Report from MSTRS MOVES Review Workgroup

Clean Air Act Advisory Committee Meeting
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What is MOVES?

- Motor Vehicle Emission Simulator
- Estimates emissions & energy use from all on-road sources over multiple scales
- Replaces MOBILE6.2 as EPA's official on-road emissions model for SIP and conformity determinations

Why Does EPA Develop Models?

- Mandated by Clean Air Act
  - Must maintain & update emission factors every 3 years
  - EPA must provide tools for state and local air agencies
- Analyses required for new rules
  - Quantify emission baseline & reductions
  - Provide input for air quality, cost/benefit analyses
- "What-If" analyses
  - Understand mobile source emission trends and their contribution to overall inventory
  - Evaluate potential for new national, regional and local policies
- Repository of emissions and activity information

Why did EPA develop MOVES?

- MOBILE series of models obsolete and increasingly difficult to maintain
- Needed platform that allowed easier updates with new emissions, fleet and activity data
- Wanted to develop platform that could include all mobile sources
- U.S. National Research Council recommendations

Why MOVES? continued

- In “Modeling Mobile Source Emissions” (2000), National Research Council made several recommendations to EPA to improve modeling:
  - Support for smaller-scale (project level) analysis
  - Improved characterization of high emitters, heavy-duty vehicles and nonroad sources
  - Improved characterization of particulate matter and toxics
  - Improved model evaluation and uncertainty analysis
  - Improved ability to interface with other models
- These recommendations became the primary objectives for MOVES

Pollutants in MOVES

- HC (THC, NMHC, NMOG, TOG, VOC)
- CO
- NO_x (NO, NO_2)
- NH_3
- SO_2
- $PM_{10,2.5}$ (OC, EC, sulfate, brake, tire)
- GHG (CO_2, CH_4, N_2O)
- Toxics
- Energy (total, petroleum, fossil)

Emissions Processes in MOVES

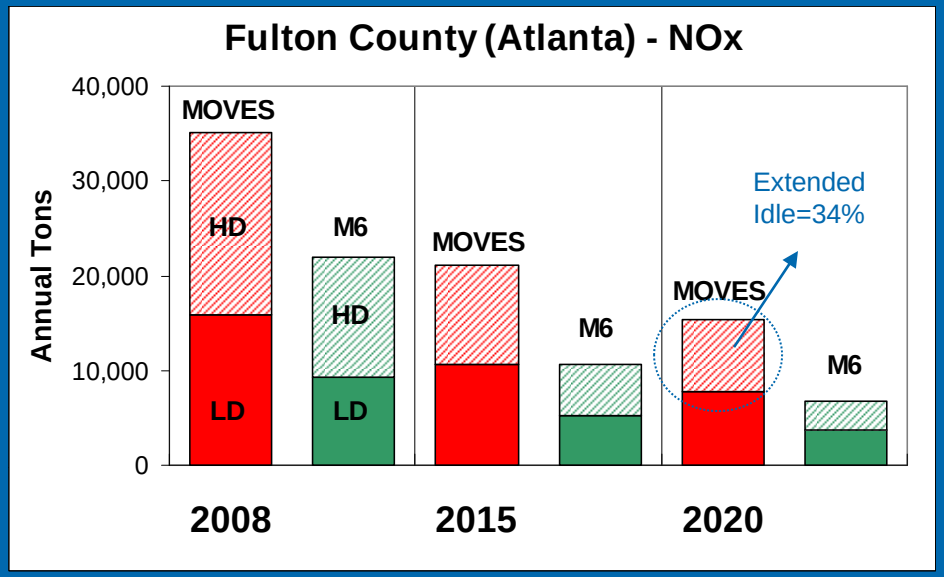
- Running
- Start
- Extended Idle (“hoteling”)
- Evaporative
  - Permeation, Vapor Venting, Liquid Leaks
- Refueling
  - Vapor loss, Spillage
- Crankcase
- Tire Wear
- Brake Wear

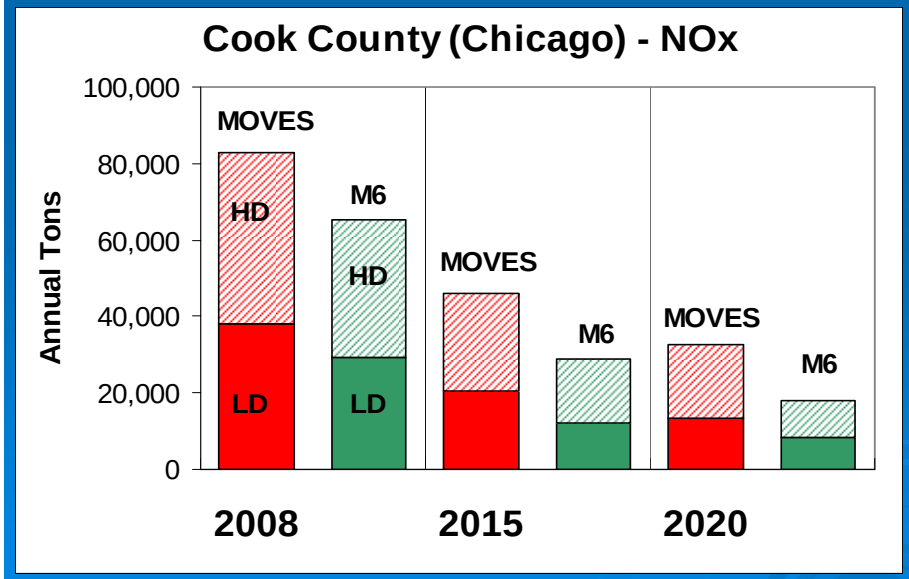
MOVES is Based on Latest Data

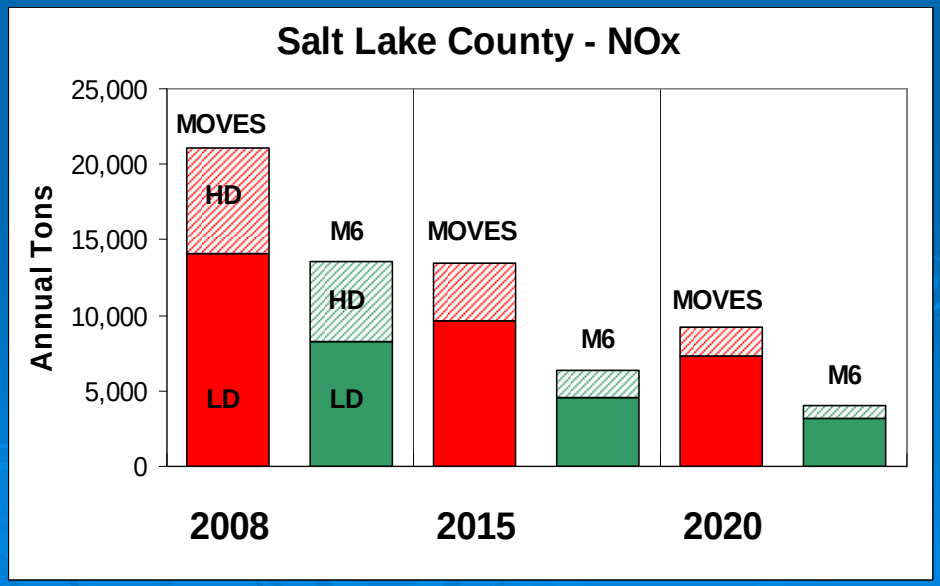
- EPA reviewed data from hundreds of thousands of cars and light trucks
  - Inspection/Maintenance, RSD, historical lab data
- Landmark study of gasoline PM in Kansas City
- First use of portable emission measurement systems (PEMS) to capture on-road heavy-duty truck emissions
- New data drives updated emission estimates

Example NO_x Results (MOVES2009)

- On-road data on heavy trucks shows higher emissions than MOBILE6 estimated from cert data
- Extended idle emissions become significant share of heavy-duty inventory in future

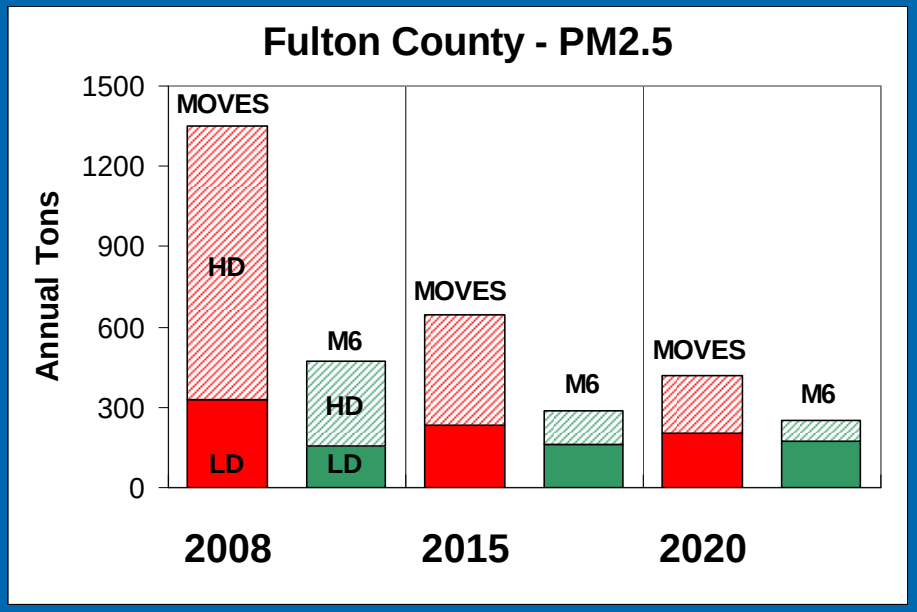


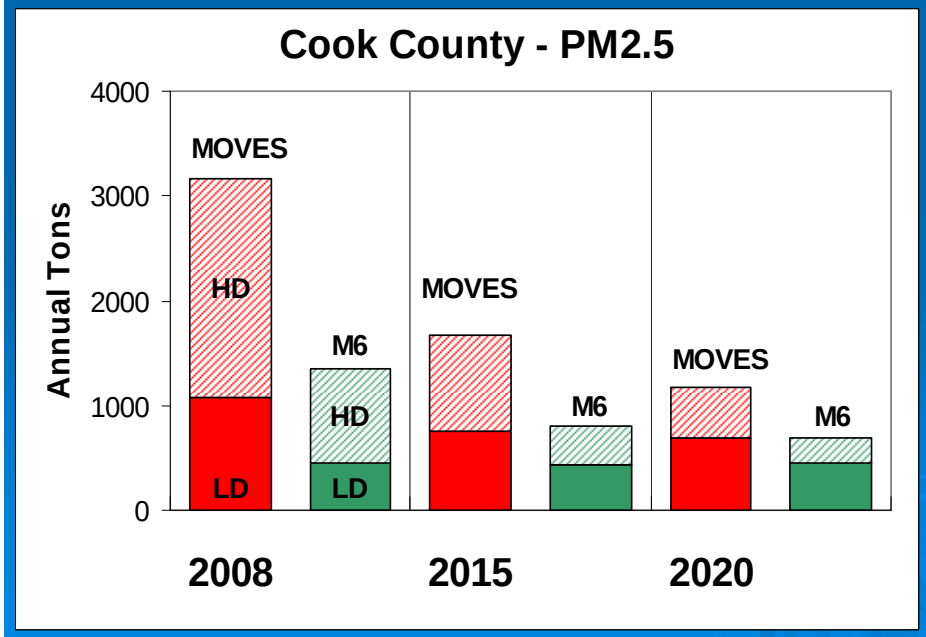


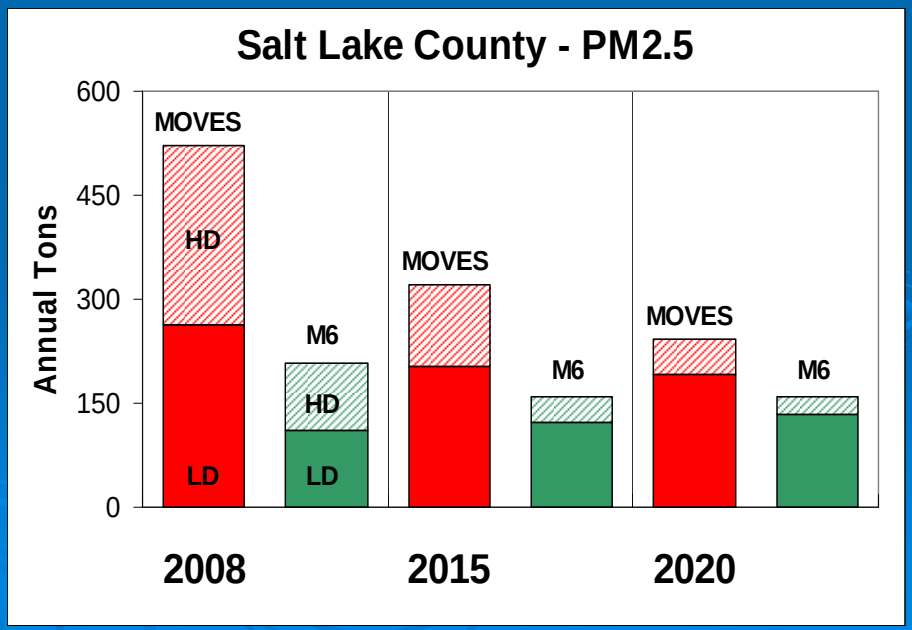


Example $PM_{2.5}$ Results (MOVES2009)

- Kansas City program found high gas PM emissions esp. at cold temps
- New data on heavy trucks shows higher deterioration than MOBILE6
- MOVES accounts for impact of vehicle speed – MOBILE did not

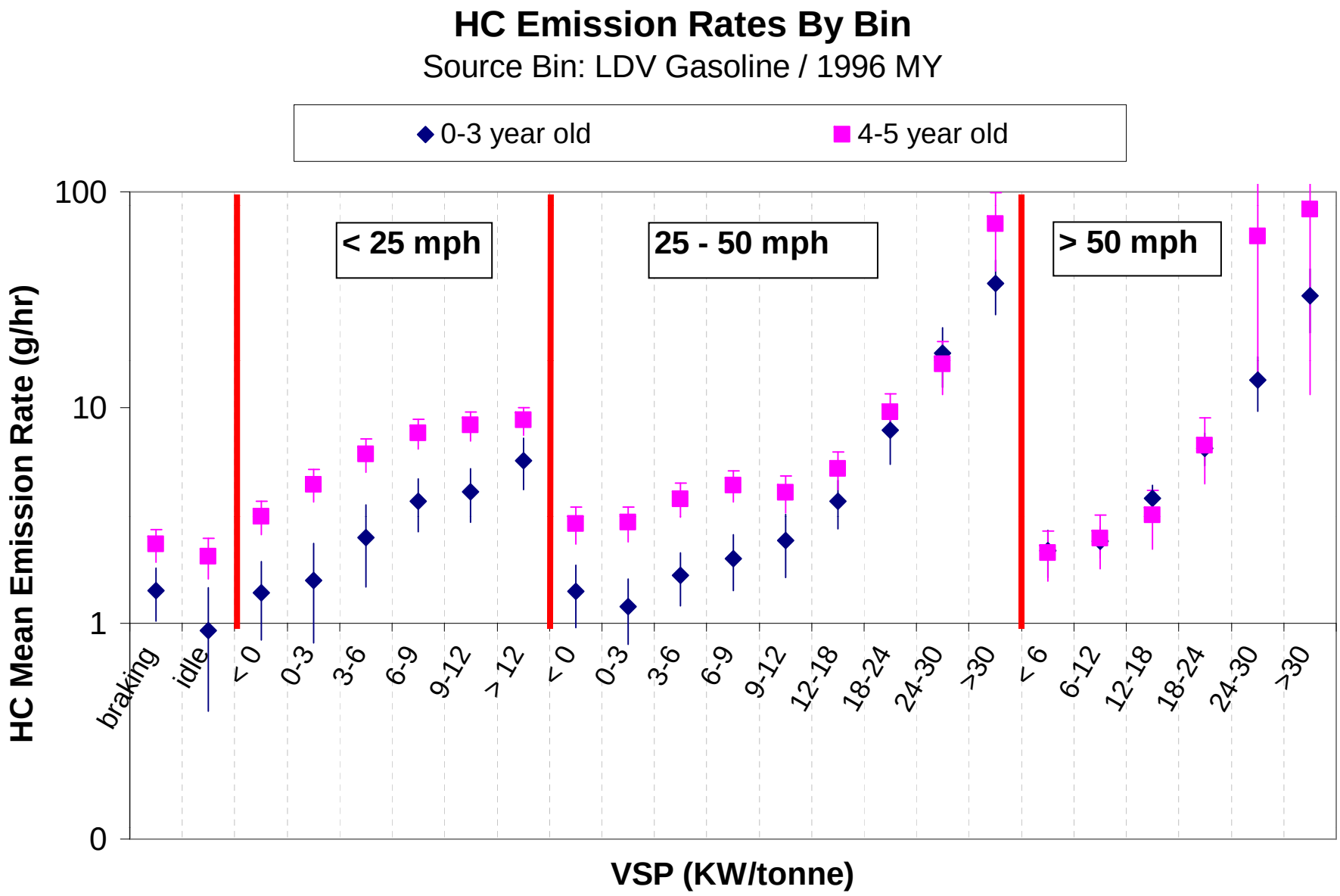


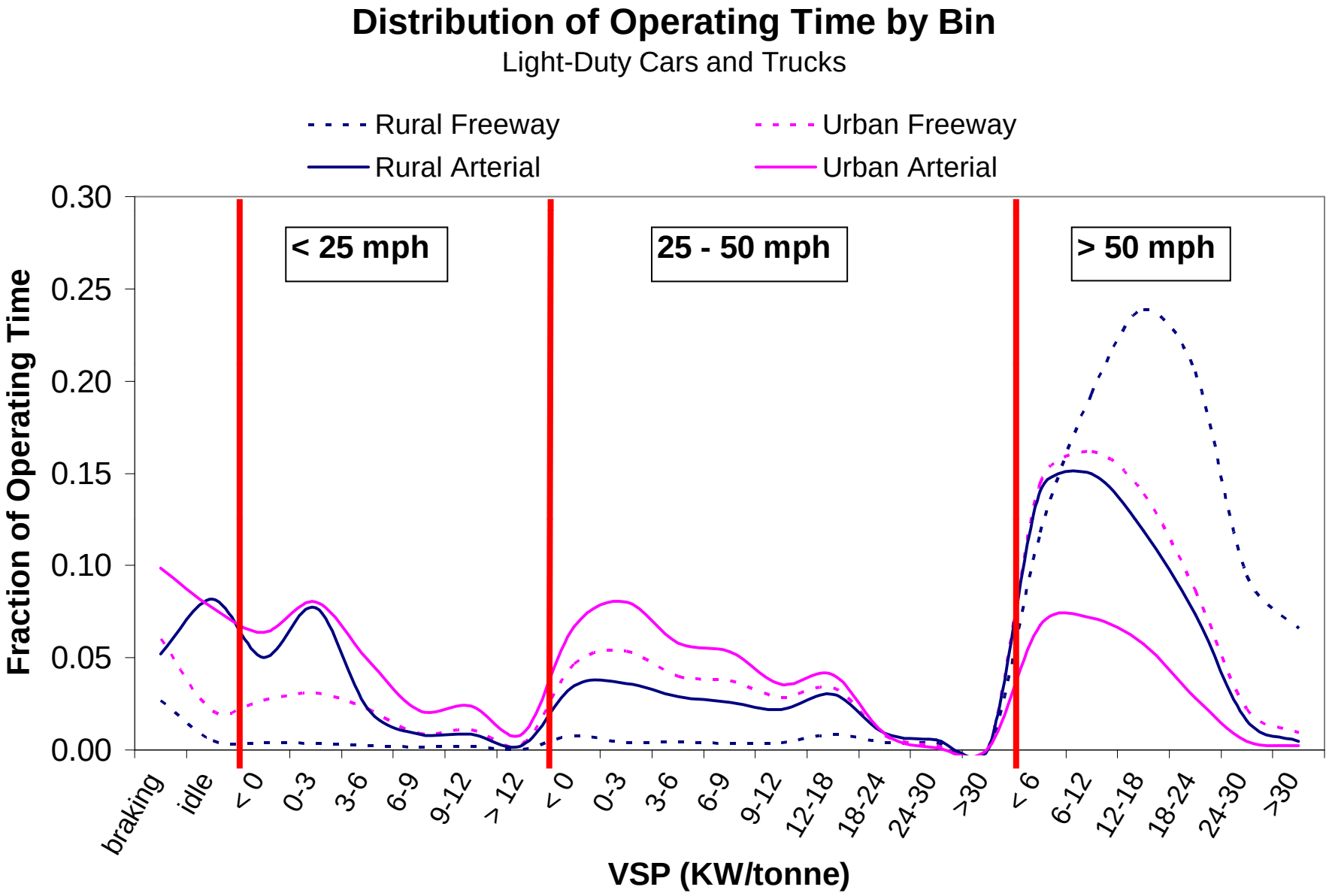




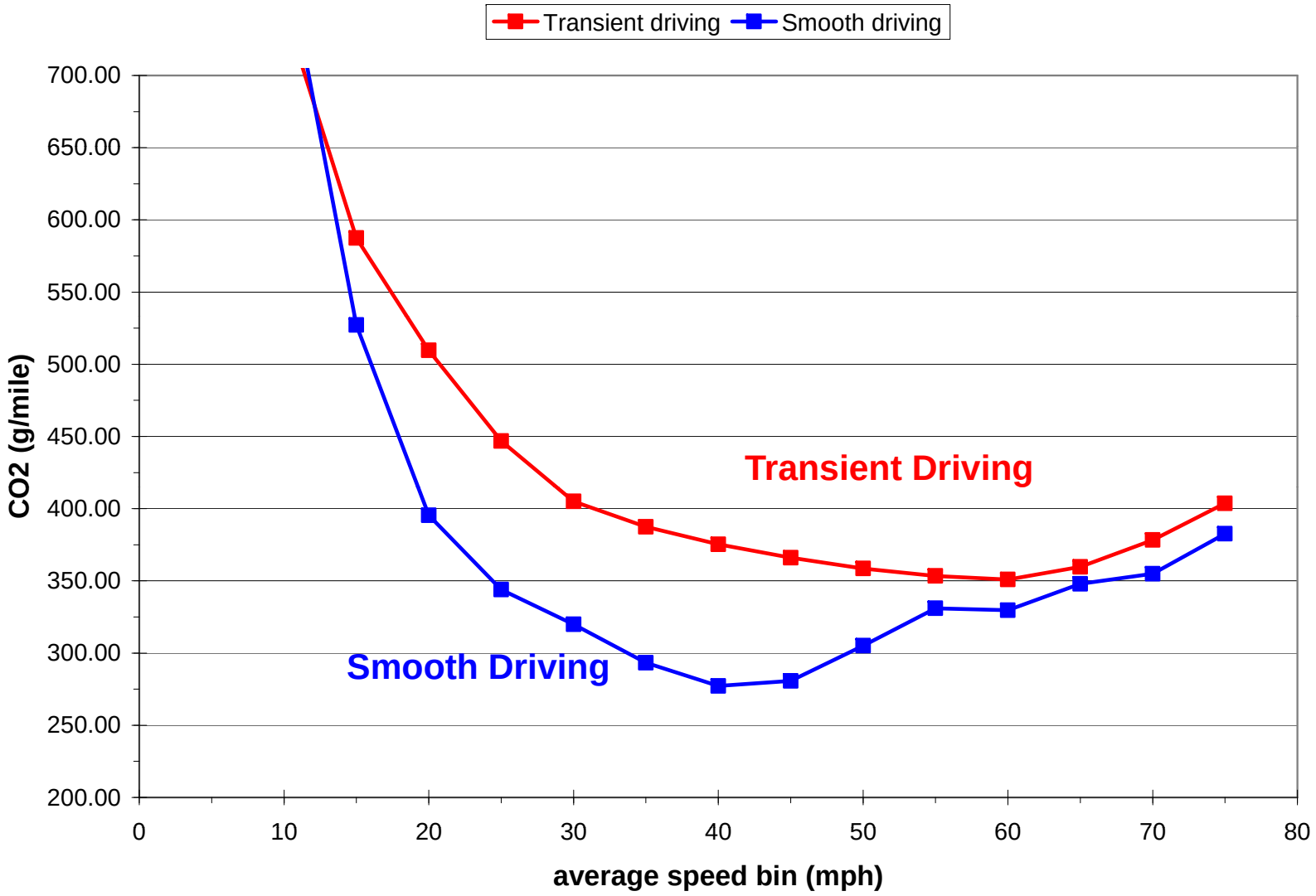
Modal “Binning” Approach

- Advancement required to meet emerging analysis needs
- Any driving pattern can be modeled
  - Adds major flexibility compared to MOBILE
- Allows direct use of data from many sources
  - Laboratory, I/M programs, RSD
- Independent validation has shown good results even for macroscale applications


HC Emission Rates By Bin
Source Bin: LDV Gasoline / 1996 MY
0-3 year old
4-5 year old
HC Mean Emission Rate (g/hr)
100
10
1
0
< 25 mph
25 - 50 mph
> 50 mph
braking
idle
< 0
0-3
3-6
6-9
9-12
> 12
< 0
0-3
3-6
6-9
9-12
12-18
18-24
24-30
>30
< 6
6-12
12-18
18-24
24-30
>30
VSP (KW/tonne)


Distribution of Operating Time by Bin
Light-Duty Cars and Trucks
Rural Freeway
Urban Freeway
Rural Arterial
Urban Arterial
Fraction of Operating Time
0.30
0.25
0.20
0.15
0.10
0.05
0.00
< 25 mph
25 - 50 mph
> 50 mph
braking
idle
< 0
0-3
3-6
6-9
9-12
> 12
< 0
0-3
3-6
6-9
9-12
12-18
18-24
24-30
>30
< 6
6-12
12-18
18-24
24-30
>30
VSP (KW/tonne)

CO_2 Impact of Traffic Smoothing



MOVES History

2000	**- NRC recommends complete overhaul of EPA mobile source models**
2001	**- EPA publishes white paper on MOVES for stakeholder and peer review** **- EPA begins developing design with input from stakeholder working group**
2002	**- MOVES "shootout" identifies best practices for modal modeling**
2005	**- First version of MOVES released – focused on energy and GHG only** **- Kansas City PM study completed**
2007	**- Demonstration version of full on-road MOVES released** **- Established new FACA workgroup to review criteria/toxic emission inputs**
2009	**- Draft (MOVES2009) released in April** **- Final (MOVES 2010) released in December**
2010	**- MOVES2010a (reflects 2012-2016 LD GHG rule)**

MOVES Review Workgroup

- Formed by MSTRS to provide input to EPA on MOVES development
- 15 meetings 2007-2010
- Workgroup members represented wide range of stakeholders
- Reviewed and provided comments on MOVES inputs and algorithms
  - Recommendations were incorporated in subsequent versions of MOVES
- MSTRS voted to forward to CAAAC

Workgroup Final Comments & Recommendations (1 of 2)

- MOVES overall structure is solid
  - Provides good deal of flexibility
- MOVES validation and corroboration work has been helpful and should continue
  - EPA has compared MOVES results to a variety of independent datasets; recommends other organizations undertake this as well
  - EPA should budget funds for ongoing improvement
- Continue to obtain feedback from a variety of users, and incorporate this feedback into model

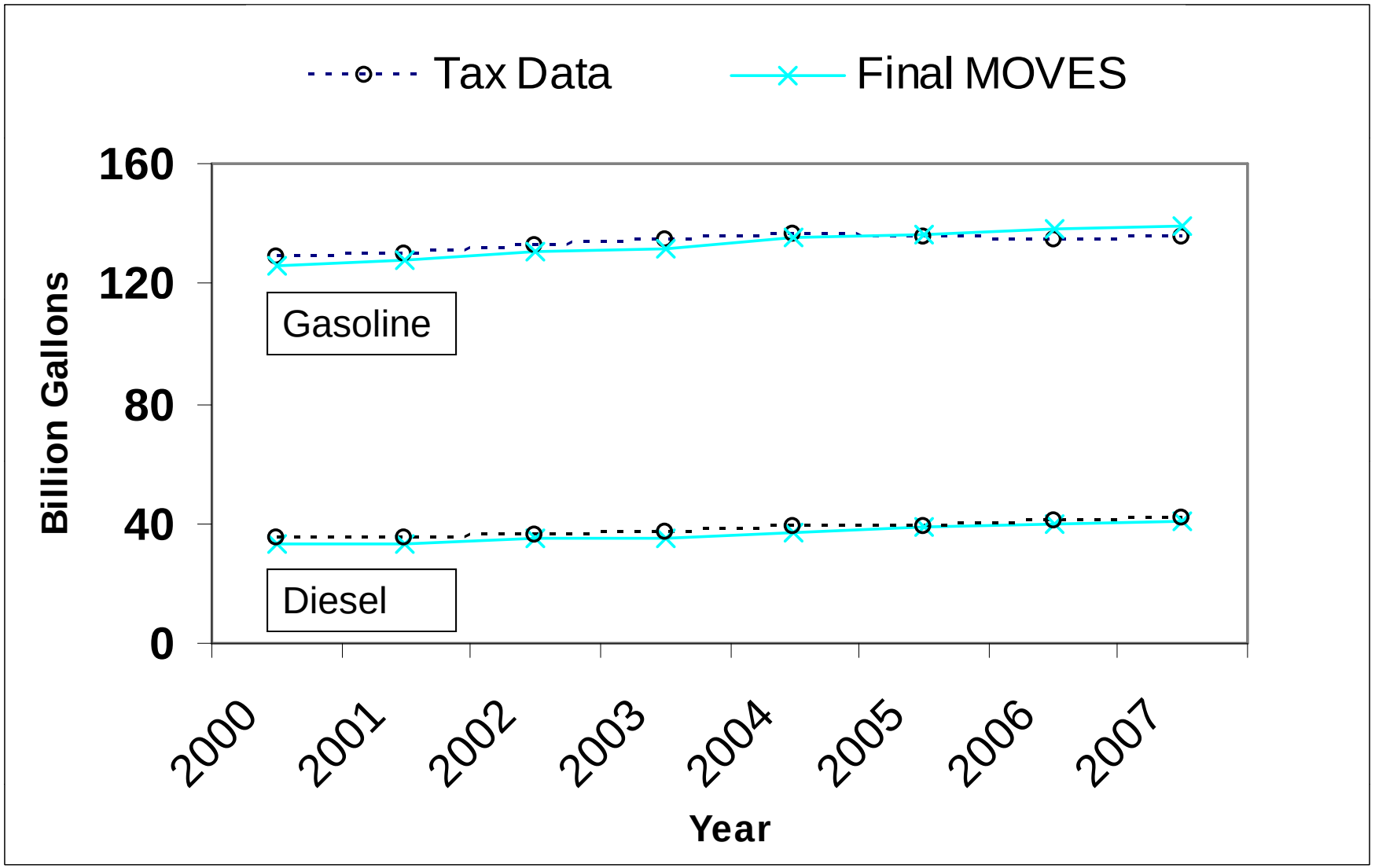
Workgroup Final Comments & Recommendations (2 of 2)

- EPA needs to continue model updates
  - Emission rates, activity profiles, as well as features
  - New rules (e.g. 2012-2016 LD GHG)
  - Expanded air toxics
  - Reduce model run time
- EPA needs long-term data collection plan
  - EPA needs to budget and plan for continued data collection
  - EPA needs to seek data from other sources as well
  - Focus on known uncertainties in the model

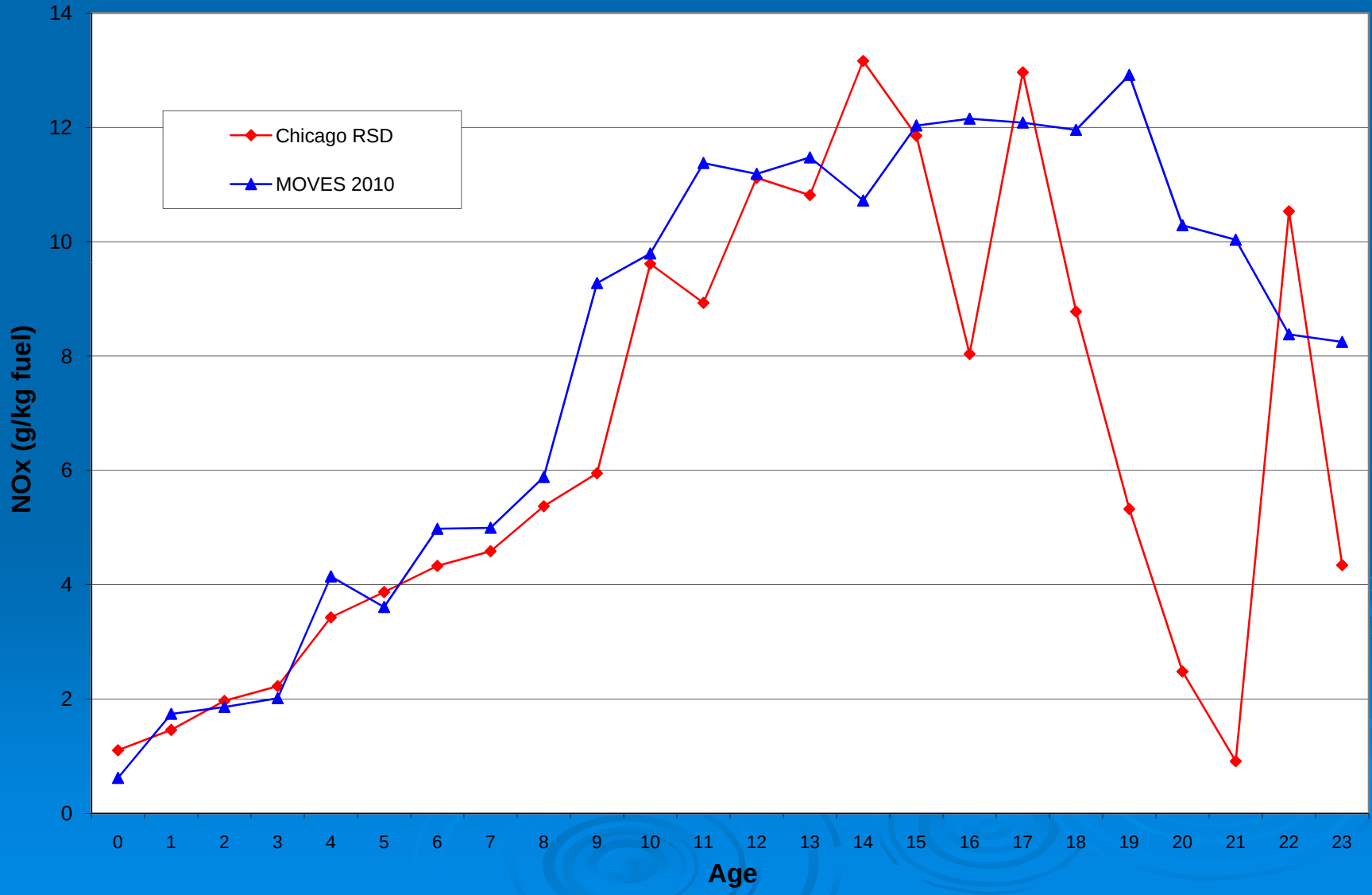
How EPA is addressing workgroup comments: Model Validation

- Comparison of MOVES fuel consumption results vs. fuel tax data
  - Direct check of GHG emissions
  - Provides top down check on model fleet, activity data that applies to criteria as well
- Comparison of emission rates vs. independent data
  - Multiple cities – RSD, I/M, dyno data
  - Report to be published
- Air quality/dispersion studies in progress

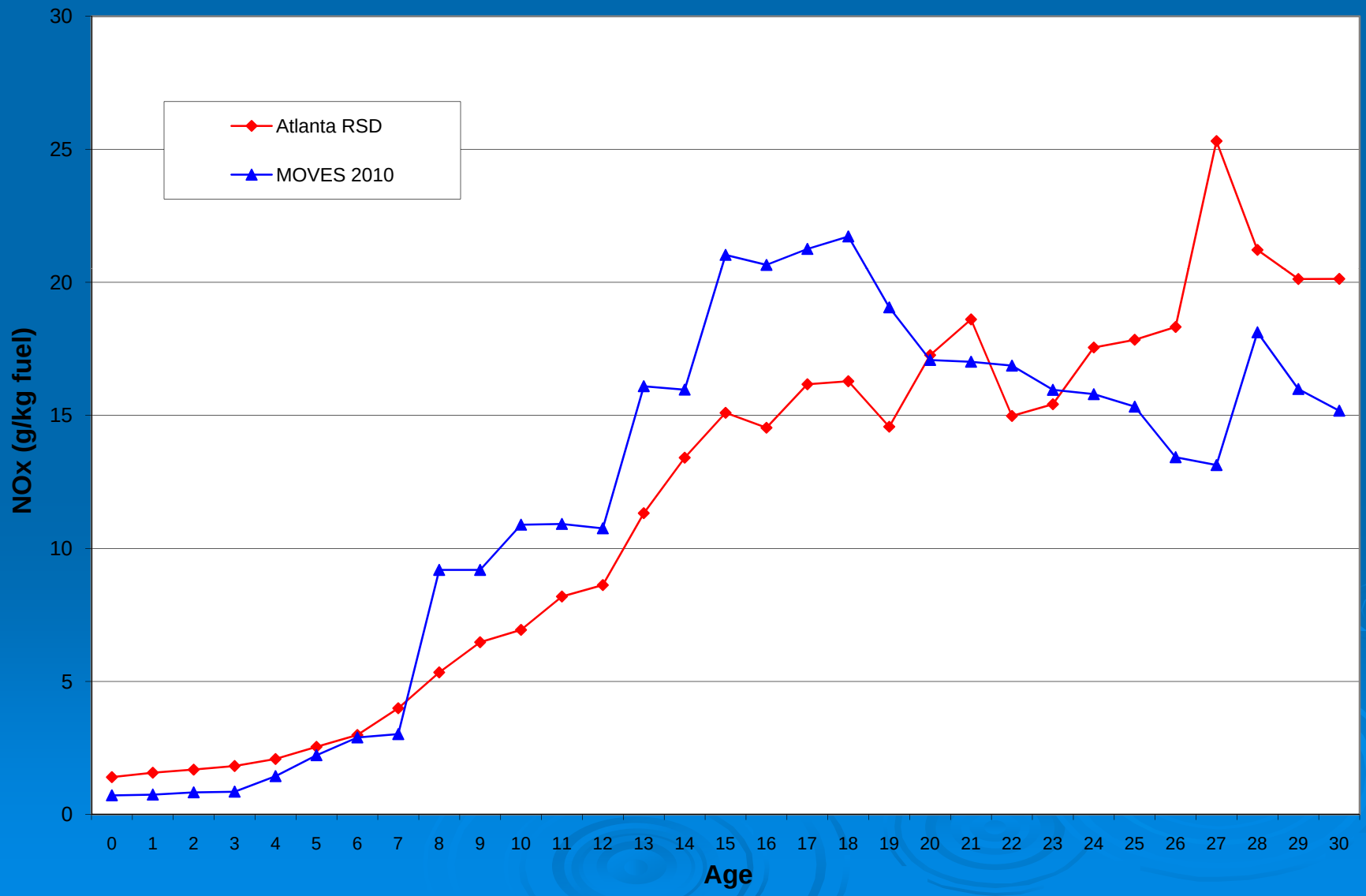
National Fuel Consumption Comparison

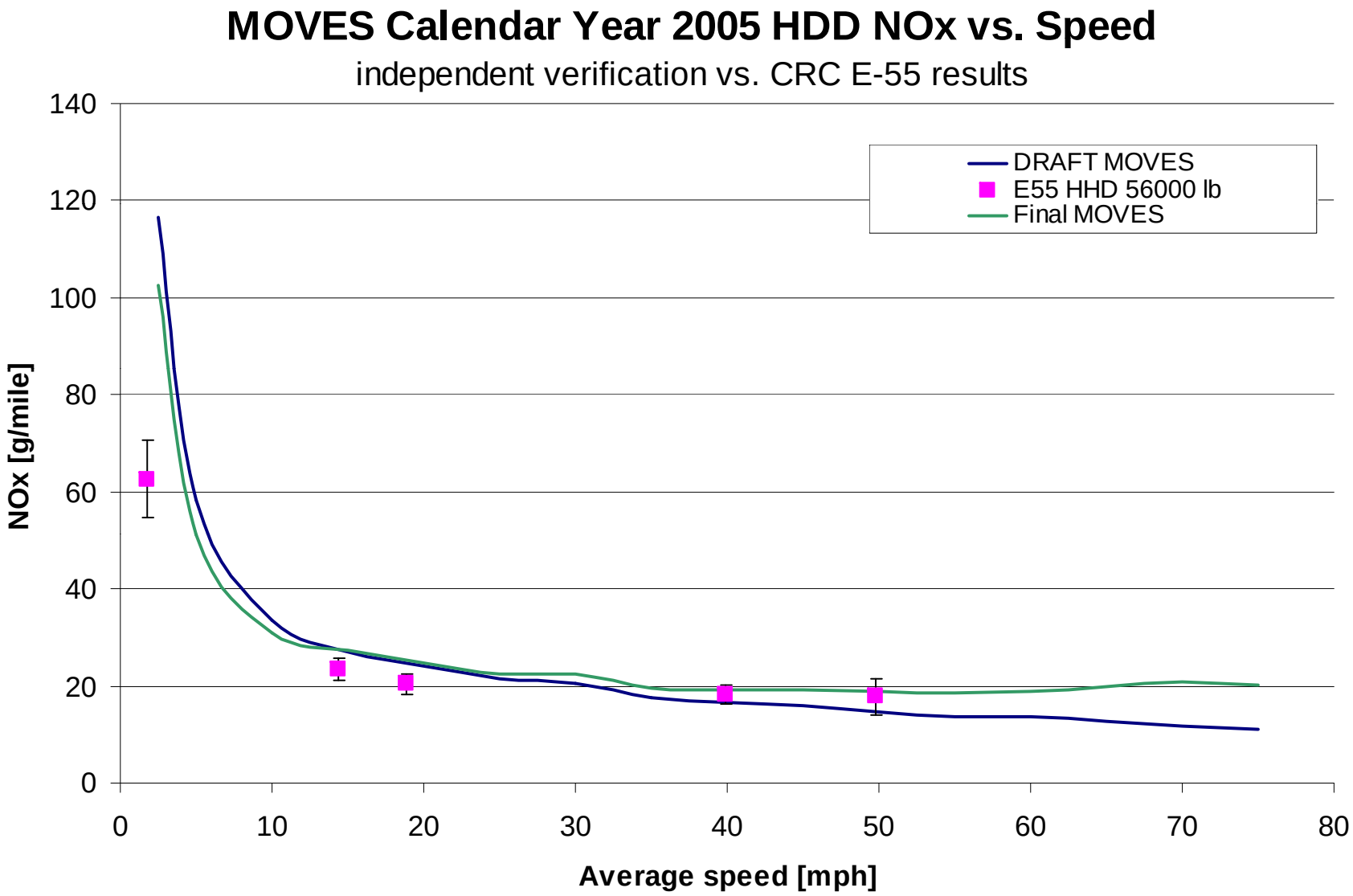


LDV NOx Fuel-Based Emission Rates by Age
MOVES vs. Chicago RSD (2004)



LDV NOx Fuel-Based Emission Rates by Age
MOVES vs. Atlanta RSD (2008)




MOVES Calendar Year 2005 HDD NOx vs. Speed
independent verification vs. CRC E-55 results
NOx [g/mile]
Average speed [mph]
DRAFT MOVES
E55 HHD 56000 lb
Final MOVES
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80

How EPA is addressing workgroup comments: Model Updates

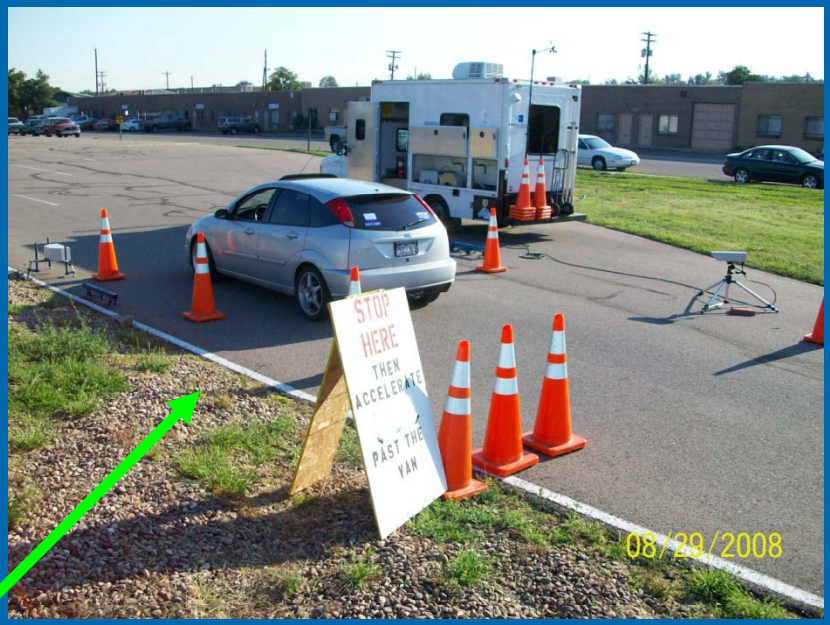
- Database approach facilitates faster updates in response to new data
- Updates requires careful consideration of the policy implications and technical justification for a model change.
- EPA will coordinate official releases taking into account the timing needs of SIP analyses

How EPA is addressing workgroup comments: Long Term Data Collection

- Rolling out new advancements in capturing real-world emissions
- Evaporative Leak Detection Study (2008-10)
  - Method developed to detect high evap vehicles using RSD
  - Confirmed using portable SHED
  - Developing way to apply to much larger RSD datasets
- Houston Port Drayage Study (2009-10)
  - First to implement hybrid of RSD and PEMS
- Tier 2 PEMS Study (2010+)
  - RSD conducted at 6 sites around Metro Detroit (~80,000 hits)
  - PEMS testing planned on Tier 2s selected based on RSD
  - Considering additional cities for 2011/2012

Evaporative “Leaker” Field Study

- Evaporative vapor emissions either contained, or leaking
- In collaboration with CRC and Colorado, developing groundbreaking approach to quantifying frequency of evap leakers
- Developed method to find evap leakers using roadside remote sensing
- Verified using portable SHED



Houston Port HD Drayage Study

- ~ 4,000 RSD hits on 1,900 trucks entering port
- PEMS testing on sample of these, stratified by emission level

PEMS Vehicle Example
MY 1994 Freightliner

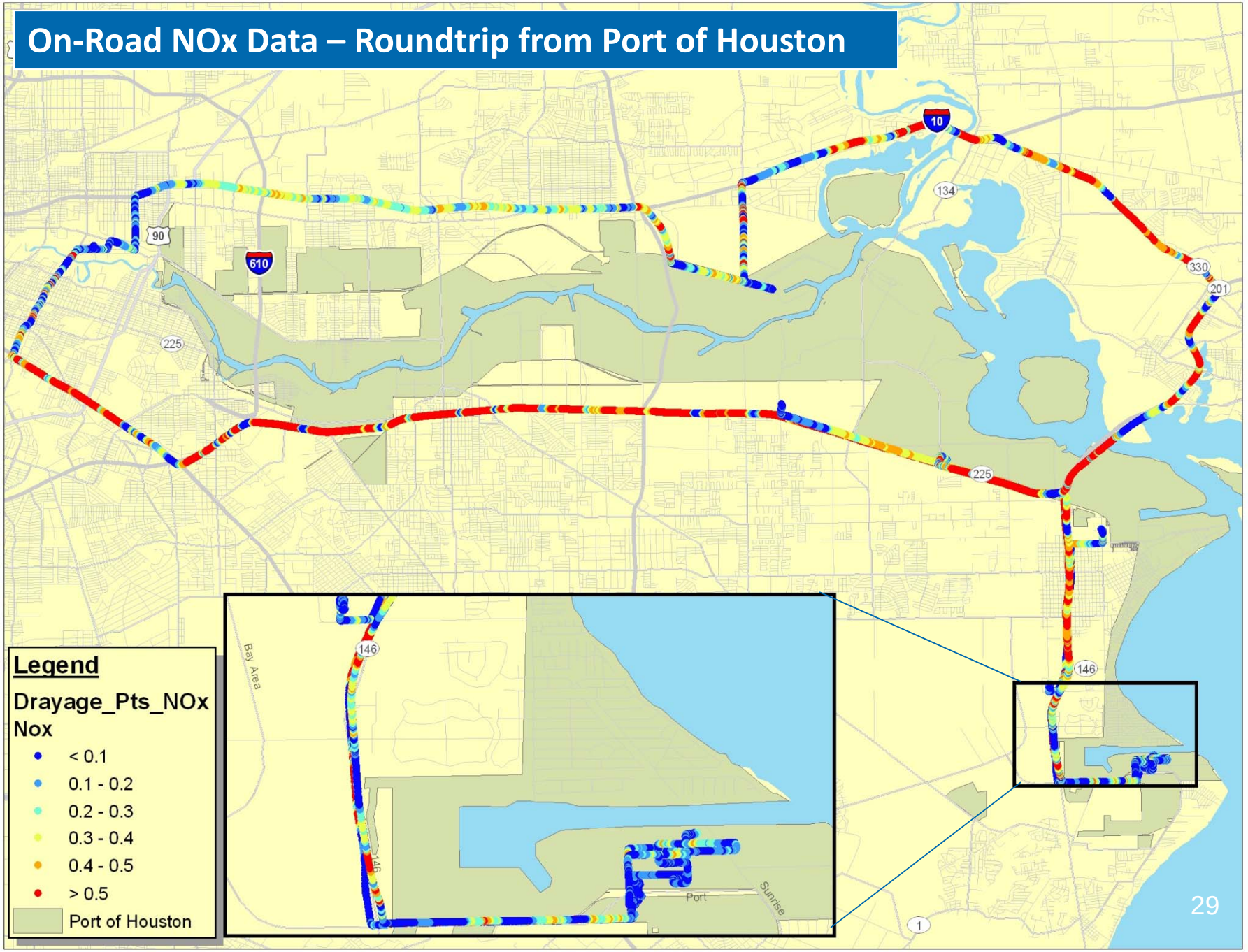
PM Filters

Semtech_DS

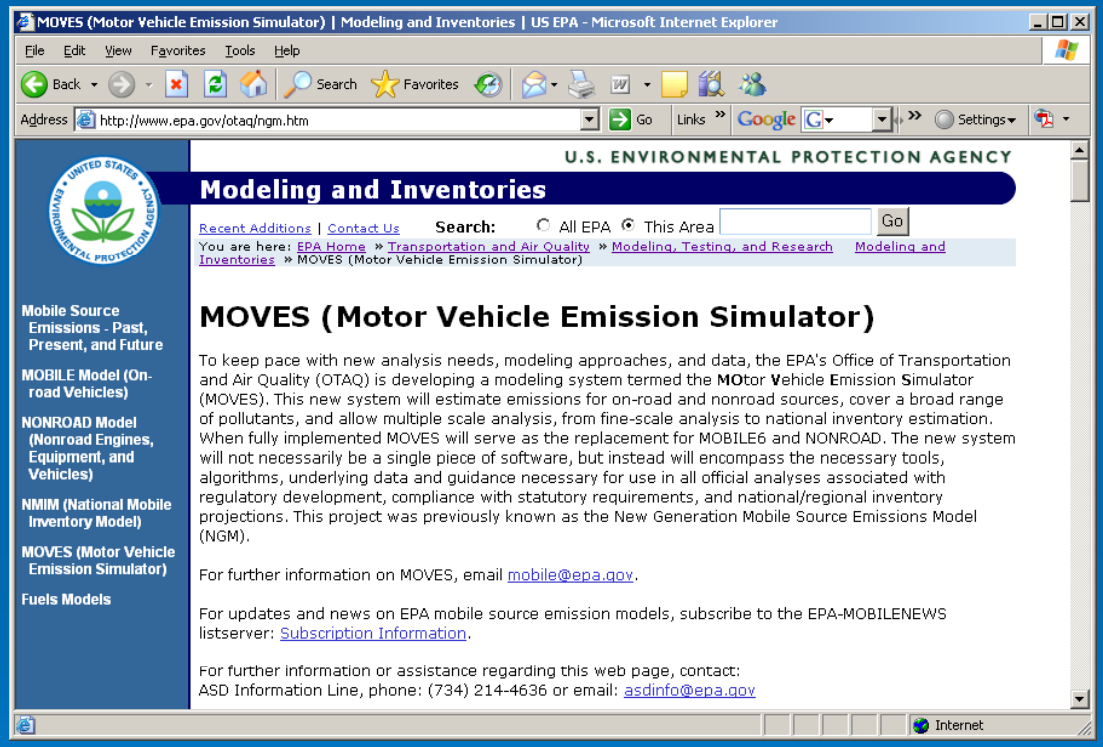
PM Proportional Sampler System

Exhaust System

On-Road NOx Data – Roundtrip from Port of Houston



Visit the MOVES website: http://www.epa.gov/otaq/moves.htm



- Software, technical documentation, conference and meeting presentations, and other helpful background materials