PennDOT's and NJDOT's Experience with MOVES

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Discussion Outline

1. **Context of emissions analysis and MOVES in PA and NJ**

2. **A manager's view of the MOVES process**

3. **Observations on technical issues**

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■ Context of Emissions Analysis and MOVES in PA and NJ

Pennsylvania Context

- **Jurisdictions**
  - 67 Counties
  - 15 MPOs   32 counties
  - 8 RPOs   35 counties

- **PennDOT Central Office provides extensive technical support as needed**
  - RPOs   All technical activities
  - 7 "small" MPOs, no travel model   Most technical activities
  - 6 "small" MPOs, with travel model   Range of technical support
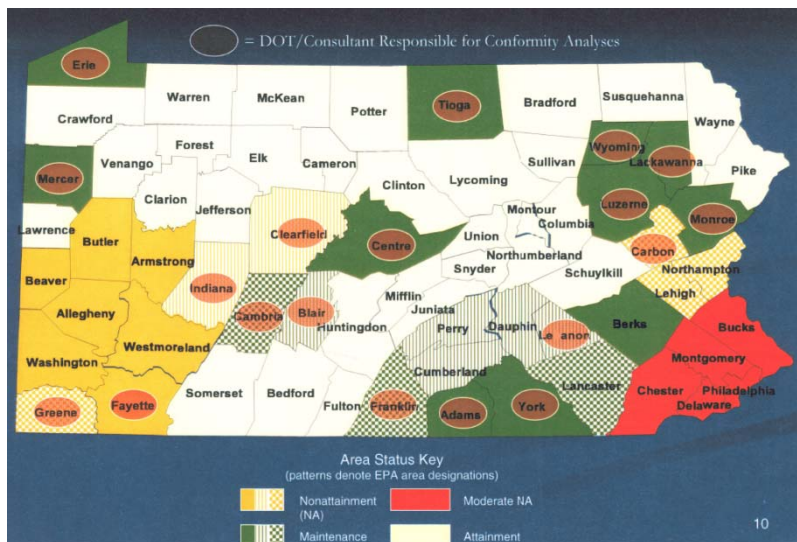 - Philadelphia, Pittsburgh MPOs   Self sufficient

- **Comprehensive consultant support by PennDOT (Baker/AECOM team)**

- **Support for air agency (PaDEP)**
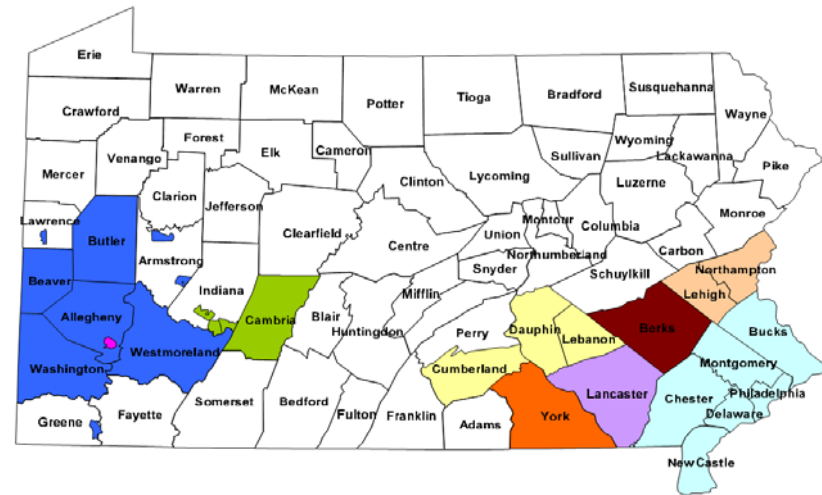
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PA Non-Attainment Status

8-hr Ozone Non-Attainment:
- 18 counties non-attainment
- 19 counties maintenance

PM-2.5 Non-Attainment:
- 20 counties non-attainment
- 8 other jurisdictions non-attainment

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New Jersey Context

- **Jurisdictions**
  - 21 counties
  - 3 MPOs   All 21 counties

- **NJDOT Central Office provides technical coordination and technology development**
  - NJTPA   (North Jersey)   Self sufficient
  - DVRPC   (Philadelphia)   Self sufficient
  - SJTPO   (South Jersey)   More support

- **Consultant support on technical issues and tool development by NJDOT (AECOM, Baker)**
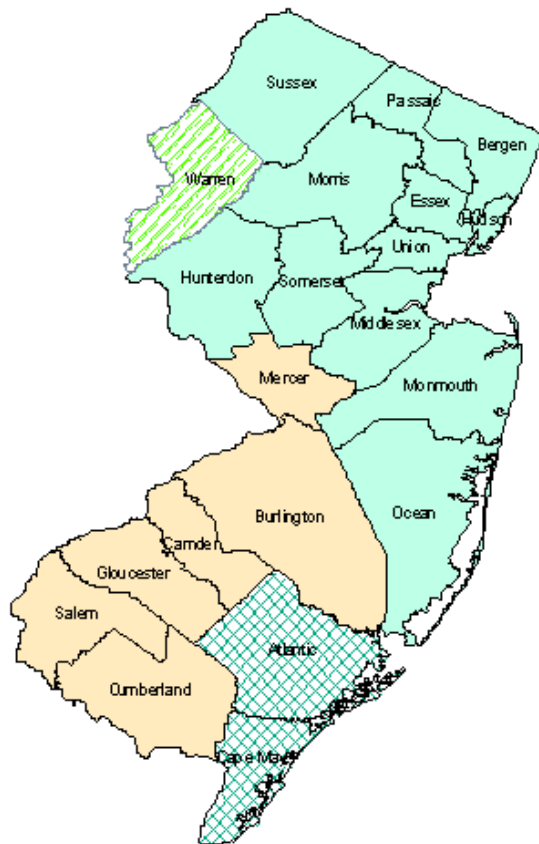
- **Support for air agency (NJDEP)**

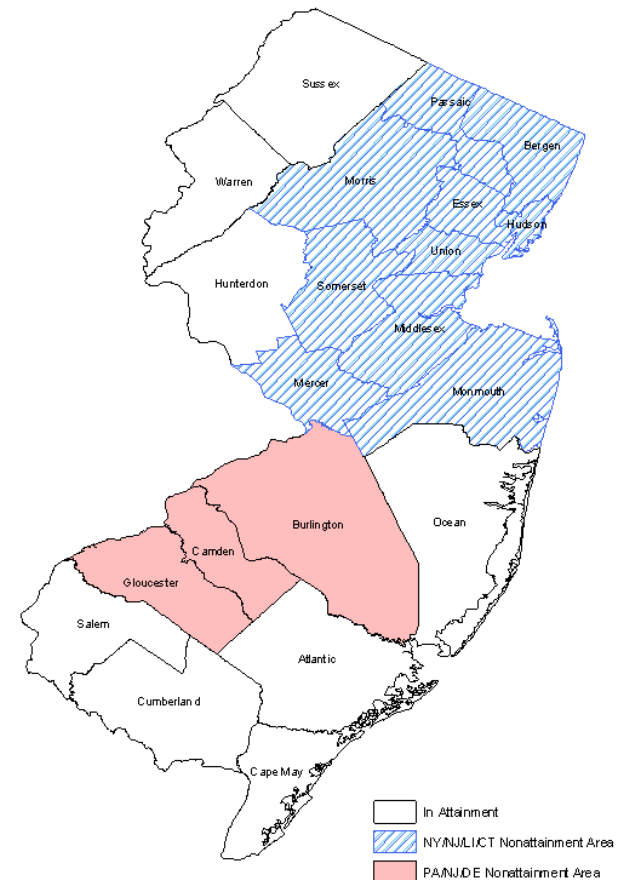- **NJTPA and SJTPO retain AECOM, DVRPC is independent**

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NJ Non-Attainment Status

1-hr Ozone Non-Attainment:
- 21 counties non-attainment and maintenance

PM-2.5 Non-Attainment:
- 13 counties non-attainment

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Technical Support

- **NJ and PA have jointly (with NYMTC) supported development of post-processing and off-model tools**
  - PPSUITE: Travel model post-processor (AECOM)
  - AQONE family: Off-model travel and emissions estimator

- **PPSUITE is the basic tool for emissions analysis for both states, except the DVRPC region (78 of 88 counties)**

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■ A Manager's View of MOVES

"I went to the training and it scared the hell out of me…."

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Schedule Implications: When must it be done?

- **Conformity grace period through March, 2012**
  - Reality: Immediate pressures   (possible SIP revisions)
  - Possible 1-year extension to March, 2013
- **Complicated:**
  - Long data development effort   (Months of preparation)
  - Long run times   (Days of runs)
  - QA/QC crucial
- **Inter-relationships**
  - Ongoing TIP / Plan cycles
  - Existing SIP MVEBs
  - New SIP requirements
  - GHG mitigation goals

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MOVES Production Times

- **Setup, run & output time many times MOBILE**

- **How long is dependent on multiple factors**
    - Hardware setup   Dedicated vs. shared, master / worker
    - File storage   Many times more, depends on context
    - Size of the area   1-2 counties OK; More, difficult
    - Complexity of the area   Limits on aggregation / representation
    - Input file creation   Batch processing
    - Run automation   Batch processing, pre/post processors
    - Output automation
    - QA/QC at every step

- **MOVES is fragile – Allow a buffer**

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MOVES Production Times

- **Consumes more resources over a longer period**
  - Managers, staff, consultants

- **Adds to critical path for key products**
  - Regional conformity
  - Project level conformity (future)
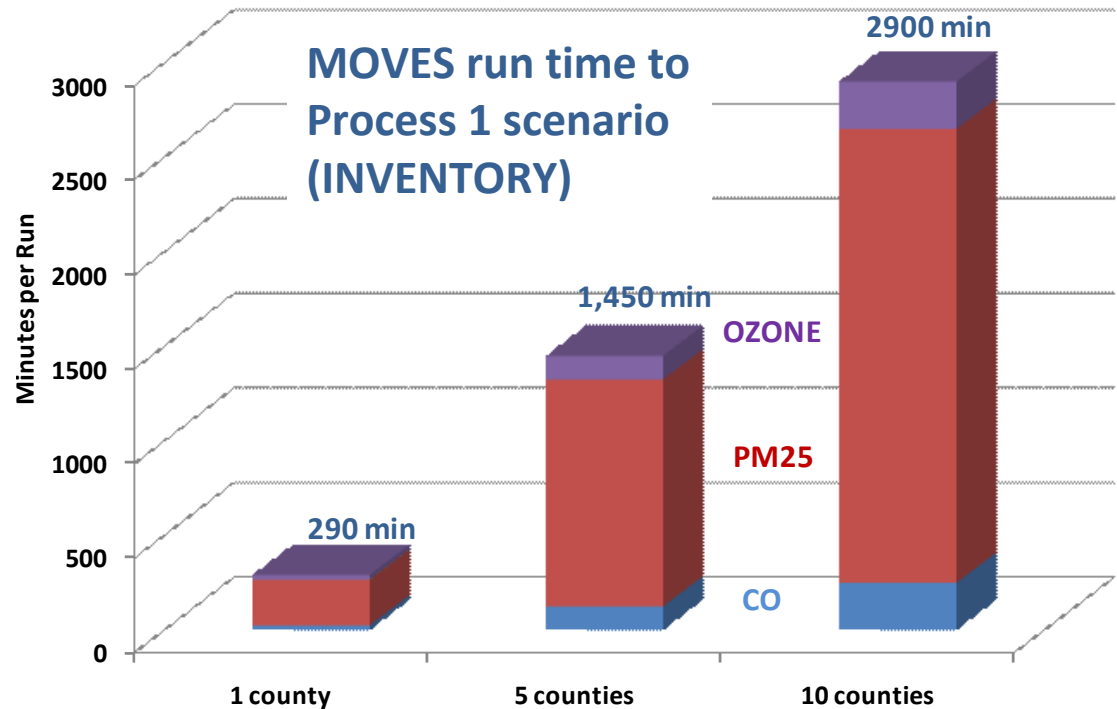 - SIPs on tight deadlines

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How Long Does It Take?

Conformity Example:

6 scenarios	6 scenarios
5 counties	1 county
145 hours	*29 hours*

Plus setup,
Pre-processing,
Post-processing

Assumes high-end processors and one
master/worker setup,
well practiced analyst, supporting software,
batch processing

MOVES run time to Process 1 scenario (INVENTORY)

Chart — Minutes per Run:
- 1 county: 290 min
- 5 counties: 1,450 min
- 10 counties: 2900 min

Legend: OZONE, PM25, CO

Y-axis values: 0, 500, 1000, 1500, 2000, 2500, 3000

Risk Management

- **What happens if something is missed?**
  - What if false positive? False negative?
  - Conformity lapse or sanctions?
  - How will we know this?

- **What can we do to minimize risk?**

- **Risk Management Steps**
  - Staff resources / training
  - Sufficient calendar
  - Good guidance
  - Active QA/QC process

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Keys to Success

■ **Computer networks: Make the commitment**

- Multiple master and worker computers work well
- AECOM: 4 masters, 6 workers
- NJDEP: 3 masters, 4 workers
- MINIMUM: 1 master, 3 workers

■ **Staff preparation**

- Staff training
  - MOVES
  - MYSQL data management
  - Computer network setup and management

- IT staff involvement

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Keys to Success

- **Early start and advance planning are critical**
  - Schedule carefully, realistically.
    - Self, planning partners, sister agencies
  - *Start Early*
  - Allow for EXPECTED and *UNEXPECTED glitches, delays*
  - Allow sufficient time – especially for first products
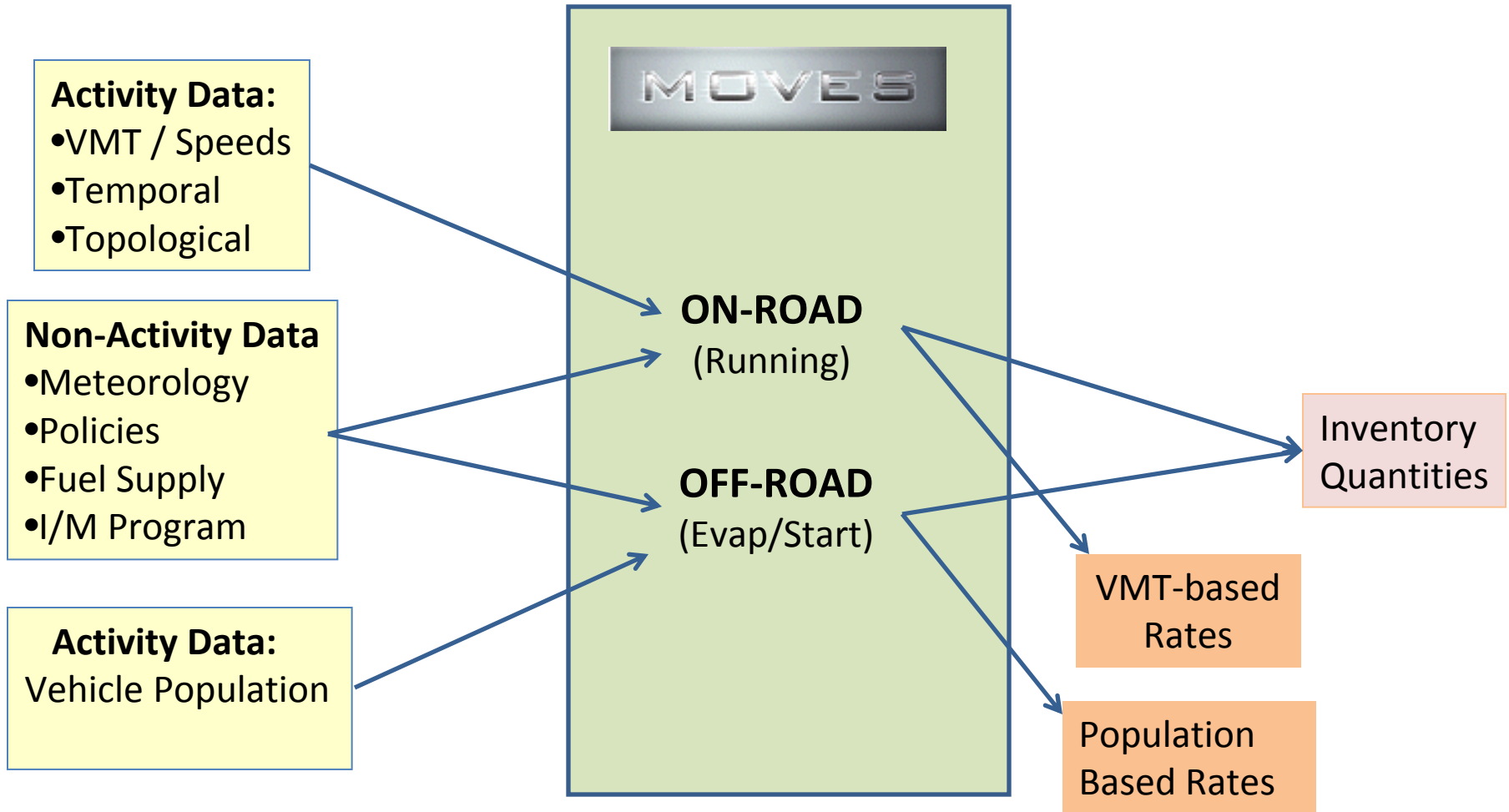 - Practice, practice, practice

- **Robust QA/QC process**
  - Standardized naming conventions and folder management are crucial
    - MOVES requires and generates thousands of files
    - Enforced conventions lead to error-free applications

Observations on Technical Issues

Things that are
VERY DIFFERENT from MOBILE

MOVES Run Components

Activity Data:
- VMT / Speeds
- Temporal
- Topological

Non-Activity Data
- Meteorology
- Policies
- Fuel Supply
- I/M Program

Activity Data:
Vehicle Population

MOVES

ON-ROAD
(Running)

OFF-ROAD
(Evap/Start)

Inventory Quantities

VMT-based Rates

Population Based Rates

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SOURCE TYPE VMT

■ **VMT input as ANNUAL total for the domain (typically county)**
- INVENTORY: Leads to calculated emission quantities
- RATE METHOD: Calculated emissions / VMT = Rate
- Beware: Even for Rate Method, accurate/consistent VMT is needed

■ **MONTH and DAY fractions:**

- Most critical for $PM_{2.5}$ analysis (12-months / annual)

- Source: Permanent count station data (4-year average)
  - Should address 12 months, weekday vs. weekend
  - Separately derived by county, freeways / arterials

- Static: Do not change with scenario / year

- Be careful of consistency:
  - Travel model represents one typical weekday (typically)
  - Factor UP to annual, back DOWN (within MOVES) to the analysis day
  - Establish the Annual total VMT once from travel model run, then (for various months/days) apply factors
  - Be sure to always use the same factors for UP and DOWN, and that input/output VMTs match

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:
    - Currently 30%+-   Future reaching 50%+-

- **Source Type Population represents the <u>number of vehicles that are present and emitting</u> sometime during the analysis day**
  - "Registered vehicles" is a surrogate
  - Advanced travel modeling methods could estimate this quantity
  - NOT travel model trip ends:
    Allocation to productions vs. attractions needed

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Current Options for SOURCE TYPE POPULATION

1. **Direct Use of Registration Data**
    - ❑ Convert M6.2 weight categories to MOVES types using EPA Guidance
    - ❑ Apply growth rates to get future years
    - ❑ May over-estimate evap/start emissions in urban areas; heavy vehicle issues

2. **Adjusted Registration Data**
    - ❑ Account for expected local vehicle starts per day (Surveys?)
    - ❑ Starts per Day assumptions not easily altered in MOVES

3. **Calculate from VMT**
    - ❑ Similar to MOBILE6.2 approach
    - ❑ VMT x 1 / (MOVES Default Miles/Veh) = # Vehicles
    - ❑ May not equate directly to # of starts; Thru traffic issues

4. **Combination (1 + 3)**
    - ❑ Recommend initial conservative approach
    - ❑ Light-Duty Vehicles – Use Registration Data
    - ❑ Heavy Vehicles – Base off VMT
    - ❑ (Very conservative approach)

2008 PA Statewide Emissions
Method 1 vs. Method 3

Vehicle Group	% Difference
Light-Duty	+ 13%
Heavy-Duty	- 37%
Total	+ 11%

MOVES Calculation Methods

- **INVENTORY Method**
  - MOVES produces emission quantities

- **EMISSION RATES Method**
  - MOVES produces a rate lookup table which user applies to VMT

MOVES Calculation Methods

- **Benefits of Inventory vs. Emission Rate Analysis**
  - PPSUITE provides transparent switch-hitting between the methods
  - Benefits are dependent on context:
    - Small jurisdictions (<5 counties)   INVENTORY simpler and faster
    - Large jurisdictions, with staff skills   INVENTORY simpler and equivalent time
    - Large jurisdictions, constrained resources RATES can be simpler, prepared in advance
  - NJ will use Inventory for both SIPs and Conformity
    - Computer clusters, consultant team and NJDEP staff resources in place, run time not an issue
  - PA will use Emission Rates for SIPs due to number of counties
    - Ability to pre-calculate emission rate tables is important
    - Smaller MPO staffs will have less direct involvement with MOVES

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Emission Differences: Inventory vs. Rate Methods

2018 Summer Weekday Test Runs

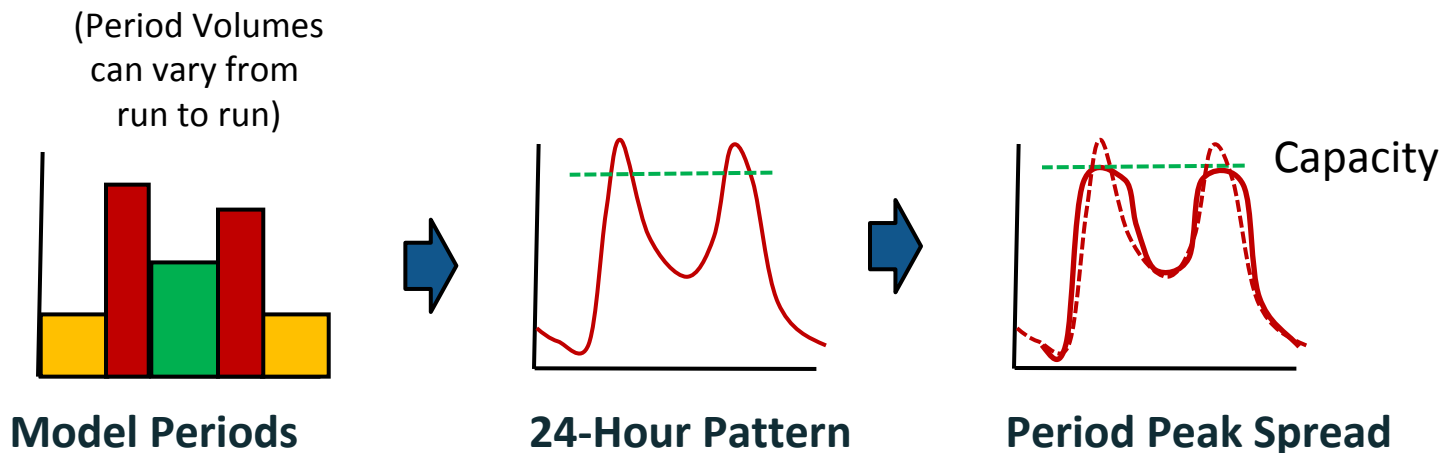| County	% Difference*		
	VOC	*NOX*	*PM2.5*
Allegheny	0 %	+ 3 %	- 2 %
Blair	0 %	0 %	- 2 %
Centre	- 1 %	+ 1 %	- 3 %
Lancaster	0 %	+ 4 %	+ 1 %
Lehigh	0 %	+ 4 %	+ 1 %
Mercer	0 %	0 %	- 2 %
Montgomery	0 %	+ 4 %	0 %
Northampton	0 %	+ 3 %	+ 1 %
York	0 %	+ 3 %	0 %
Difference Range	**0-1%**	**0-4%**	**0-3%**

*   - % = Inventory is Lower than Rate Method
+ % = Inventory is Higher than Rate Method

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Things that are similar to MOBILE

SOURCE TYPE VMT

■ HOUR fractions

- Source: Travel model, post processor, pattern data

- Dynamic: SHOULD change with model scenario / year

- Post-processing of model outputs needed to transform volumes from 4 periods (typical) to hour volumes and fractions of daily VMT

(Period Volumes can vary from run to run)

Model Periods   **24-Hour Pattern**   Capacity   **Period Peak Spread**

SOURCE TYPE VMT (cont'd)

■ Vehicle Type distribution

- Dynamic: Should change with model scenario / year

- Source: Travel model auto/truck/bus volumes
             Vehicle type pattern data

Model	HPMS Class	NJDOT Traffic Counts	
Auto		1 Motorcycle	Class ID 1
Auto		2 Passenger Car	Class ID 2
Comml		3 Other 2 axle-4 tire vehicle	Class ID 3
Bus		4 Bus	
		Class ID 4	
Truck + 6 + 7		5 Single Unit Truck	Class ID 5
Truck + 9 + 10 + 11 + 12 + 13		6 Combination Truck	Class ID 8

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AVERAGE SPEED DISTRIBUTION

- **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

- **Crucial variable in MOVES' calculation of emissions**
  - Speed bin distribution (AVERAGE SPEED DISTRIBUTION file) is allocated **according to VHT, not VMT**

- **Some form of Post Processing is necessary:**
  - Simpler method:
    - Link-level aggregate analysis
  - More robust method (PPSUITE)
    - Link and Intersection based
    - Toll plaza (ETC) analysis
    - Incident delays

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ROAD TYPE DISTRIBUTION

- **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 type
    - By area types

Model Facility Type
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	

Activity Data: RAMP FRACTION

■ **Fraction of VHT driving on ramps vs. limited access roadways ("Restricted")**

■ **Two values only for entire domain:**

- Rural Restricted Access
- Urban Restricted Access

■ **Calculated on the fly from model network facility types and travel times on ramp**

- Post processing typically required
- Most current models include ramp detail in network coding
- Could reasonably be calculated once, given the level of abstraction
- Scenario-specific calculation provides sensitivity to TIP ramp improvement projects

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VEHICLE AGE DISTRIBUTION

- **Age distributions are tabulated separately for each county**
  - Developed by county due to economic differences
  - Based on NJMVC registration data, prepared by NJDEP
- **Distributions are prepared for one current (base) year and applied to future years without modification**

OTHER DATA

- **Inspection / Maintenance Programs**
  - Single statewide program and file (NJ).
  - I/M is unique to each model year, so I/M files were prepared for each analysis year with model year sliding

- **Fuel Supply and Programs**
  - Complex: 5 fuel mixes in each county due to the variety of suppliers and seasonal variants
  - Changes in future years reflecting policies

- **Meteorology**
  - Average temperature and average humidity for each hour, by month and across 10 years
  - For NJ, data was obtained for 6 airports and 10 years from WeatherBank, Inc.

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Speed & VMT Post Processing

## PPSUITE Post Processing Software
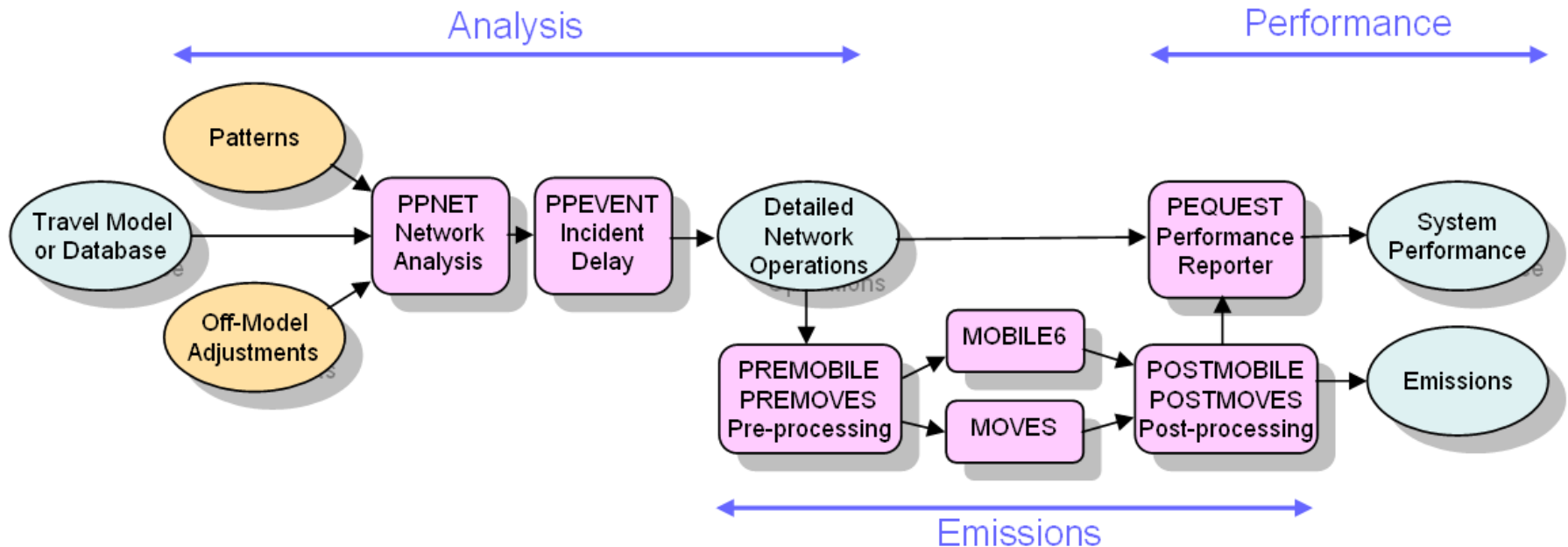
Batch Processor Support

- **Large number of runs suggests need for batch control and scripting**
  - NJTPA = 845 runs per conformity determination (13 counties)
  - Error-free run setups are critical
    (MOVES input files including run specifications)
  - Replicable results

- **CENTRAL process control software**
  - Batch process controller and scripting tool
  - Fully integrated with PPSUITE and MOVES
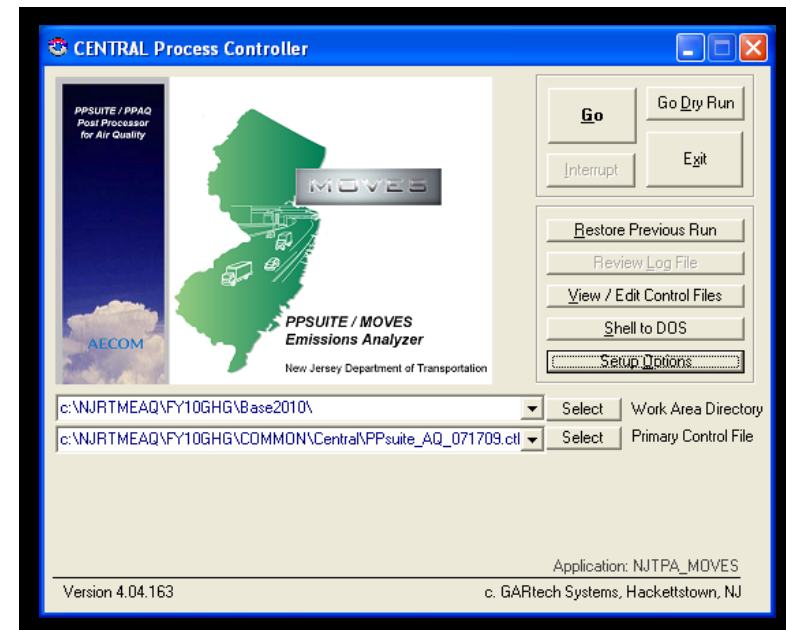
SUMMARY

- **Current version of MOVES (MOVES2010a) is performing well**

- **Run times are significantly decreased from earlier versions and appear manageable**

- **Be careful while choosing and preparing input data**
  - Opportunity to "start over" with data
  - Setting up travel model outputs and links
  - Other Activity and Non-Activity sources

- **Be organized and prepare well in advance**
  - Data preparation
  - Data management
  - Staff training
  - Computer cluster
  - Software setups and support tools

- **Contemplate some form of batch processing**

- **Allow ample time for the first Conformity Analysis runs**
  - Conformity "dry run" several months before actual conformity runs

- **Prepare staff training and quality control**

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