7.5	0.014267
1	1	1	1999	1	22	0.5641	61.263	6.65	4.7481	108.6004	6.39	0.018986
1	1	1	1999	1	23	0.7192	120.271	6.65	4.7481	167.2209	5.99	0.069
1	1	1	1999	1	24	7.4669	47.256	1.35	0.9639	6.3287	50	0.006
1	1	1	1999	1	25	4.9388	134.484	6.88	4.9123	27.2301	6.21	0.001296
1	1	1	1999	1	26	0.8066	78.205	6.65	4.7481	96.9596	3.61	0.002
1	1	1	1999	1	27	0.5223	14.222	6.65	4.7481	27.2301	6.21	0.001704
1	1	1	1999	1	28	0.4277	21.718	8.06	5.7548	50.7764	15.6	0.001939

Data repeated for all RUN, Scenario combinations

This example is aggregated output – 28 vehicle types for each RUN,SCENARIO

MOBILE6 SPEEDVMT File

Hour	MOBILE6 SPEED BINS											57.5-62.5	>62.5	
	0.0-2.5	2.5-7.5	7.5-12.5			
2 1	.0000	.0000	.0000	.0200	.0420	.1660	.1170	.1430	.1400	.1930	.1420	.0370	.0000	.0000
2 2	.0290	.0090	.0130	.0090	.0910	.1540	.1110	.1370	.1330	.1680	.1300	.0160	.0000	.0000
2 3	.0130	.0080	.0200	.0090	.0740	.1590	.1090	.1460	.1300	.1760	.1350	.0210	.0000	.0000
2 4	.0000	.0060	.0140	.0230	.0420	.1750	.0940	.1670	.1290	.1840	.1380	.0280	.0000	.0000
2 5	.0010	.0080	.0200	.0180	.0460	.1750	.0950	.1650	.1280	.1800	.1390	.0250	.0000	.0000
2 6	.0160	.0080	.0200	.0090	.0730	.1590	.1090	.1450	.1300	.1750	.1350	.0210	.0000	.0000
2 7	.0140	.0210	.0120	.0100	.0890	.1540	.1110	.1390	.1330	.1690	.1310	.0170	.0000	.0000
2 8	.0320	.0060	.0110	.0090	.0840	.1550	.1090	.1420	.1310	.1710	.1320	.0180	.0000	.0000
2 9	.0440	.0010	.0080	.0120	.1030	.1470	.1120	.1340	.1320	.1670	.1260	.0140	.0000	.0000
2 10	.0480	.0000	.0030	.0730	.1140	.1090	.1330	.1100	.1310	.1630	.1100	.0060	.0000	.0000
2 11	.0450	.0000	.0290	.0770	.1080	.1290	.1000	.1160	.1280	.1600	.1040	.0040	.0000	.0000
2 12	.0450	.0000	.0140	.0760	.1130	.1130	.1200	.1130	.1300	.1600	.1110	.0050	.0000	.0000
2 13	.0310	.0140	.0090	.0080	.0880	.1510	.1090	.1330	.1380	.1670	.1350	.0170	.0000	.0000
2 14	.0180	.0070	.0110	.0160	.0430	.1710	.0920	.1600	.1300	.1820	.1420	.0280	.0000	.0000
2 15	.0000	.0090	.0080	.0120	.0390	.1640	.1100	.1440	.1370	.1960	.1430	.0380	.0000	.0000
2 16	.0000	.0000	.0000	.0010	.0360	.1590	.1370	.1200	.1490	.1970	.1540	.0470	.0000	.0000
2 17	.0000	.0000	.0000	.0000	.0030	.1350	.1940	.0890	.1720	.1810	.1710	.0550	.0000	.0000
2 18	.0000	.0000	.0000	.0000	.0000	.0970	.2330	.0760	.1870	.1680	.1820	.0570	.0000	.0000
2 19	.0000	.0000	.0000	.0000	.0000	.0700	.2520	.0740	.1980	.1610	.1860	.0590	.0000	.0000
2 20	.0000	.0000	.0000	.0000	.0000	.0640	.2510	.0800	.2000	.1600	.1850	.0600	.0000	.0000
2 21	.0000	.0000	.0000	.0000	.0000	.0620	.2510	.0820	.2020	.1600	.1840	.0590	.0000	.0000
2 22	.0000	.0000	.0000	.0000	.0000	.0640	.2480	.0820	.2060	.1590	.1830	.0580	.0000	.0000
2 23	.0010	.0000	.0000	.0000	.0000	.0670	.2500	.0780	.2030	.1590	.1840	.0580	.0000	.0000
2 24	.0000	.0000	.0000	.0000	.0000	.0980	.2340	.0770	.1910	.1680	.1770	.0550	.0000	.0000

Can Represent one average speed by balancing bins

Or Can represent a distribution of speeds for the RUN, SCENARIO being analyzed