



A Framework for the development of an International version of the MOVES model

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Introduction

- EPA intends to modify MOVES for the purpose of estimating vehicle emissions in other countries
- Initial research into MOVES International development documented in a white paper by Koupal et al.
 - <http://www.epa.gov/oms/models/moves/MOVES2010a/paper137-tap2010.pdf>



MOVES International Approach

- Overall goal is to create a generalized process for modifying MOVES for Int'l application.
- Initial project will create a *framework* for MOVES expansion
 - Identify preliminary steps
 - Begin applying steps to Java codebase and MySQL structure
 - Initially, intended to be used in limited analysis conditions for light duty vehicles
 - Identify potential future improvements



Recommend a “Tiered” approach to customization

- EPA’s Tiered Approach – required because full customization of the model would require intensive data collection and analysis
 - Tier 1: Use MOVES County Data Manager for input of local data
 - Activity, fleet, fuel data and other parameters
 - Would still use US-centric emission rates and drive cycles
 - Tier 2: Implementation of Int’l Emissions Standards
 - Develop alternate emission rate tables
 - Take into account fleet penetration and implementation dates
 - Would still use US-centric drive cycles, vehicle classes, road types, etc.
 - Tier 3: Complete Java / MySQL code transformation
 - Allow for customized vehicle classes, road types, drive cycles
 - Requires most effort in both development and data analysis

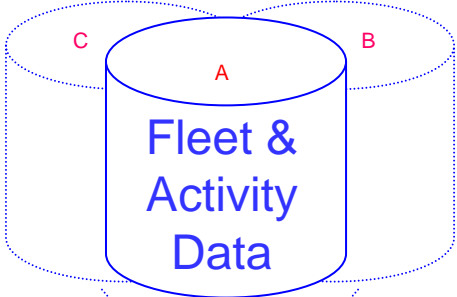
U.S. IMPLEMENTATION

National Scale
U.S. Defaults



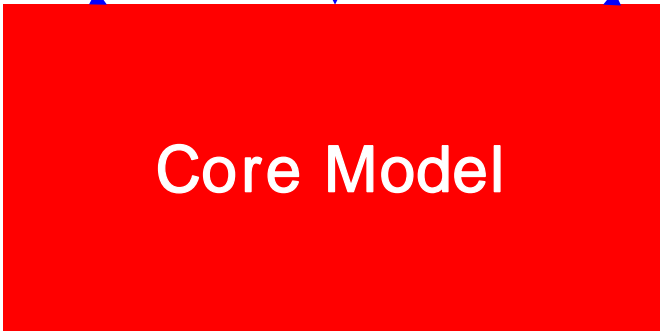
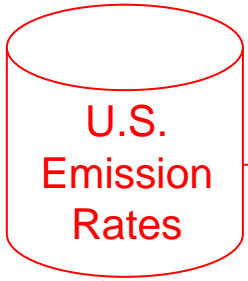
or

County Scale
User-Supplied
by County

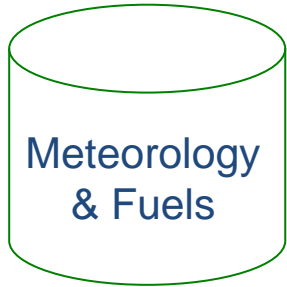


or

Project Scale
User-Supplied For
Specific Project

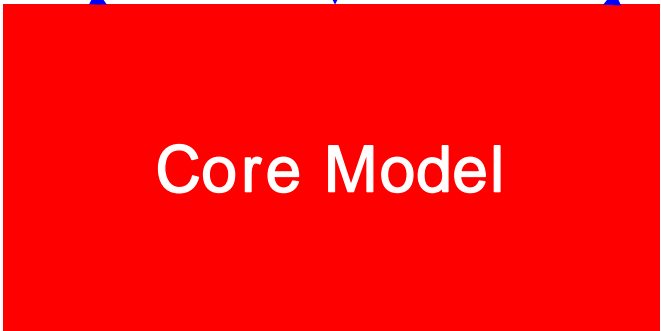
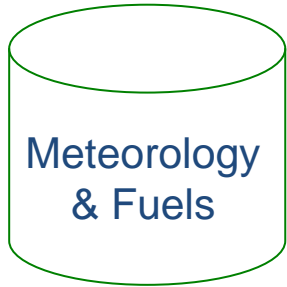
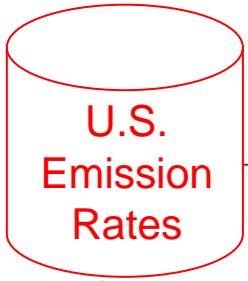
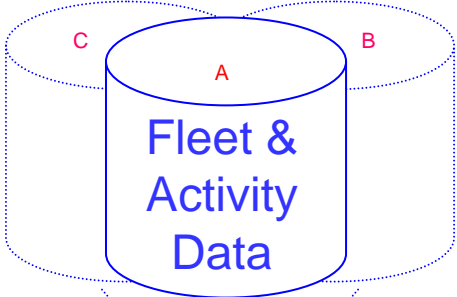


U.S. County Level



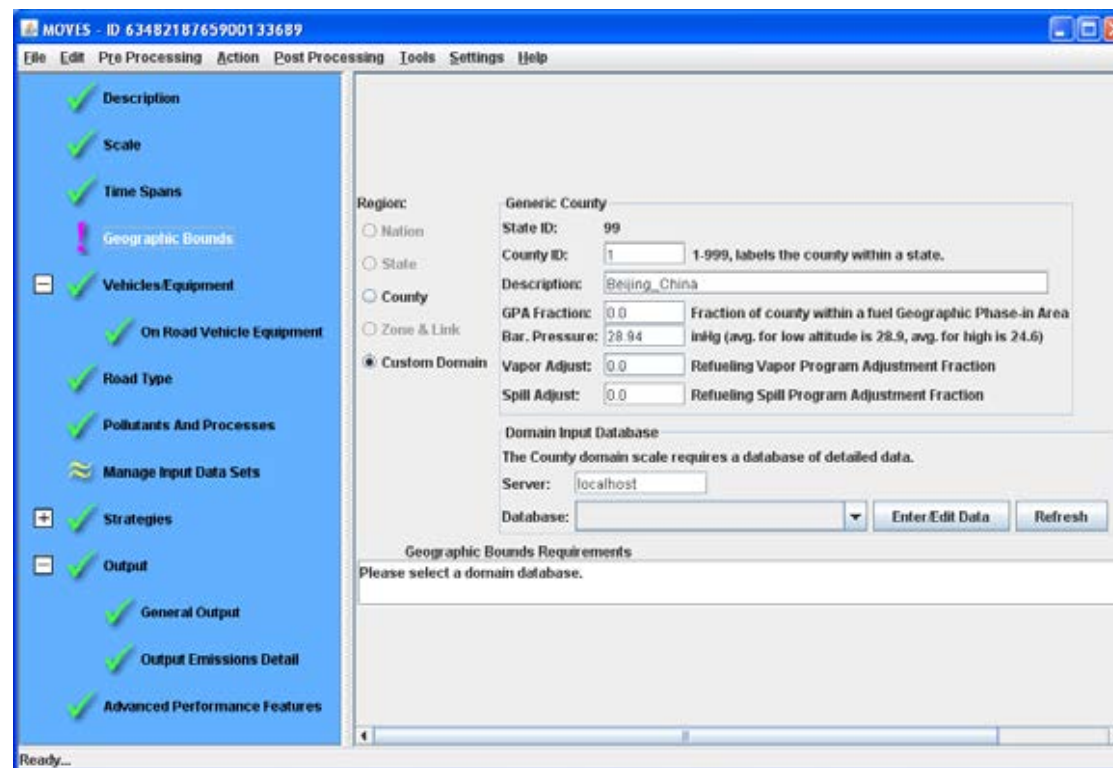
Default or
User-Supplied

OUTPUT



MOVES designed to be adapted for international use

- “Custom domain” option allows international users to define and customize their region



The screenshot displays the MOVES software interface, titled "MOVES - ID 6348218765900133689". The interface includes a menu bar (File, Edit, Pre Processing, Action, Post Processing, Tools, Settings, Help) and a left-hand navigation pane with various options, many of which are checked with green checkmarks. The "Custom Domain" option is selected in the "Region" section. The main configuration area shows the following settings:

- Region:** Custom Domain (selected)
- Generic County:**
 - State ID: 99
 - County ID: 1 (Note: 1-999, labels the county within a state.)
 - Description: Beijing_China
 - GPA Fraction: 0.0 (Note: Fraction of county within a fuel Geographic Phase-in Area)
 - Bar. Pressure: 28.94 inHg (avg. for low altitude is 28.9, avg. for high is 24.6)
 - Vapor Adjust: 0.0 (Note: Refueling Vapor Program Adjustment Fraction)
 - Spill Adjust: 0.0 (Note: Refueling Spill Program Adjustment Fraction)
- Domain Input Database:**
 - The County domain scale requires a database of detailed data.
 - Server: localhost
 - Database: [Dropdown menu]
 - Buttons: Enter/Edit Data, Refresh
- Geographic Bounds Requirements:** Please select a domain database.

MOVES **County Data Manager** can be used to easily set up custom database of “1st Tier” data

- Accepts inputs for custom fleet, fuel and activity in MS Excel format, converts to MySQL data used by the model

MOVES County Data Manager

Vehicle Type VMT Zone Road Activity IM/Reflash Programs Tools

Meteorology Data Road Type Distribution Source Type Population

RunSpec Summary Database Age Distribution Average Speed Distribution Fuel Supply Fuel Formulation

Select or create a database to hold the imported data.

Server: localhost

Database: Beijing_Inputs Create Database Refresh

Log: Clear All Imported Data

Database Done

ERG



Initial MOVES Coding Changes

- Allow for use of the MOVES Custom Domain option in input of localized data
- Code updates proposed:
 - Allow for the fleet to be certified to any US or Euro standard
 - Fuel Effects Generator (Java) must be generalized
 - Sulfur Model (SQL) must be generalized
 - Importer will account for metric and English units
 - InputDataManager to be restricted during import of int'l data
- MySQL Table Updates: *numerous*, see below

Initial MOVES Coding Changes

Partial List of MySQL Tables Requiring Update

Table	Model Year	Model Year Group	Source Bin	Age	Rates	Ratios or Coeffs
atBaseEmissions						X
atRatioGas2						X
atRatioNonGas		X				
crankcaseEmissionRatio		X				X
cumTVVCoeffs		X				X
		X			X	
emissionRate			X		X	
emissionRateByAge			X	X	X	
fuelModelWtFactor		X				
fuelModelYearGroup		X				



Emission Rate Converter

- ERG will develop a software tool to create a suite of emission rate tables for input to MOVES
- Tool will allow user to enter standards and phase-ins by vehicle class and model year
- If no new data are available, tool will map existing MOVES rates to desired standards



Emission Standard Ratios: Euro to U.S. Tier 1

- ERG will use data available from Europe and/or Hong Kong to develop FTP, US06 and LA92 emissions estimates for Euro-cert vehicles
- For this data, instantaneous VSP will be calculated on a sec-by-sec basis

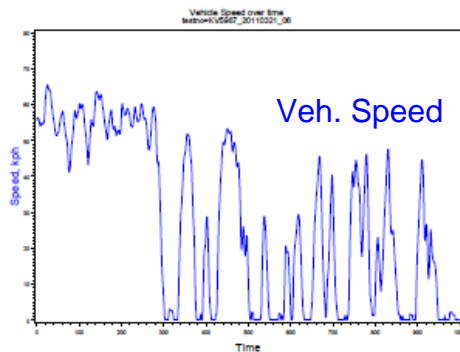
$$VSP_{v,t} = \frac{Av_t + Bv_t^2 + Cv_t^3 + mv_t a_t + mgv_{vertical}}{m}$$

- HC, CO, and NOx emissions will be binned by VSP and vehicles speed, and average emissions calculated. See example below.

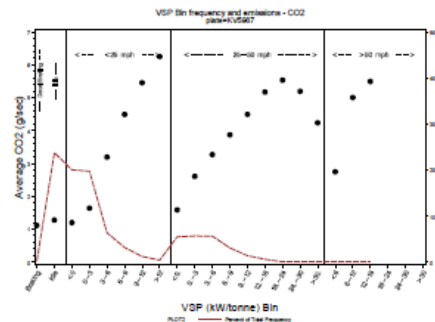
Analysis of Emissions Data by VSP

Method for Estimating FTP-Equivalent Emissions

Calculate VSP from vehicle speed, acceleration, mass, and road grade for each



Classify data observations into 32 bins depending on VSP and vehicle speed



Find average emission level in each VSP bin

Find distribution of time spent in each VSP bin for a similar weight vehicle over the FTP cycle

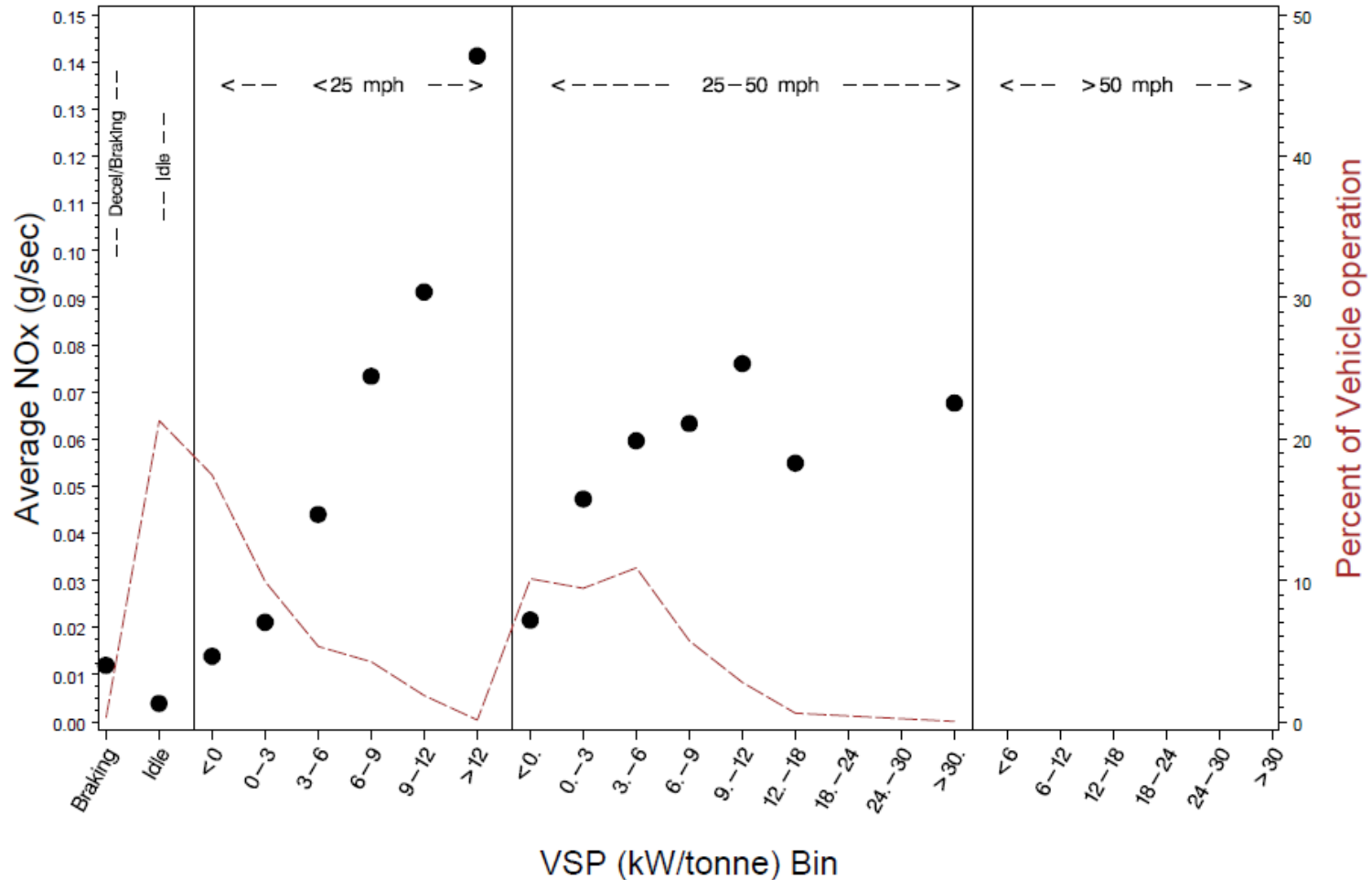
Multiply calculated average emissions by the FTP's VSP bin time distribution and sum for all bins

FTP-Equivalent Emission Level



Example Emissions and Operation by VSP

VSP Bin frequency and emissions - NOx
plate=KV5987





Conversion to FTP-Estimated Emissions

- We then have average emissions binned by VSP from the test vehicle (Em_i), and the distribution of operation time in each VSP bin over the FTP cycle ($T_{FTP,i}$)

$$\sum Emissions = \sum_i^{32 \text{ VSP Bins} \rightarrow \#Bins} Em_i \times T_i$$

Total Emissions equal the sum of the average emissions of each bin multiplied by the time operating in each bin

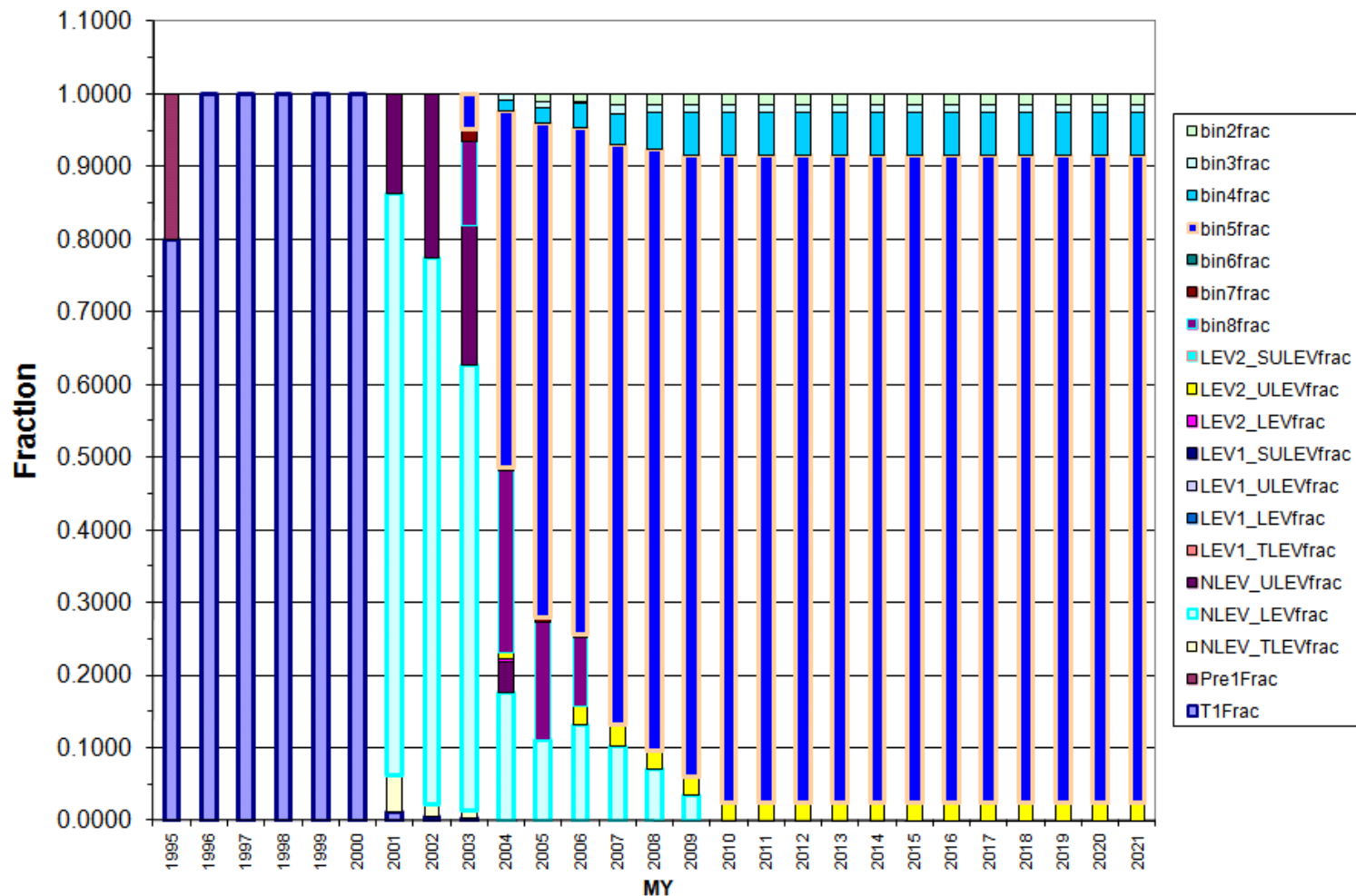
$$\sum Emissions_{FTP} = \sum_i^{32 \text{ VSP Bins} \rightarrow \#Bins} Em_i \times T_{FTP,i}$$

FTP Emissions equal the sum of each bin's average emissions multiplied by each bin's operating time in the FTP cycle

- Using this re-weighting method, equivalent FTP cycle emissions can be estimated
 - Not all test vehicles were operated over all VSP bins encountered in the FTP. For these vehicles we can extrapolate the trends seen in the lower VSP and speed bins



Develop Model Year Matrices by International Area



Proposed Input Screen for MOVES International

The screenshot shows a software window titled "MOVES International Emission Rate Calculator". The interface is divided into two main sections: "Model Year Selection" and "Technology Fractions".

Model Year Selection: This section contains two columns of input boxes labeled "Begin" and "End". The data entered is as follows:

Begin	End
1981	1985
1986	1990
1991	1996
1997	2002
2002	2008
2008	2013

Technology Fractions: This section contains four columns of input boxes labeled "Euro I", "Euro II", "Euro III", and "Euro IV". The data entered is as follows:

Euro I	Euro II	Euro III	Euro IV
0.9	0.1		
0.8	0.2		
0.3	0.5	0.2	

At the bottom right of the window, there are two buttons: "Calculate" and "Export to XLS".



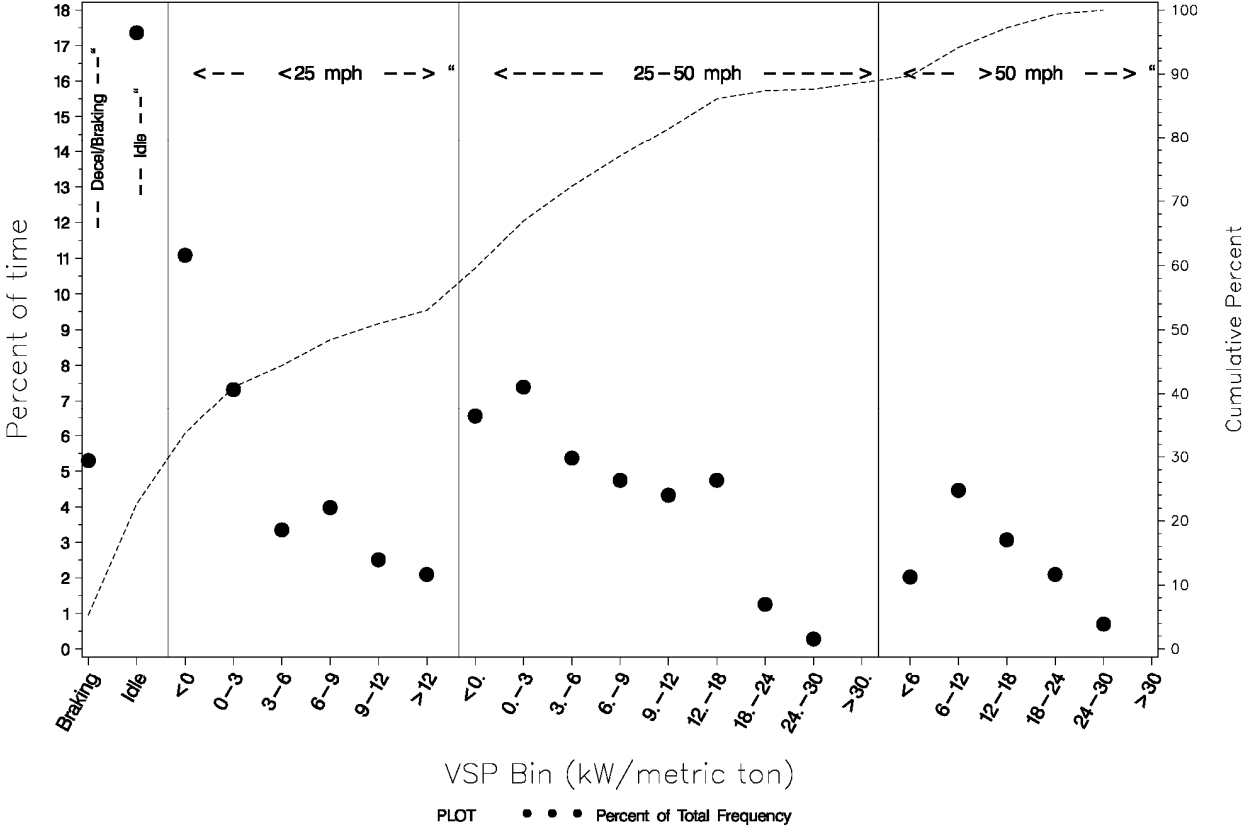
Future MOVES Int'l Updates

- Addition of vehicle classes (taxis, BRTs, etc)
- Additions/updates to road types or drive schedules
- Additional language support
- All updates will require extensive code testing, execution of model test cases, and documentation



Drive Cycle Temporal Distribution

Time Spent by VSP Bin - la92



la92.sas 16FEB11 12:08

ERG Annotation Example -SK

