

Review of MOVES Draft Design

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Purpose of this work

- **Review of the EPA's plans for the MOVES model to replace MOBILE6**
 - Approach design
 - Available data
 - Issues specific to greenhouse gases
 - New emissions measurement methods

Organization

- **Vehicle selection and fleet characterization**
- **Emissions modeling**
- **In-use adjustments**
- **Activity data integration**
- **Accuracy, bias, and uncertainty**
- **Greenhouse gas specifics**
- **Portable Emission Monitoring System (PEMS)**

Fleet definitions

- **Vehicle bin definitions**
 - Many unique bin descriptions to populate or combine
- **Data availability (as of Sept. 15, 2003)**

Vehicle Class	Weight (lbs)	Precontrol ~ (<1980)	Tier 0 ~ (1980 – 1995)	Tier 1 ~ (1996 – 2001)
LDGV	All	2,237	35,088	1,643
LDGT1	<6,000 ¹	86	4,691	663
LDGT2	>6,000	37	249	5
LDDV	Any	7	30	1
LDDT	Any	0	18	0
		Precontrol ~ (<1985)	Intermediate ~ (1985 – 1993)	Advanced ~ (1994 – 2001)
HDGV	Any	0	39	39
LHDDV	<19,500	0	7	13
MHDDV	19.5 – 33 k	4	15	21
HHHDDV	>33,000	14	22	18
Bus		2	5	42

Light-duty high emitters

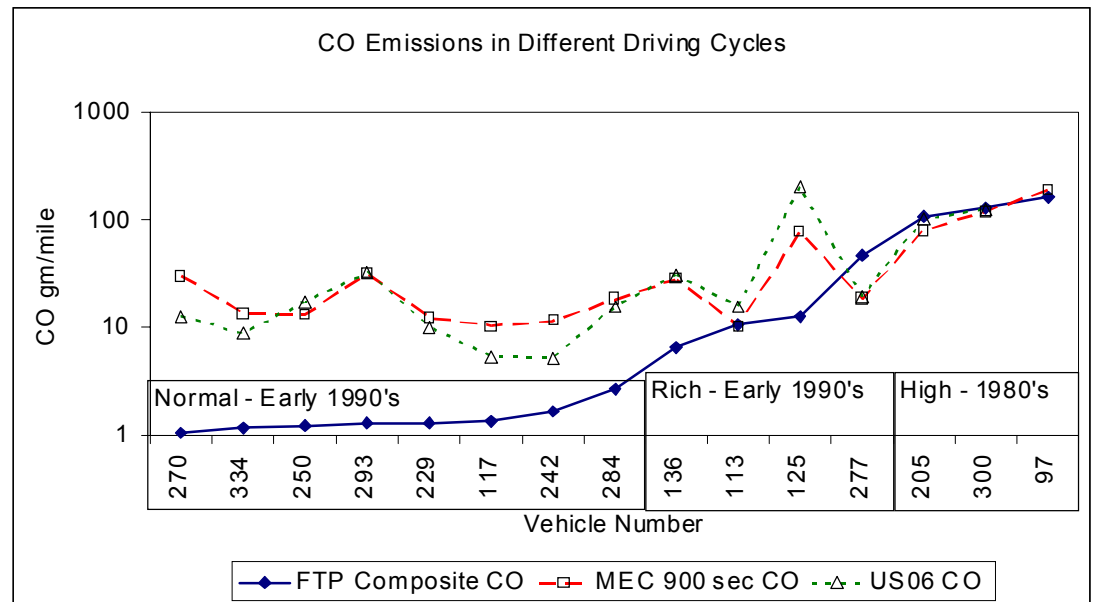
- **Data availability low (>2 g/mile HC or NOx)**

Vehicle Class	Weight (lbs)	Precontrol ~ (<1980)	Tier 0 ~ (1980 – 1995)	Tier 1 ~ (1996 – 2001)
LDGV	All	599	1072	2
LDGT1	<6,000 ¹	39	294	0
LDGT2	>6,000	11	20	0

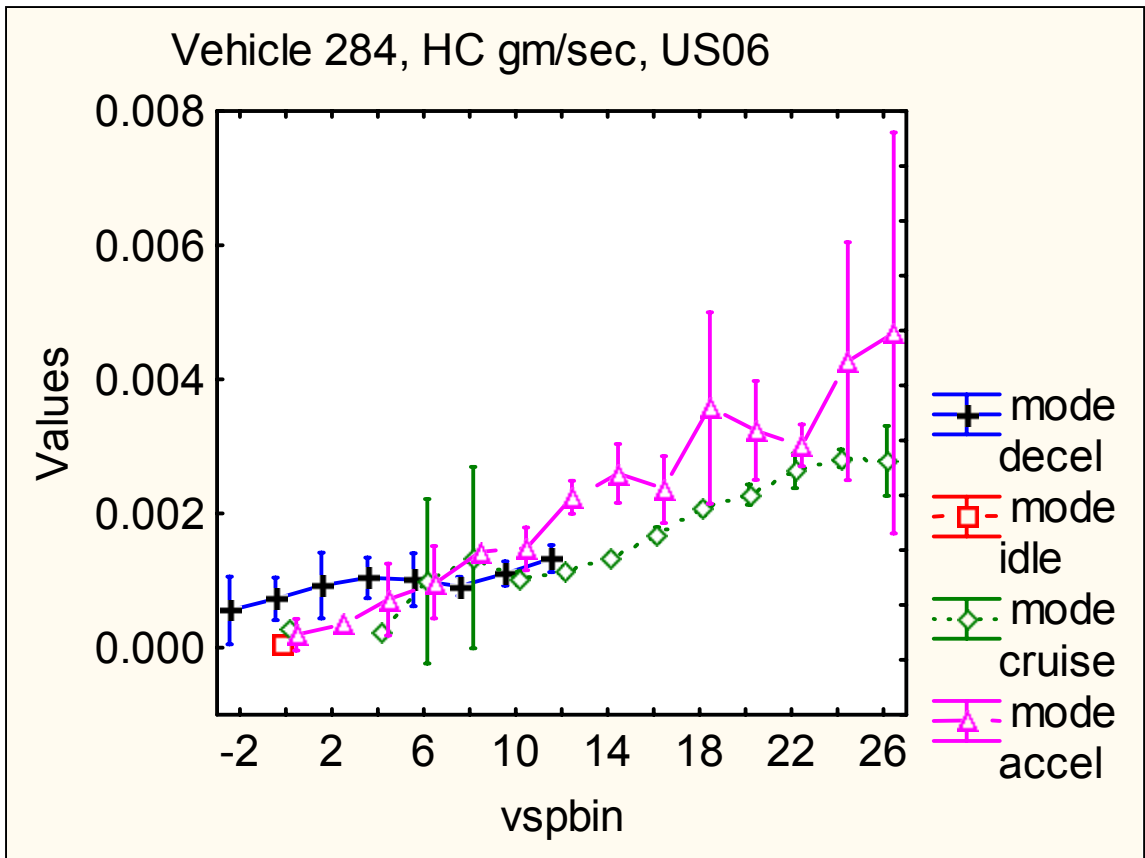
- **Unknown selection bias**
 - Remote sensing to determine high emitter fleet fractions
 - Define types of high emitters

Light-duty high emitters (cont.)

- **Identify high emitter fleet fractions by in-use sampling**
 - Removes selection bias
 - Allows selective testing for high emitters
 - Characterize the vehicle behavior at sites

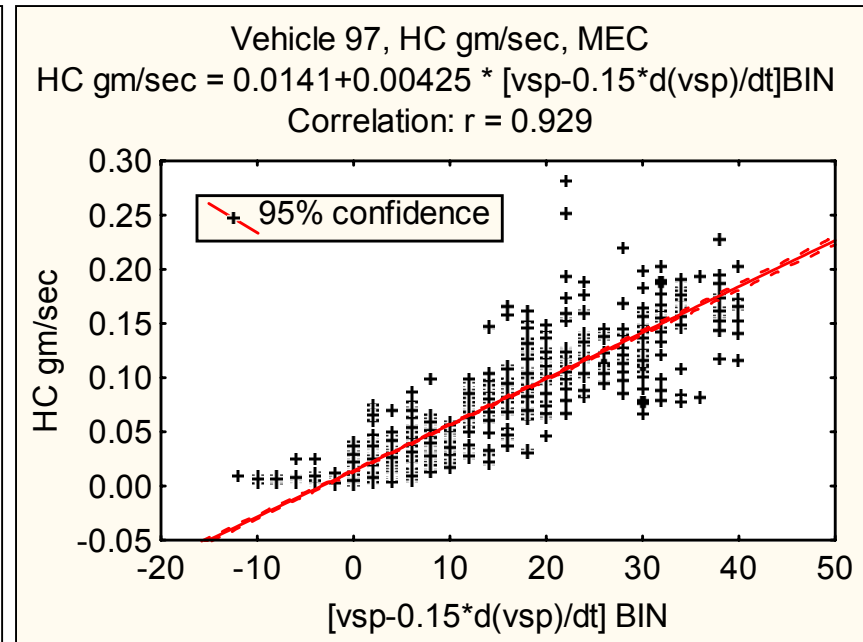
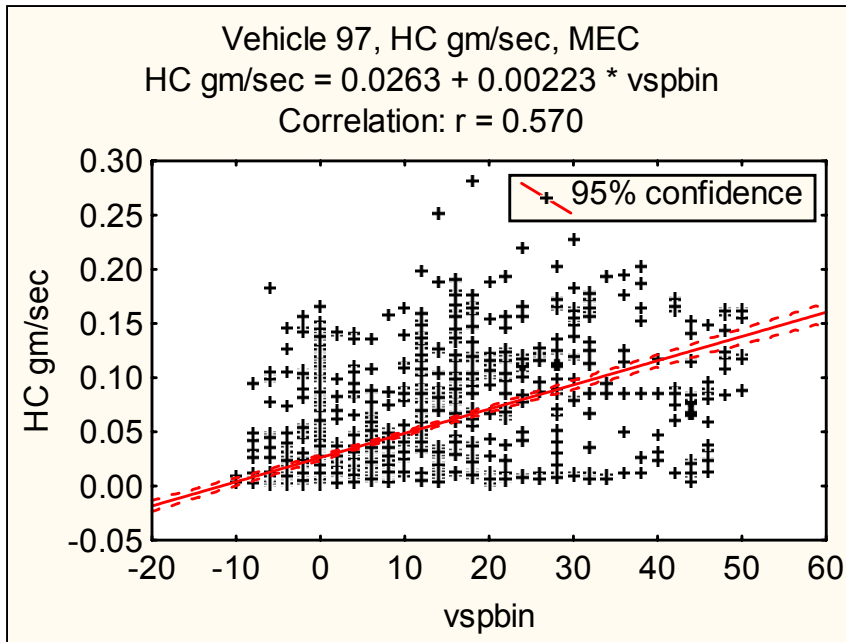


Emission modeling (light-duty normal)



Is it mode
(acceleration,
cruise, etc.)?

Emission modeling (light-duty high emitter)



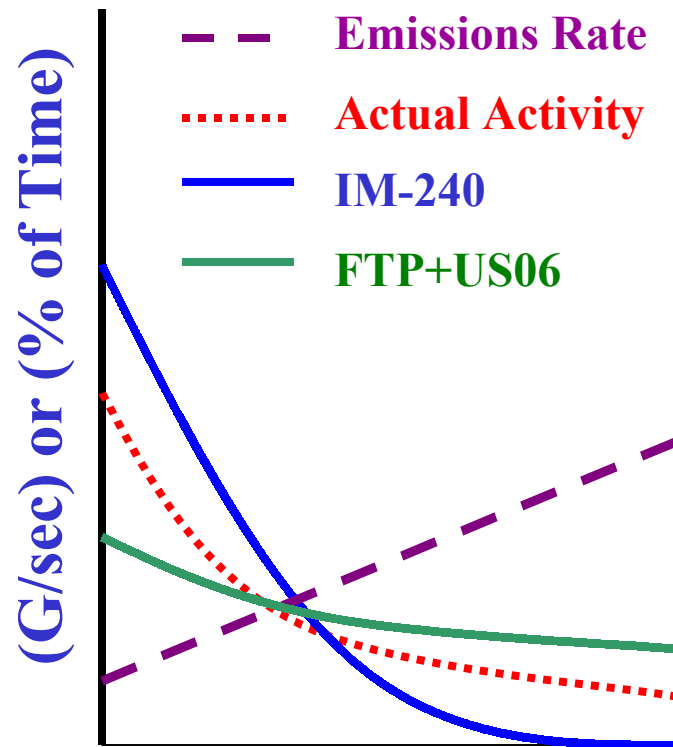
Or $d(VSP)/dt$?

Additional vehicle activity variables are necessary and to identify other failure modes.

Binning emissions and activity

- **Understand that bins are an interim step**
- **But why bin for the final analysis?**
- **Replace bins with analytical expressions determined from data regressions**
- **Bins could lead to bias, especially at high VSP where IM-240 data does not occur**

Binning bias – Example for a combined > 15 VSP Bin



Example VSP Bin

Example EF for VSP>20 2 times

Instrumented Vehicles (EF ~ 1)

VSP Bin 15 – 20;	73%
VSP Bin >20;	27%

Data IM-240 (EF ~ 0.89)

VSP Bin 15 – 20;	87%
VSP Bin >20;	13%

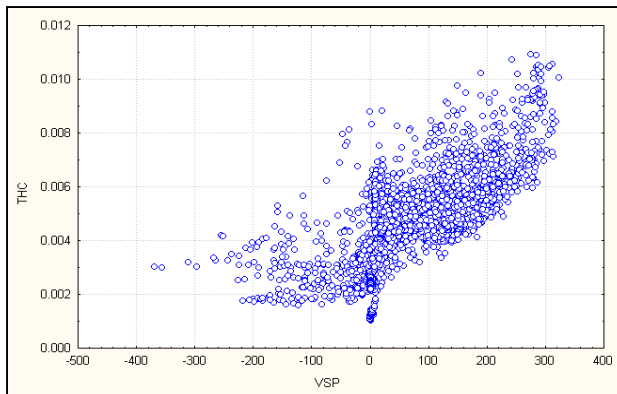
Data FTP + US06 (EF ~ 1.12)

VSP Bin 15 – 20;	58%
VSP Bin >20;	42%

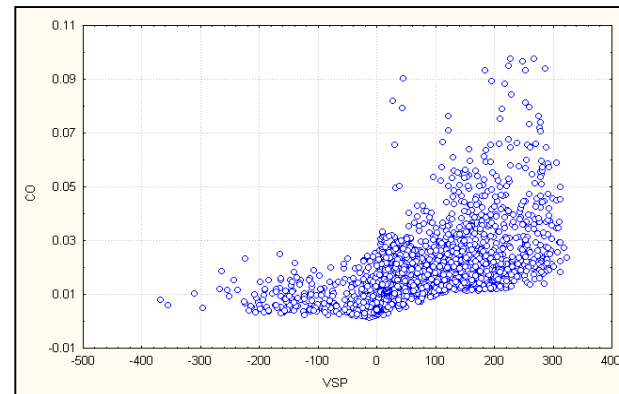
Emission modeling (heavy-duty)

- CO₂ and NO_x correlated with VSP (NO_x modal discussed in CRC E-55)
- CO (CO correlates with PM) and THC need additional investigation; speed, recent VSP, and $d(\text{VSP})/d(t)$ all potential important variables

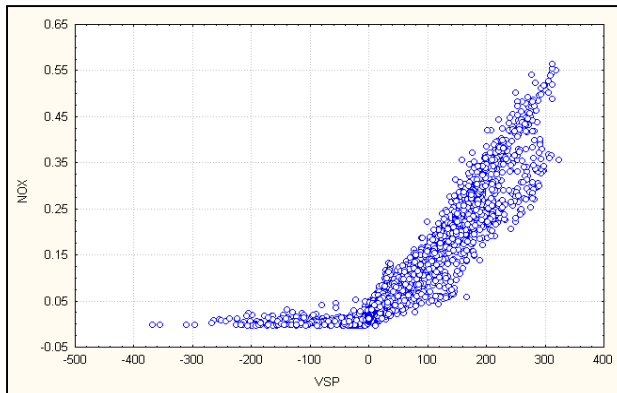
THC



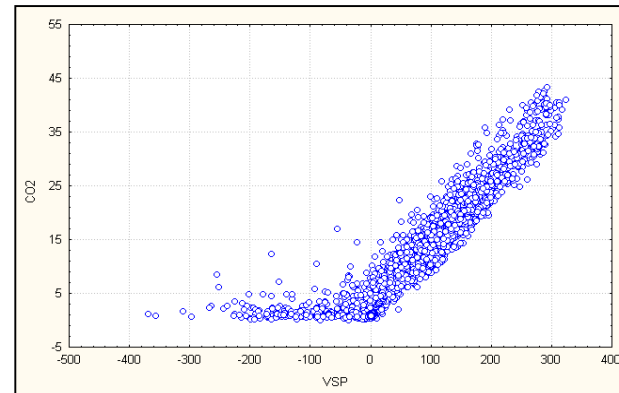
CO



NO_x



CO₂

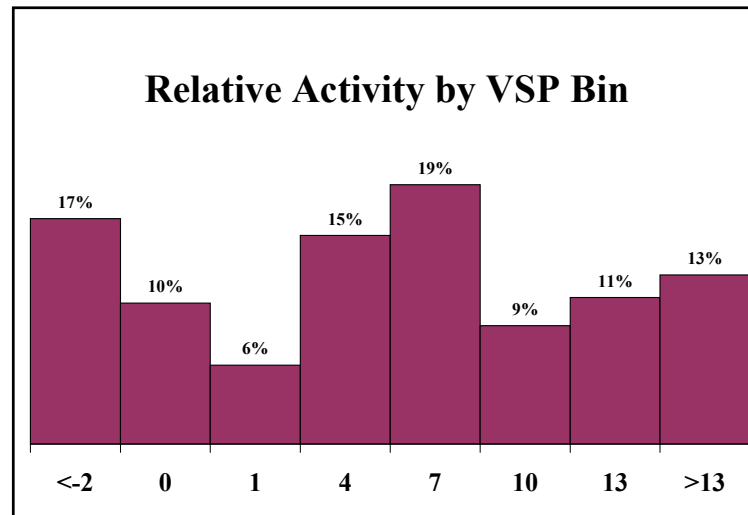


In-use adjustments

- **Humidity corrections**
 - Date to studies in 1970s
- **Temperature and Altitude corrections**
 - Cycle total adjustments only
- **Fuel effects (Cycle totals only)**
- **Current adjustments of laboratory or PEMS data should be revisited**
- **Adjustment different by VSP level or other modes?**

Incorporation of activity data

- **Significant increase in data collection needs**
 - Currently only speed and VMT, so vehicle behavior offers the opportunity for a vast improvement
 - VSP and other behavior distributions by congestion level and roadway type
 - Model encourages smaller road links else a wider range of activity distributions, such as shown for a 2 intersection link



Accuracy, bias, and uncertainty

- **Unknown vehicle and activity bin descriptions**
- **Uncertainty within each bin (need to collect more data for the largest and most variable emissions)**
 - High emitters or high usage vehicles
 - High VSP or other high emission activity
 - Cold starts
- **Larger number of bins increases the uncertainty by reducing data within each bin especially in terms of number of vehicles**
- **Current proposals to estimate uncertainty have not yet addressed the proper range of input variable uncertainty**

Greenhouse gas issues

- **Fuel consumption correlates well with VSP for light and heavy-duty vehicles**
- **PERE can be used to inform modeling**
- **Necessary to include other greenhouse gases?**
 - N_2O , 3% of CO_2 importance within transportation
 - CH_4 , 0.2% of CO_2 importance within transportation

PEMS method

- **Time matching description lacking**
 - Could vary by VSP level
 - Adds to noise at 1 Hz level
- **Cycle totals comparable with laboratory methods**
- **Data filtering (raw laboratory and PEMS results incompatible at 1 Hz level due to exhaust flow data)**
- **Activity collection**
 - Roadway type
 - Congestion conditions instead of just speed
 - Not just average conditions but distributions

Summary and Recommendations

- **Vehicle definitions**
 - Bin definitions may need to be combined
 - Identify high emitters fleet fractions from in-use measurements and target testing to high emitters
 - Investigate how new vehicles\technologies behave and age
- **Emissions Modeling**
 - Modeling of regulated pollutants and high emitters will require additional light-duty vehicle activity terms
 - Additional activity terms are also helpful for modeling light-duty normal emitters and fuel consumption
 - Diesel CO (PM) emissions deserve more investigation
 - Reconsider binning vehicle activity in favor of regressions

Summary and Recommendations

- **In-use adjustments; dated and incompatible with MOVES using vehicle activity parameters**
- **Raise the level of interest in activity data collection**
- **Analysis should consider the number of vehicle bins in terms of data population; target testing on high emitters, high VSP, high usage**
- **Greenhouse gases; fuel consumption easiest to model, why worry about nitrous oxide and methane?**
- **PEMS measurements comparable with laboratory but more emphasis on data filtering**

Acknowledgement

- **Coordinating Research Council**
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