TDOT’s Transition to MOVES

Current Activities and Future Plans

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AECOM

Tennessee Model Users Group Meeting
November 10, 2011
TDOT’s MOTIVATION

Why are we here?
MOTIVATION

- **MOVES will impose new demands on TDOT, TDEC and MPO resources**
  - Input Data
  - Staff
  - Conformity Process

- **Some relaxation to the time pressures**
  - Grace period has been extended (3/2/2013)
  - Announcement of a new ozone standard has been postponed
  - But time pressures remain

- **This is an opportunity to formalize how TDOT can support the transition to MOVES**
  - Technical Resources
  - Financial Resources
TDOT’s Response

- **Strategic Planning for the Transition to MOVES**
  - Retained AECOM
  - Inventory of Current Status and Practices
  - Recommendations for Actions
  - Schedule for the Transition

- **TDOT’s Commitment**
  - Support the Cost of Model Updates
  - Provide Centralized Support Services
THE STRATEGIC PLAN
OBJECTIVES OF THE STRATEGIC PLAN

- Help TDOT, TDEC, MPOs, TPOs to prepare for and incorporate MOVES into their technical procedures

- Address:
  - Affected parties
  - Data requirements
  - Travel modeling practices
  - Processing methods
  - Hardware and software resources
  - Staff training

- Outline needed technical development and support
ELEMENTS OF THE STRATEGIC PLAN

- **Interviews**
  - MPOs and TPOs, TDEC, TDOT
  - Current / anticipated practices and capabilities
  - Model status and approaches
  - MOVES-specific activities, resources, needs

- **Assessment**
  - What is needed?

- **Recommendations**
  - Travel demand and post processor modeling approach
  - Data Acquisition
  - Process Management
  - Schedule
## CONFORMITY BUDGET TEST STATUS

<table>
<thead>
<tr>
<th>City</th>
<th>NOX Status With MOVES</th>
<th>PM-2.5 Status With MOVES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol</td>
<td>N? ?</td>
<td>N</td>
</tr>
<tr>
<td>Chattanooga</td>
<td>N? ?</td>
<td>R +</td>
</tr>
<tr>
<td>Clarksville</td>
<td>R ?</td>
<td>N</td>
</tr>
<tr>
<td>Johnson City</td>
<td>N? ?</td>
<td>N</td>
</tr>
<tr>
<td>Kingsport</td>
<td>N? ?</td>
<td>N</td>
</tr>
<tr>
<td>Knoxville</td>
<td>R +</td>
<td>R X</td>
</tr>
<tr>
<td>Memphis</td>
<td>R +</td>
<td>N</td>
</tr>
<tr>
<td>Nashville</td>
<td>N? ?</td>
<td>N</td>
</tr>
</tbody>
</table>

- **R** Test required
- **N** Test not required
- **N?** Test not required but may be (new standards)
- **?** Not known
- **+** Not known, margins available
- **X** No margin available
TRAVEL MODELS: GENERAL OBSERVATIONS

- **Fidelity and complexity varies from area to area**
  - Knoxville, Nashville, Memphis are more robust

- **Key features to support emissions analysis**
  - Multiple time periods vs. single daily
  - Separate auto / truck estimates
  - Mode choice sub-models (less important for emissions)

- **Emissions post processing**
  - 5 of 8 have a MOBILE6 post-processor
  - Only Chattanooga has begun a MOVES post-processor
GUIDING PRINCIPLES

Objective should be to be as accurate and complete as possible, within available resources

- MOVES provides default data and distributions
- HOWEVER: USEPA recommends use of local data and disaggregated distributions

Disaggregated and locally-based analyses are more sensitive to project effects
MOVES DATA NEEDS

- **Activity Data**
  1. VMT by Vehicle Type
  2. Hour Fractions
  3,4. Day/Month Fractions
  5. Average Speed Distribution by Vehicle Type
  6. Road Type Fractions
  7. Ramp Fractions
  8. Source Type Population

- **Non-Activity Data**
  9. Vehicle Age Distribution
  10. Inspection / Maintenance Programs
  11,12. Fuel Formulation and Fuel Supply
  13. Meteorology
MOVES INPUT DATA #1: VMT by Vehicle Type

- MOVES Inputs should include locally-derived Vehicle Type fractions

- Sources:
  - Travel model auto & truck assigned volumes
  - Vehicle type patterns derived from classification counts
  - Motor fuel sales (from gas tax receipts)
  - MOVES defaults where no data is available
## CURRENT VEHICLE TYPE CAPABILITY OF MODELS

<table>
<thead>
<tr>
<th>City</th>
<th>Model Vehicle Types</th>
<th>Post Processor (MOBILE6) Vehicle Types</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol</td>
<td>Autos, Trucks</td>
<td>Total</td>
</tr>
<tr>
<td>Chattanooga</td>
<td>Autos, 3 Trucks</td>
<td>Total</td>
</tr>
<tr>
<td>Clarksville</td>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td>Johnson City</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Kingsport</td>
<td>Autos, 2 Trucks</td>
<td></td>
</tr>
<tr>
<td>Knoxville</td>
<td>Autos, 2 Trucks</td>
<td>3 -&gt; 16 Types</td>
</tr>
<tr>
<td>Memphis</td>
<td>Autos, 2 Trucks</td>
<td>3- &gt; 16 Types</td>
</tr>
<tr>
<td>Nashville</td>
<td>Autos, 3 Trucks</td>
<td>HPMS 16 Types</td>
</tr>
</tbody>
</table>
## Suggested Vehicle Type Capability

<table>
<thead>
<tr>
<th>Model Vehicle Types</th>
<th>Post Processor (MOBILE6) Vehicle Types</th>
<th>Suggested Enhancement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bristol</strong></td>
<td>Autos, Trucks</td>
<td>Total</td>
</tr>
<tr>
<td><strong>Chattanooga</strong></td>
<td>Autos, 3 Trucks</td>
<td>Total</td>
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<td><strong>Clarksville</strong></td>
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<td>Total</td>
<td></td>
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<td></td>
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<td><strong>Nashville</strong></td>
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<td>HPMS 16 Types</td>
</tr>
</tbody>
</table>
SUGGESTED ACTIONS: VMT by Vehicle Type

- **Models with Vehicle Type Capability**
  - Calibrate / validate as needed
  - Post process to disaggregate model vehicle type VMT (2-4 types) to MOVES vehicle type VMT (13 types)

- **Models without Vehicle Type Capability**
  - Migrate toward adding vehicle-type capability to travel model
  - Post process to disaggregate model vehicle type VMT (2-4 types) to MOVES vehicle type VMT (13 types)

- **Support Data**
  - Vehicle type distributions by TDOT and UT
  - Additional data collection (class counts) to improve sample by county / functional class to underlie pattern files
MOVES inputs should include locally-derived temporal fractions

Sources:
- Travel model time period assigned volumes
- Hourly volume patterns derived from traffic counts
- Preferable to compute fractions on the fly
## TEMPORAL CAPABILITY OF MODELS

<table>
<thead>
<tr>
<th>City</th>
<th>Model Time Periods</th>
<th>Post Processor (MOBILE6) Time periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol</td>
<td>Daily</td>
<td>Daily</td>
</tr>
<tr>
<td>Chattanooga</td>
<td>Daily</td>
<td>Daily</td>
</tr>
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<td>Daily</td>
<td></td>
</tr>
<tr>
<td>Johnson City</td>
<td>Daily</td>
<td></td>
</tr>
<tr>
<td>Kingsport</td>
<td>Daily</td>
<td></td>
</tr>
<tr>
<td>Knoxville</td>
<td>3 periods</td>
<td>3 periods</td>
</tr>
<tr>
<td>Memphis</td>
<td>4 periods</td>
<td>4 periods</td>
</tr>
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<td>3 periods</td>
<td>Daily</td>
</tr>
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</table>
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</tr>
</thead>
<tbody>
<tr>
<td>Bristol</td>
<td>Daily</td>
<td>Daily</td>
<td>Model by time period and post process to hourly</td>
</tr>
<tr>
<td>Chattanooga</td>
<td>Daily</td>
<td>Daily</td>
<td>Model by time period and post process to hourly</td>
</tr>
<tr>
<td>Clarksville</td>
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<td>Model by time period and post process to hourly</td>
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<tr>
<td>Knoxville</td>
<td>3 periods</td>
<td>3 periods</td>
<td>Post process to hourly</td>
</tr>
<tr>
<td>Memphis</td>
<td>4 periods</td>
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<td>Post process to hourly</td>
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<tr>
<td>Nashville</td>
<td>3 periods</td>
<td>Daily</td>
<td>Post process to hourly</td>
</tr>
</tbody>
</table>
SUGGESTED ACTIONS: HOUR FRACTIONS

- **Models with Temporal Capability**
  - Calibrate / validate as needed
  - Post process to disaggregate period VMT to hourly VMT, compute hour fractions

- **Models without Temporal Capability**
  - Migrate toward adding temporal capability to travel model
  - Post process to disaggregate period VMT to hourly VMT, compute hour fractions

- **Support Data**
  - Hourly distributions by TDOT and UT
  - Additional data collection to improve sample by county / functional class (to underlie pattern files)
MOVES Inputs should include locally-derived temporal fractions

- Model Typical Day -> Annual -> MOVES Analysis Day

Sources:
- Patterns derived from TDOT’s daily/seasonal factors and permanent count stations (TDOT, UT)

Suggested Actions:
- TDOT / UT data development is underway
MOVES INPUT DATA #5: AVERAGE SPEED DISTRIBUTIONS

- Speed inputs to MOVES are a key indicator of transportation improvement impacts

- Sources:
  - Travel models
  - Speed surveys (spot vs. space, coverage issues)
  - Travel model / emissions post processors
MOVES INPUT DATA #5: AVERAGE SPEED DISTRIBUTIONS

- Model-calculated speeds are insufficient for MOVES analysis
  - Hourly distribution of speeds typically not available (period at best)
  - Less opportunity for VMT adjustments
    - Daily/seasonal variation
    - HPMS VMT reconciliation
    - Off-model projects
  - Model validation issues
  - Traffic Operations Analysis: Over-saturated conditions not handled well

- Crucial variable in MOVES’ calculation of emissions

- Some form of Post Processing is necessary:
  - Simpler method:
    - Link-level aggregate analysis
  - More robust method (PPSUITE)
    - Link and Intersection based
    - Tools for conformity-specific network analysis
WHY ARE HOURLY SPEEDS IMPORTANT

Single Daily Volume and Average Daily Speed

Hourly Volumes and Speeds

AM (Inbound)

PM (Outbound)
WHY ARE HOURLY SPEEDS IMPORTANT

Single Daily Volume and Average Daily Speed

Hourly Volumes and Speeds

UNDERSTATES PEAK VOLUMES

OVERSTATES PEAK SPEEDS

AM (Inbound)

PM (Outbound)
WHY ARE HOURLY SPEEDS IMPORTANT

Single Daily Volume and Average Daily Speed

Hourly Volumes and Speeds

AM (Inbound)

PM (Outbound)

OVERSTATES PEAK VOLUMES

UNDERSTATES PEAK SPEEDS
SUGGESTED ACTIONS:
AVERAGE SPEED DISTRIBUTIONS

- **Models with Speed Post Processing Capability**
  - Enhance to support MOVES standards
  - Calibrate, validate as needed for hourly analysis
  - Post process to disaggregate period / daily speeds to hourly speeds, aggregate to 16 speed bins

- **Models without Speed Post Processing Capability**
  - Migrate toward adding speed post processing capability to travel model
  - Calibrate, validate as needed for hourly analysis
  - Post process to disaggregate period / daily speeds to hourly speeds, aggregate to 16 speed bins

- **Support Data**
  - Speed surveys, other calibration data
MOVES INPUT DATA #6: ROAD TYPE FRACTIONS

- MOVES Inputs must be categorized according to four road types
  - Urban / Rural
  - Restricted / Unrestricted

- Sources:
  - Analysis of network topology (one-time)
  - Travel model network (one-time or on-the-fly)
MOVES INPUT DATA #6: ROAD TYPE FRACTIONS

- Fraction of VMT on each MOVES Road Type, by Source Type ID
- Mapping Scheme Required
  - Model Facility Type
  - Model Area Type
  - To Road Type
  - ROAD TYPE DISTRIBUTION fractions are computed on the fly, based on % of:
    - Calculated VMT on links
    - By facility and area type
- Grapple with Off-Network VMT

**Model Facility Type (typical)**
.
.
1) Freeway
2) Expressway
3) Principal Arterial Divided
4) Principal Arterial Undivided
5) Arterial Divided
6) Arterial Undivided
7) Minor Arterial
8) Collectors / Local
9) High-Speed Ramp
10) Medium-Speed Ramp
11) Low-Speed Ramp
12) Centroid Connector

**Model Area Type**
.
.
1) CBD
2) Urban
3) Urban Fringe
4) Suburban
5) Exurban

**MOVES Road Type**
.
.
2) Urban Restricted
3) Urban Unrestricted
4) Rural Restricted
5) Rural Unrestricted
SUGGESTED ACTIONS: ROAD TYPE FRACTIONS

- Implement Within Post Processor
  - Functional Class / Facility Type / Road Type mapping scheme
  - Sensitivity to scenarios by on-the-fly calculation

- Support Data
  - HPMS VMT by Functional Class: VMT Reconciliation Process
MOVES INPUT DATA #7: RAMP FRACTIONS

- MOVES Inputs should include locally-derived ramp fractions
  - MOVES default (8%) overstates ramp share of VHT
  - What is a ramp?

- Sources:
  - Off-model: Analysis of network topology (one-time)
  - On-model: Travel model network assigned volumes (one-time or on-the-fly)

- Suggested Actions:
  - Implement post-processor support
  - Calculate at run time for sensitivity to scenarios
MOVES INPUT DATA #8: SOURCE TYPE POPULATION

- **SOURCE TYPE POPULATION** drives off-road emissions:
  - Starts / soaks / evaporatives
  - Can be a dominant portion of total emissions in comparison to running emissions:

- Source Type Population represents the number of vehicles present and emitting during the analysis day

- Currently, the number of registered vehicles (with adjustments) in the domain is taken as a surrogate for Source Type Population
One Typical Method

- Autos: Registration data
- Motorcycles: Registration data
- Buses: Registration data and agency-provided data (Transit bus garages, number of school buses)
- Other 2-axle, 4-tire vehicles: Registration data
- Trucks: External (through) vs. internal travel problematic
  Long haul vs. short haul estimate problematic
  Use local truck VMT with MOVES default
  VMT:Population ratios

Suggested Actions:

- TDOT / UT data development is underway
MOVES INPUT DATA #9: VEHICLE AGE DISTRIBUTION

- MOVES Inputs must be derived from local motor vehicle registration data

- Sources:
  - TN Dept of Revenue tabulation

- Suggested Actions:
  - Dept of Revenue data has been received
  - TDOT / UT data development is underway
MOVES INPUT DATA #10: INSPECTION / MAINTENANCE PROGRAMS

- MOVES Inputs must describe the local program
  - I/M in 7 counties

- Sources:
  - TDEC / Local Air Agency conversion of MOBILE6 specifications

- Suggested Actions:
  - TDEC data development is underway
MOVES Inputs must describe local fuel characteristics

- Fuel Formulation: Attributes of specific fuels
- Fuel Supply: Market share by county

Sources:
- Assembled from sampling data by TDEC

Suggested Actions:
- TDEC data development is underway
MOVES INPUT DATA #13: METEOROLOGY

- MOVES Inputs must describe the local meteorologic conditions

- Sources:
  - Assembled from weather station data by TDEC
  - 2000 – 2009 data prepared, ongoing effort

- Suggested Actions:
  - TDEC data development is underway
### MOVES METHOD: RATES vs. INVENTORY

<table>
<thead>
<tr>
<th></th>
<th>Inventory</th>
<th>Rate Lookup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simplicity of Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advance Runs and Setups Required</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run Execution Times (Conformity)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Run Times (Statewide)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Audit Trail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardware Resources</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Method yet to be determined with input from MPOs/TPOs, TDOT, TDEC

- PPSUITE post processor switch-hits painlessly
- Results can be identical, if internal adjustments are properly applied to account for MOVES “anomalies”

Suggested actions

- Further testing and consultation
- Prototype application
RECOMMENDATIONS
### RECOMMENDATIONS

- **Travel model enhancements to estimate travel by time of day and by vehicle types**

<table>
<thead>
<tr>
<th>MPO/TPO</th>
<th>Travel Model Time-of-Day Capability</th>
<th>Time-of-Day Sub-model Needed?</th>
<th>Vehicle Type (Trucks) Capability</th>
<th>Truck Sub-model Needed?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bristol MPO</td>
<td>24-hour only</td>
<td>Yes</td>
<td>Autos, trucks</td>
<td>Yes</td>
</tr>
<tr>
<td>Chattanooga MPO</td>
<td>24-hour only</td>
<td>Yes</td>
<td>Autos, (3 truck types; but not validated)</td>
<td>Yes</td>
</tr>
<tr>
<td>Clarksville MPO</td>
<td>24-hour only</td>
<td>Yes</td>
<td>Total traffic</td>
<td>Yes</td>
</tr>
<tr>
<td>Johnson City TPO</td>
<td>24-hour only</td>
<td>Yes</td>
<td>“All vehicles” only</td>
<td>Yes</td>
</tr>
<tr>
<td>Kingsport MPO</td>
<td>24-hour only</td>
<td>Yes</td>
<td>Autos, 2 truck types</td>
<td>No</td>
</tr>
<tr>
<td>Knoxville TPO</td>
<td>3 time periods</td>
<td>No</td>
<td>2 truck types</td>
<td>No</td>
</tr>
<tr>
<td>Memphis MPO</td>
<td>4 time periods</td>
<td>No</td>
<td>2 truck types</td>
<td>No</td>
</tr>
<tr>
<td>Nashville MPO</td>
<td>3 time periods; aggregated to daily prior to AQ model input</td>
<td>No</td>
<td>3 truck types, not input to emissions model</td>
<td>No</td>
</tr>
</tbody>
</table>
RECOMMENDATIONS (cont’d)

- **Consistent post-processing platform**
  - Enables enhanced analysis of travel model outputs
  - MOVES-ready
  - Facilitates centralized technical support
  - Consistent with non-modeled counties (TDOT) and TDEC technical activities (e.g. SIP budgets)
  - Prototype PPSUITE application (with a TN region) will be installed
    - Platform for reviewing / testing data
    - Opportunity to evaluate processing methods
RECOMMENDATIONS (cont’d)

Data Acquisition

- Adopt / adapt data being prepared by UT
  - Month, day, hour fractions
  - Source Type Population
  - Vehicle Age distributions

- Adopt / adapt non-activity data being prepared by TDEC
  - Inspection / Maintenance
  - Fuel Formulation and Supply
  - Meteorology

- Additional data collection for county-level vehicle type distributions, speed data for validation and non-modeled counties
Process Management

- Data Review Team:
  - Core Group: Technical review
  - Policy Group: Agency coordination

- TNMUG or similar User Group
  - Forum for discussion and technical coordination
  - Workshops and telephone / web conferencing

- Overall QA/QC process

- Assessment of County Inventory vs. Rate Lookup methods
  - TDOT leadership with TDEC
SCHEDULE
# MOVES IMPLEMENTATION SCHEDULE

<table>
<thead>
<tr>
<th>MOVES GRACE PERIOD ENDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATA Team: Core Policy Groups</td>
</tr>
<tr>
<td>Data Transfer/Update</td>
</tr>
<tr>
<td>TREC</td>
</tr>
<tr>
<td>POST Processor Prototype</td>
</tr>
<tr>
<td>MPO TPO Travel Model Updates</td>
</tr>
<tr>
<td>Time of Day, Truck Submodels</td>
</tr>
<tr>
<td>Standardized Post Processor</td>
</tr>
<tr>
<td>DAQC Processed</td>
</tr>
<tr>
<td>TREC/TPED Evaluation</td>
</tr>
<tr>
<td>Post Processing Tools</td>
</tr>
<tr>
<td>Sensitivity Tests</td>
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<tr>
<td>Inventory vs. Rate</td>
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<tr>
<td>MOVES Budget Comparison Runs</td>
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<tr>
<td>Identify Need for New SIPS</td>
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<tr>
<td>Conduct SIP Revisions as Needed</td>
</tr>
<tr>
<td>Travel Model Runs</td>
</tr>
<tr>
<td>NIP Processing</td>
</tr>
</tbody>
</table>

Updated November 3, 2011
NEXT STEPS
NEXT STEPS

- **Management Webinar (Nov. 21, 2011)**
  - TDOT’s Proposal to Offer:
    - Model Enhancements and Updates
    - Pilot Post Processor
    - Technical Support and Assistance
  - Data development
  - Rate vs. Inventory Method Issues

- **Prototype Installation to Demonstrate / Evaluate:**
  - Data Issues
  - Processing

- **Policy and Core Group Meetings**

- **Travel Model Improvements**