# MOVES

Indiana Modelers Meeting
January 27, 2011

# MOVES - Motor Vehicle Emissions Simulator

- Official EPA emissions model, released March 2010
- Replaces MOBILE6 (2002), MOBILE first released in 1978.
- EPA granted 2-year grace period before MOVES required for use in conformity and SIPs (March 2012).
- MOVES also to be used for project-level analysis such as CMAQ and PM hot-spot.

# MOVES

- Based on many more emission test results
- Emissions more dependent on engine load
- Provides emission rates or inventory
- 38 pollutants, including air toxics and greenhouse gases
- SQL database structure

# MOVES vs. MOBILE

MOVES results in much higher emissions as compared to MOBILE

Based on OKI data, includes new data for MOVES

- VOC ↑ 6%
- $NO_x$ ↑ 65%
- PM2.5 ↑ 270%

# PM2.5 SIP Revision for Cincinnati Nonattainment Area

- PM2.5 Annual Standard Redesignation
- 2 separate budgets (KY, OH/IN combined)
- Annual PM2.5, SO2, $NO_x$
- Analysis Years = 2005, 2008, 2011, 2015, 2018, 2021.
- 2015 and 2021 to become new budget years
- Option to use MOVES or MOBILE – opted for MOVES to avoid future conformity problem.
- MOVES portion submitted Aug. 2010

MOVES - S:\Data\AQmaster\MOVES_Databases\2015\Input_Excel_Importers\Ohio_2015\ohio_2015_dailyemissions.mrs - ID 3253882863020091410

File Edit Pre Processing Action Post Processing Tools Settings Help

- Description
- Scale
- Time Spans
- Geographic Bounds
- Vehicles/Equipment
  - On Road Vehicle
- Road Type
- Pollutants And Proces
- Manage Input Data Se
- Strategies
  - Alternative Vehic
  - On-Road Retrofi
  - Rate Of Progres
- Output
- Advanced Performanc

**Domain/Scale**

- National — Use the default national database with default state and local allocation factors.

  Caution: Do not use this scale setting for SIP or conformity analyses. The allocation factors and other defaults applied at the state or county level have not been verified against specific state or county data and do not meet regulatory requirements for SIPs and conformity determinations.

- County — Select or define a single county that is the entire domain.

  Note: Use this scale setting for SIP and regional conformity analysis. Use of this scale setting requires user-supplied local data for most activity and fleet inputs.

- Project — Use project domain inputs.

  Note: Use this scale setting for project-level analysis for conformity, NEPA, or any other regulatory purpose. Use of this scale setting requires user-supplied data at the link level for activity and fleet inputs that describe a particular transportation project.

**Calculation Type**

- Inventory — Mass and/or Energy within a region and time span.
- Emission Rates — Mass and/or Energy per unit of activity.

MOVESScenarioID: OhioCustomDomian

Caution: Changing these selections changes the contents of other input panels. These changes may include losing previous data contents.

Open an existing RunSpec

11:59 AM
12/7/2010

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**Time Aggregation Level**

○ Year ○ Month ○ Day ◉ Hour

**Years**

Select Year: 2011 Add

Years:

2011

Remove

**Months**

| | |
|---|---|
| ☐ January | ☑ July |
| ☐ February | ☐ August |
| ☐ March | ☐ September |
| ☑ April | ☐ October |
| ☐ May | ☐ November |
| ☐ June | ☐ December |

Select All Clear All

**Days**

☐ Weekend

☑ Weekdays

Select All Clear All

**Hours**

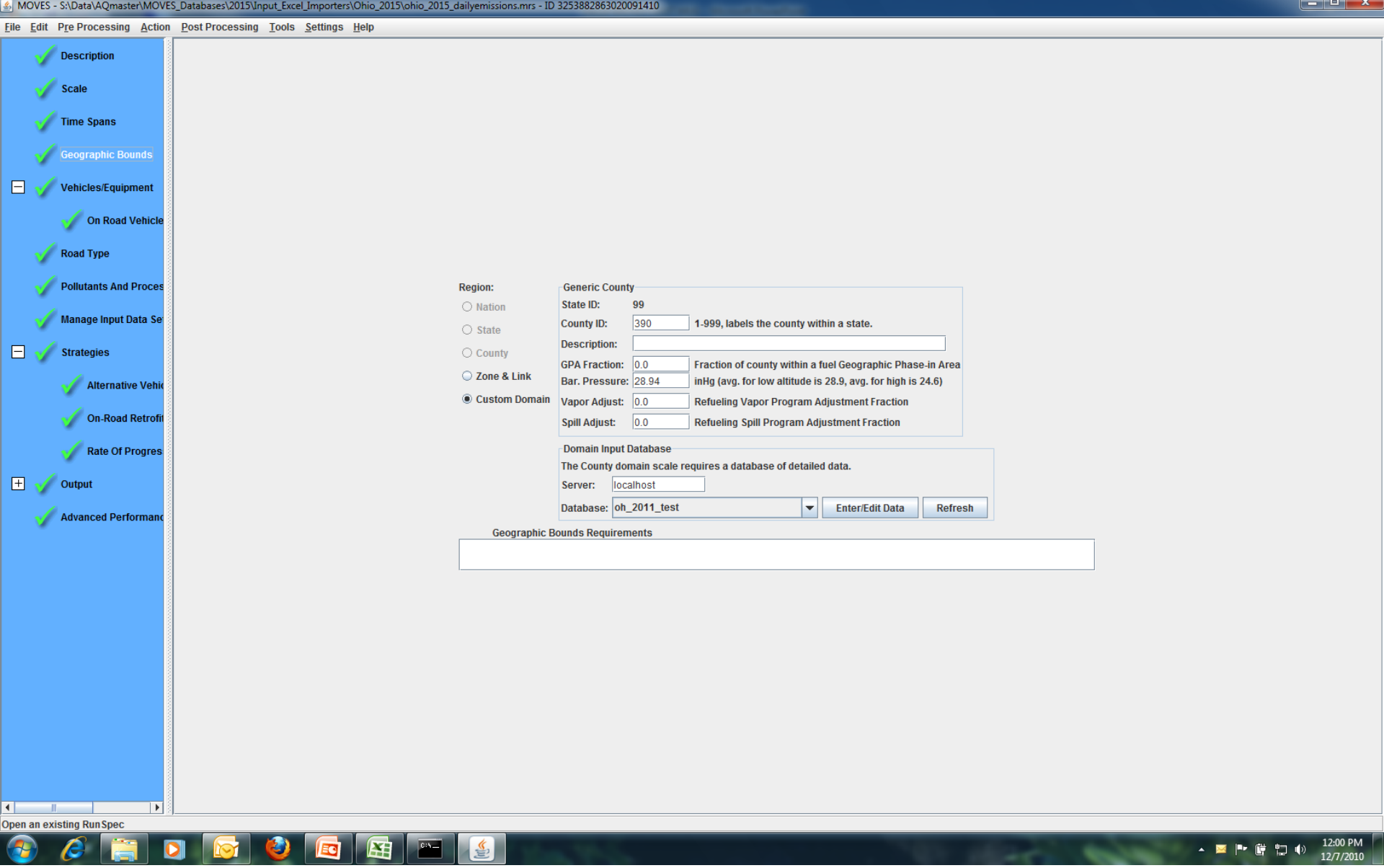
Start Hour: 00:00 - 00:59

End Hour: 23:00 - 23:59

Select All Clear All

Open an existing RunSpec

12:00 PM
12/7/2010


MOVES - S:\Data\AQmaster\MOVES_Databases\2015\Input_Excel_Importers\Ohio_2015\ohio_2015_dailyemissions.mrs - ID 3253882863020091410
File Edit Pre Processing Action Post Processing Tools Settings Help
Description
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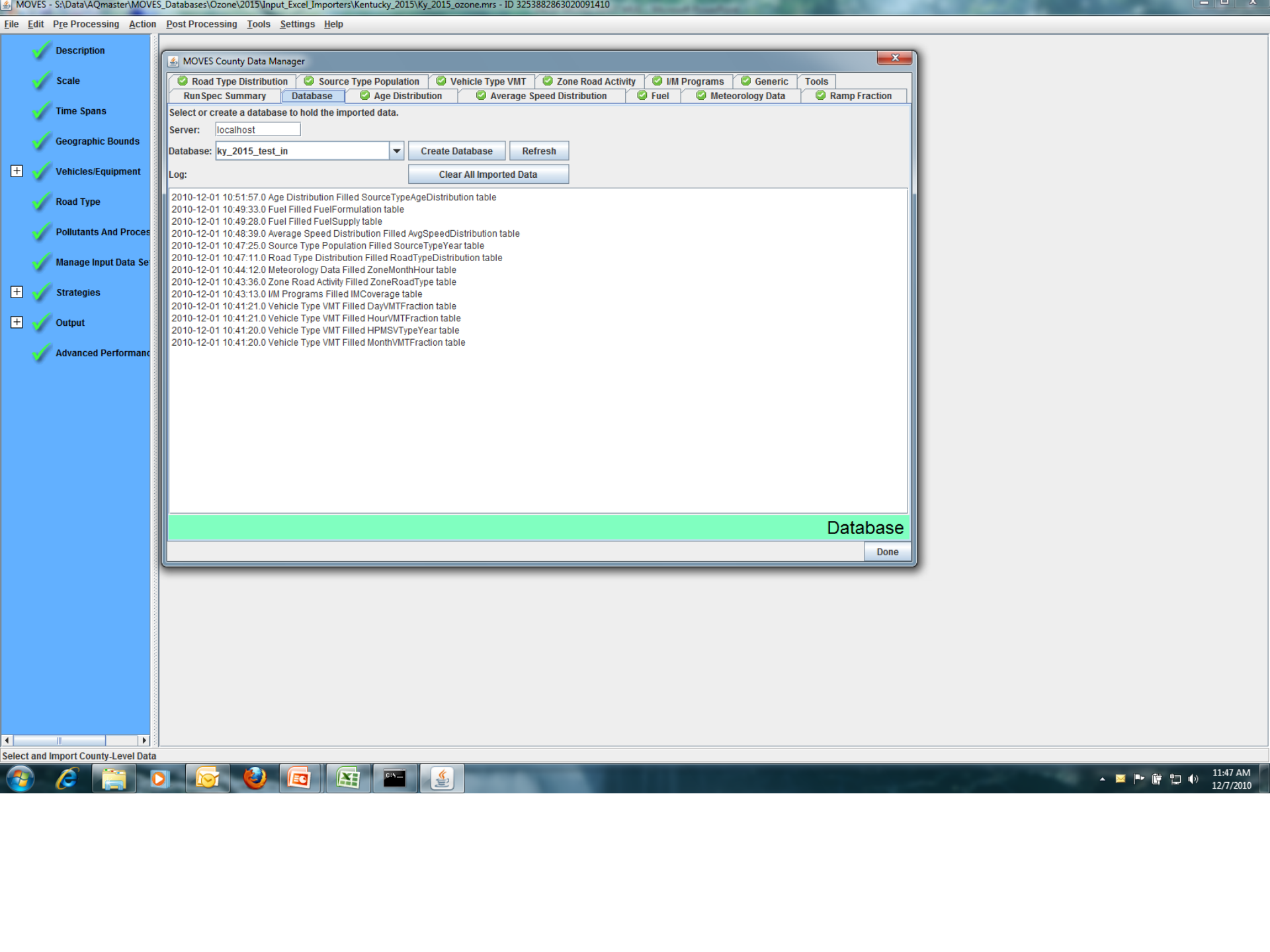
On-Road Retrofi
Rate Of Progres
Output
Advanced Performanc
Region:
Nation
State
County
Zone & Link
Custom Domain
Generic County
State ID: 99
County ID: 390 1-999, labels the county within a state.
Description:
GPA Fraction: 0.0 Fraction of county within a fuel Geographic Phase-in Area
Bar. Pressure: 28.94 inHg (avg. for low altitude is 28.9, avg. for high is 24.6)
Vapor Adjust: 0.0 Refueling Vapor Program Adjustment Fraction
Spill Adjust: 0.0 Refueling Spill Program Adjustment Fraction
Domain Input Database
The County domain scale requires a database of detailed data.
Server: localhost
Database: oh_2011_test
Enter/Edit Data
Refresh
Geographic Bounds Requirements
Open an existing RunSpec
12:00 PM
12/7/2010


MOVES - S:\Data\AQmaster\MOVES_Databases\Ozone\2015\Input_Excel_Importers\Kentucky_2015\Ky_2015_ozone.mrs - ID 3253882863020091410
File Edit Pre Processing Action Post Processing Tools Settings Help
Description
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Advanced Performanc
MOVES County Data Manager
Road Type Distribution
Source Type Population
Vehicle Type VMT
Zone Road Activity
I/M Programs
Generic
Tools
RunSpec Summary
Database
Age Distribution
Average Speed Distribution
Fuel
Meteorology Data
Ramp Fraction
Select or create a database to hold the imported data.
Server: localhost
Database: ky_2015_test_in
Create Database
Refresh
Log:
Clear All Imported Data
2010-12-01 10:51:57.0 Age Distribution Filled SourceTypeAgeDistribution table
2010-12-01 10:49:33.0 Fuel Filled FuelFormulation table
2010-12-01 10:49:28.0 Fuel Filled FuelSupply table
2010-12-01 10:48:39.0 Average Speed Distribution Filled AvgSpeedDistribution table
2010-12-01 10:47:25.0 Source Type Population Filled SourceTypeYear table
2010-12-01 10:47:11.0 Road Type Distribution Filled RoadTypeDistribution table
2010-12-01 10:44:12.0 Meteorology Data Filled ZoneMonthHour table
2010-12-01 10:43:36.0 Zone Road Activity Filled ZoneRoadType table
2010-12-01 10:43:13.0 I/M Programs Filled IMCoverage table
2010-12-01 10:41:21.0 Vehicle Type VMT Filled DayVMTFraction table
2010-12-01 10:41:21.0 Vehicle Type VMT Filled HourVMTFraction table
2010-12-01 10:41:20.0 Vehicle Type VMT Filled HPMSVTypeYear table
2010-12-01 10:41:20.0 Vehicle Type VMT Filled MonthVMTFraction table
Database
Done
Select and Import County-Level Data
11:47 AM
12/7/2010

MOVES - S:\Data\AQmaster\MOVES_Databases\2015\Input_Excel_Importers\Ohio_2015\ohio_2015_dailyemissions.mrs - ID 3253882863020091410

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**Fuels:**

- Compressed Natural Gas (CNG)
- Diesel Fuel
- Electricity
- Gasoline
- Liquefied Petroleum Gas (LPG)
- Placeholder Fuel Type

Select All

**Source Use Types:**

- Combination Long-haul Truck
- Combination Short-haul Truck
- Intercity Bus
- Light Commercial Truck
- Motor Home
- Motorcycle
- Passenger Car
- Passenger Truck
- Refuse Truck
- School Bus
- Single Unit Long-haul Truck
- Single Unit Short-haul Truck
- Transit Bus

Select All

**Selections:**

- Diesel Fuel - Combination Long-haul Truck
- Diesel Fuel - Combination Short-haul Truck
- Diesel Fuel - Intercity Bus
- Diesel Fuel - Light Commercial Truck
- Diesel Fuel - Motor Home
- Diesel Fuel - Refuse Truck
- Diesel Fuel - School Bus
- Diesel Fuel - Single Unit Long-haul Truck
- Diesel Fuel - Single Unit Short-haul Truck
- Diesel Fuel - Transit Bus
- Gasoline - Motorcycle
- Gasoline - Passenger Car
- Gasoline - Passenger Truck

Delete

Add Fuel/Type Combinations

Open an existing RunSpec

12:01 PM
12/7/2010

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Available Road Types:

- Off-Network
- Rural Restricted Access
- Rural Unrestricted Access
- Urban Restricted Access
- Urban Unrestricted Access

Selected Road Types:

- Off-Network
- Rural Restricted Access
- Rural Unrestricted Access
- Urban Restricted Access
- Urban Unrestricted Access

Select All | Add | Delete

Open an existing RunSpec

12:02 PM
12/7/2010

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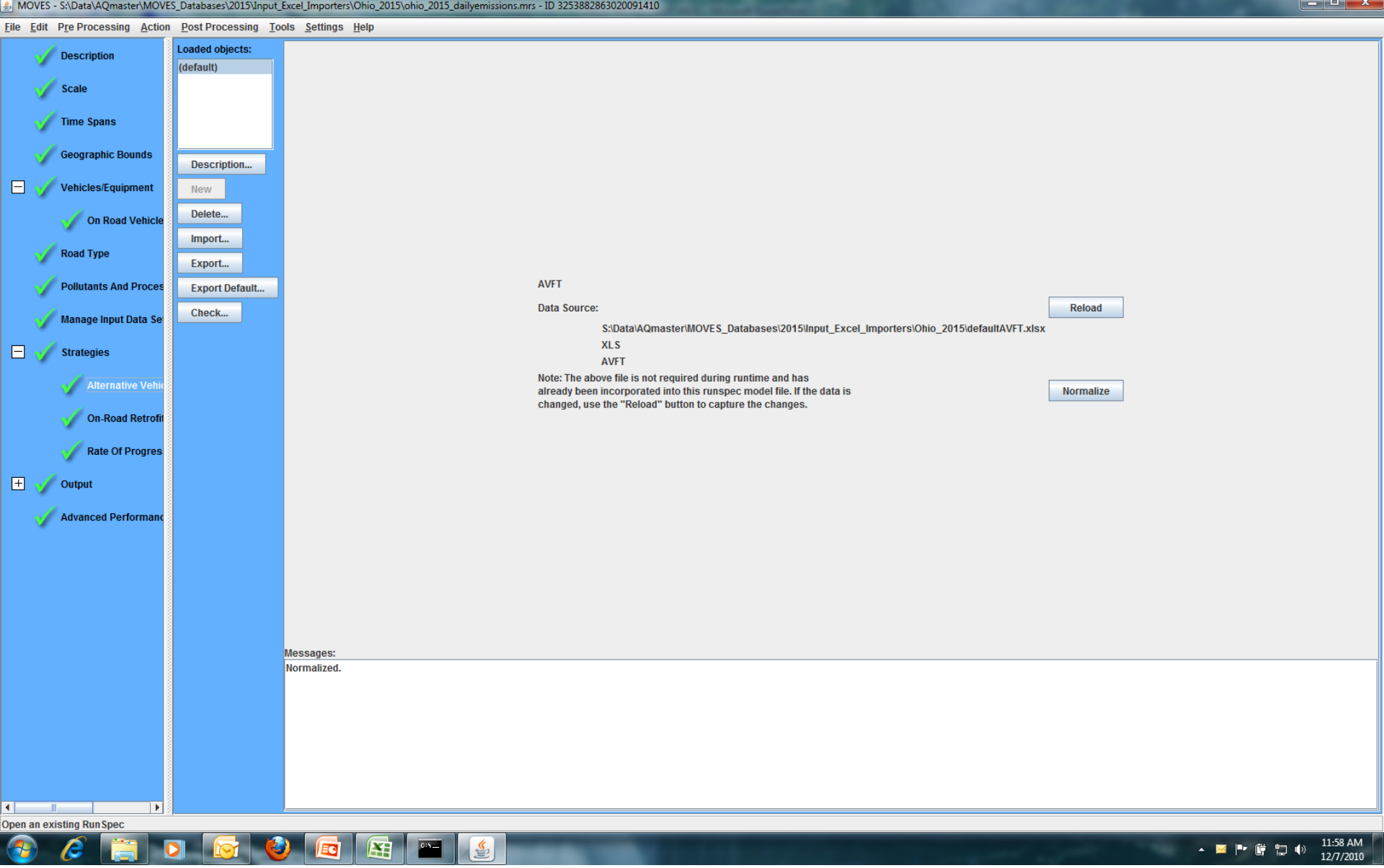
| | Running Exhaust | Start Exhaust | Brakewear | Tirewear | Evap Permeation | Evap Fuel Vapor Venting | Evap Fuel Leaks | Crankcase Running Exhaust | Crankcase Start Exhaust | Crankcase Extended Idle Exhaust | Refue |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Gaseous Hydrocarbons | | | | | | | | | | | |
| Non-Methane Hydrocarbons | | | | | | | | | | | |
| Non-Methane Organic Gases | | | | | | | | | | | |
| Total Organic Gases | | | | | | | | | | | |
| Volatile Organic Compounds | | | | | | | | | | | |
| Carbon Monoxide (CO) | | | | | | | | | | | |
| ✔ Oxides of Nitrogen (NOx) | ✔ | ✔ | | | | | | ✔ | ✔ | ✔ | |
| Ammonia (NH3) | | | | | | | | | | | |
| Nitrogen Oxide (NO) | | | | | | | | | | | |
| Nitrogen Dioxide (NO2) | | | | | | | | | | | |
| ✔ Sulfur Dioxide (SO2) | ✔ | ✔ | | | | | | ✔ | ✔ | ✔ | |
| Primary Exhaust PM10 - Total | | | | | | | | | | | |
| Primary PM10 - Organic Carbon | | | | | | | | | | | |
| Primary PM10 - Elemental Carbon | | | | | | | | | | | |
| Primary PM10 - Sulfate Particulate | | | | | | | | | | | |
| Primary PM10 - Brakewear Particulate | | | | | | | | | | | |
| Primary PM10 - Tirewear Particulate | | | | | | | | | | | |
| ✔ Primary Exhaust PM2.5 - Total | ✔ | ✔ | | | | | | ✔ | ✔ | ✔ | |
| ✔ Primary PM2.5 - Organic Carbon | ✔ | ✔ | | | | | | ✔ | ✔ | ✔ | |
| ✔ Primary PM2.5 - Elemental Carbon | ✔ | ✔ | | | | | | ✔ | ✔ | ✔ | |
| ✔ Primary PM2.5 - Sulfate Particulate | ✔ | ✔ | | | | | | ✔ | ✔ | ✔ | |
| ✔ Primary PM2.5 - Brakewear Particulate | | | ✔ | | | | | | | | |
| ✔ Primary PM2.5 - Tirewear Particulate | | | | ✔ | | | | | | | |
| ✔ Total Energy Consumption | ✔ | ✔ | | | | | | | | | |
| Petroleum Energy Consumption | | | | | | | | | | | |
| Fossil Fuel Energy Consumption | | | | | | | | | | | |
| Brake Specific Fuel Consumption (BSFC) | | | | | | | | | | | |
| Methane (CH4) | | | | | | | | | | | |
| Nitrous Oxide (N2O) | | | | | | | | | | | |
| Atmospheric CO2 | | | | | | | | | | | |
| CO2 Equivalent | | | | | | | | | | | |
| Benzene | | | | | | | | | | | |
| Ethanol | | | | | | | | | | | |
| MTBE | | | | | | | | | | | |
| Naphthalene | | | | | | | | | | | |
| 1,3-Butadiene | | | | | | | | | | | |
| Formaldehyde | | | | | | | | | | | |
| Acetaldehyde | | | | | | | | | | | |
| Acrolein | | | | | | | | | | | |

Open an existing RunSpec

12:04 PM
12/7/2010


MOVES - S:\Data\AQmaster\MOVES_Databases\2015\Input_Excel_Importers\Ohio_2015\ohio_2015_dailyemissions.mrs - ID 3253882863020091410
File Edit Pre Processing Action Post Processing Tools Settings Help
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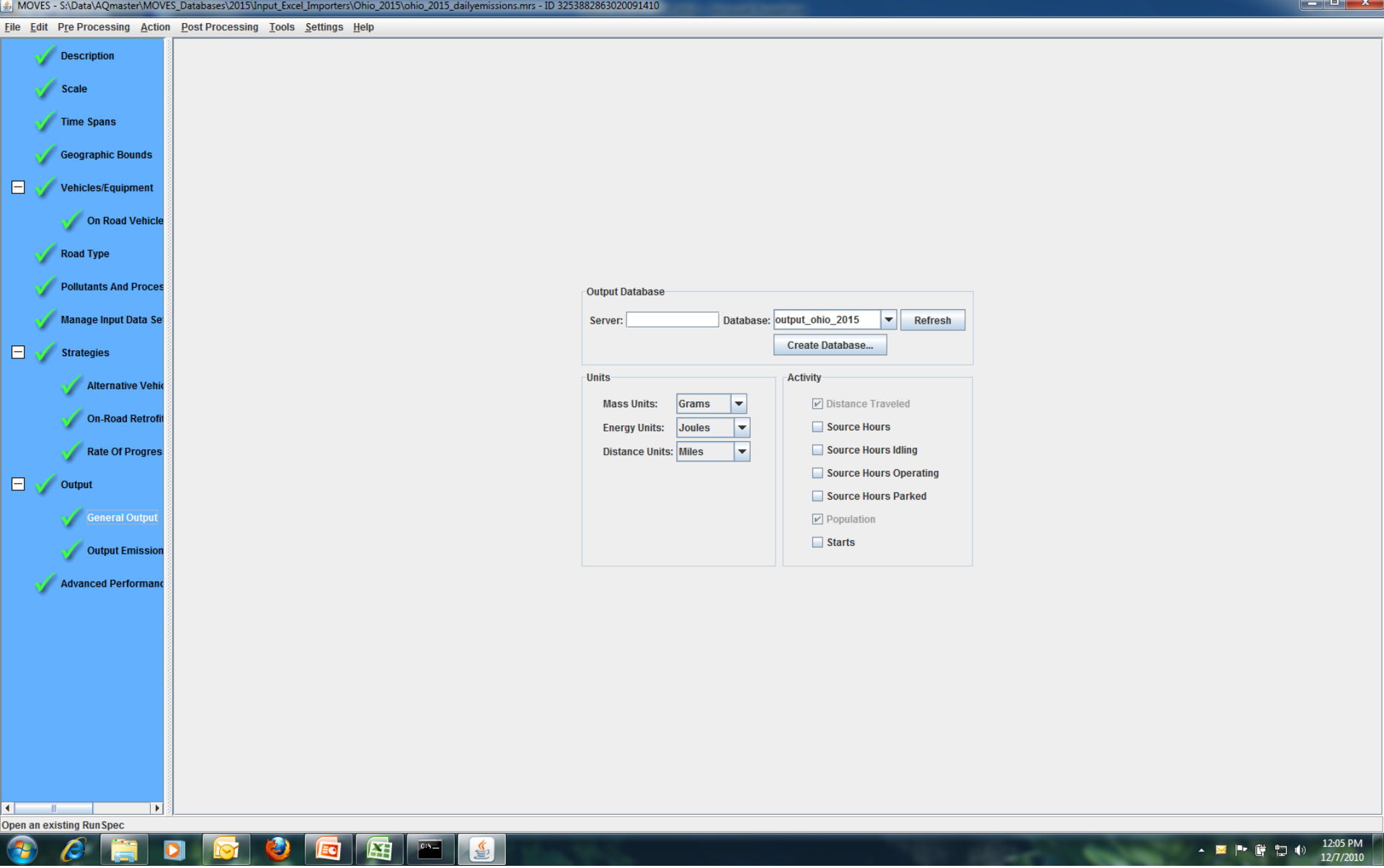
Alternative Vehi
On-Road Retrofi
Rate Of Progres
Output
Advanced Performanc
Loaded objects:
(default)
Description...
New
Delete...
Import...
Export...
Export Default...
Check...
AVFT
Data Source:
Reload
S:\Data\AQmaster\MOVES_Databases\2015\Input_Excel_Importers\Ohio_2015\defaultAVFT.xlsx
XLS
AVFT
Note: The above file is not required during runtime and has already been incorporated into this runspec model file. If the data is changed, use the "Reload" button to capture the changes.
Normalize
Messages:
Normalized.
Open an existing RunSpec
11:58 AM
12/7/2010


MOVES - S:\Data\AQmaster\MOVES_Databases\2015\Input_Excel_Importers\Ohio_2015\ohio_2015_dailyemissions.mrs - ID 3253882863020091410
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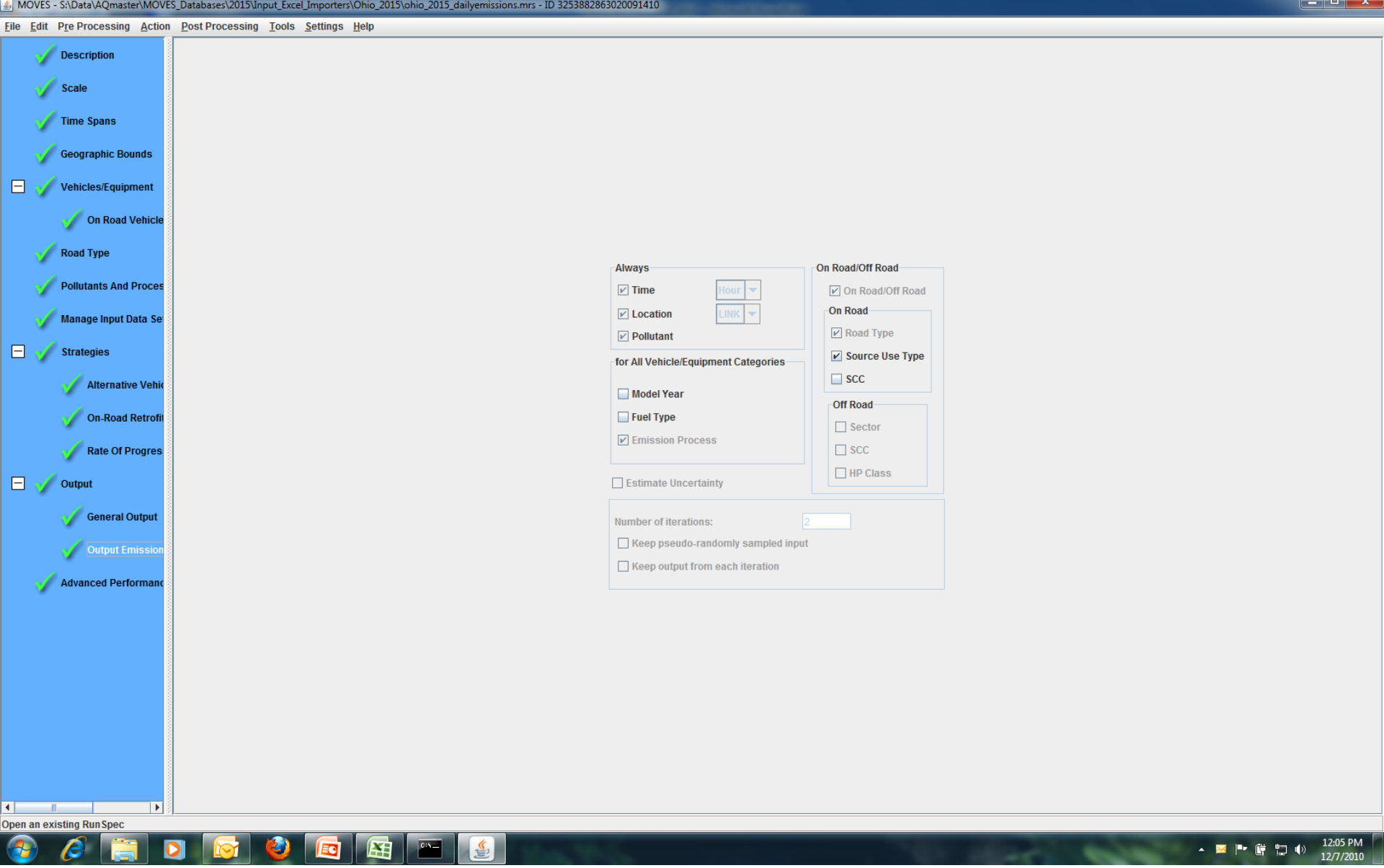
Alternative Vehi
On-Road Retrofi
Rate Of Progres
Output
General Output
Output Emission
Advanced Performanc
Output Database
Server:
Database: output_ohio_2015
Refresh
Create Database...
Units
Mass Units: Grams
Energy Units: Joules
Distance Units: Miles
Activity
Distance Traveled
Source Hours
Source Hours Idling
Source Hours Operating
Source Hours Parked
Population
Starts
Open an existing RunSpec
12:05 PM
12/7/2010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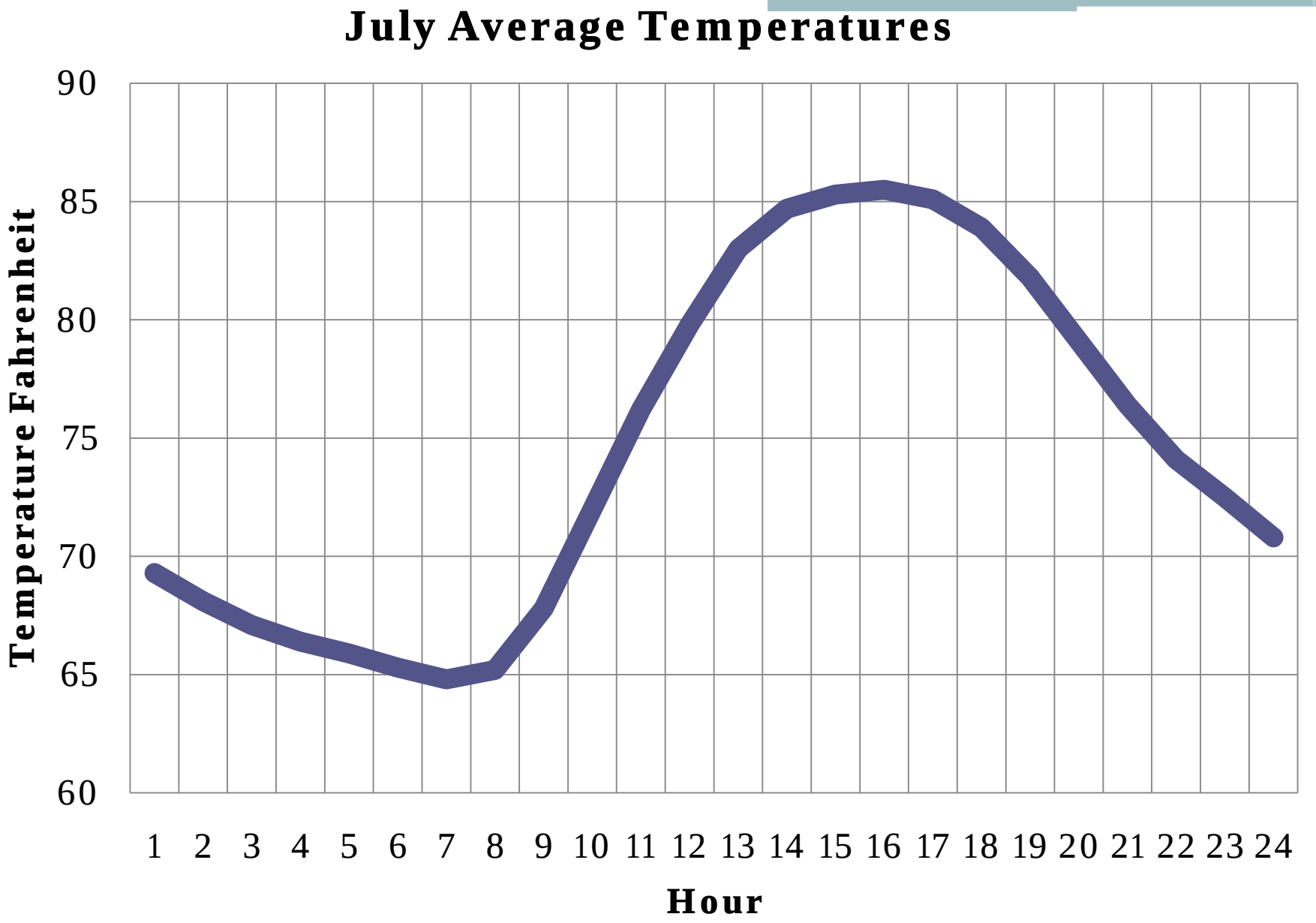
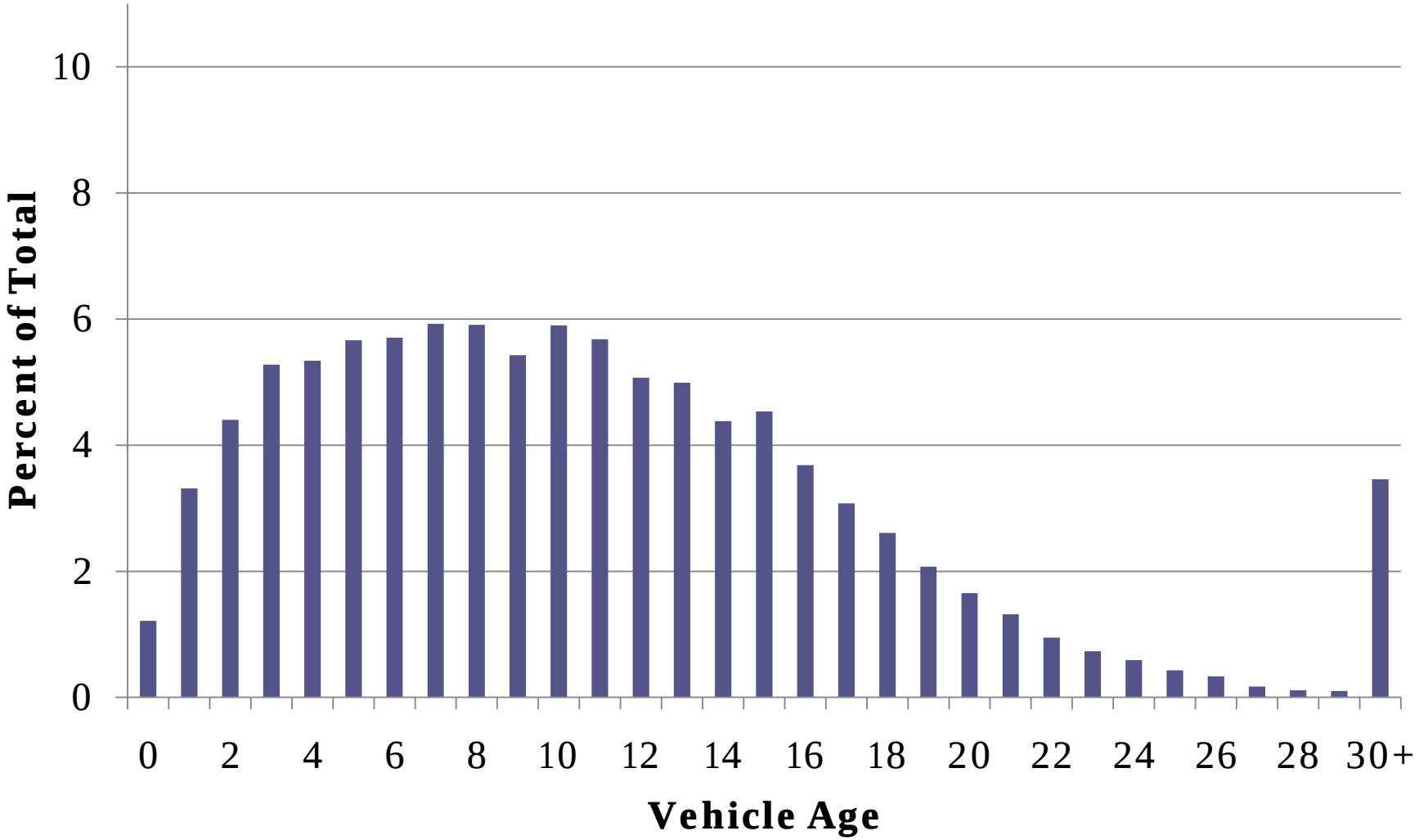
Rate Of Progres
Output
General Output
Output Emission
Advanced Performanc
Always
Time
Hour
Location
LINK
Pollutant
for All Vehicle/Equipment Categories
Model Year
Fuel Type
Emission Process
Estimate Uncertainty
On Road/Off Road
On Road/Off Road
On Road
Road Type
Source Use Type
SCC
Off Road
Sector
SCC
HP Class
Number of iterations:
2
Keep pseudo-randomly sampled input
Keep output from each iteration
Open an existing RunSpec
12:05 PM
12/7/2010

# Factors Impacting Emissions

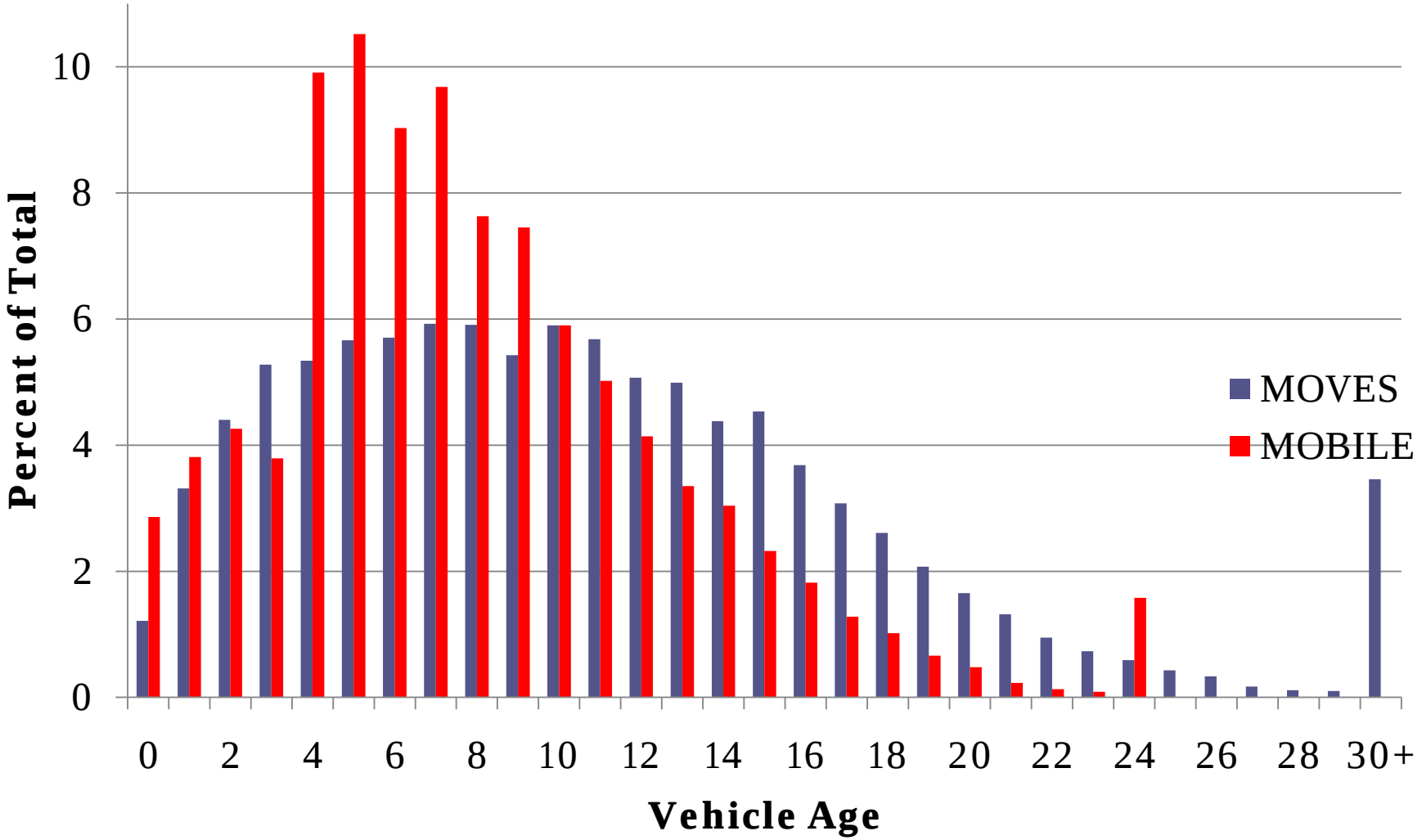
- Meteorology
  - Temperature
  - Humidity
- Fleet characteristics
  - Age of fleet
  - Vehicle type
  - Analysis Year – future vehicles subject to more stringent emission standards
- Fuel Supply
  - Reformulated Gas, Low RVP
- Transportation System
  - Road type (surrogate for driving pattern)
  - Vehicle miles traveled (VMT)
  - Speed


July Average Temperatures
Temperature Fahrenheit
90
85
80
75
70
65
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Hour

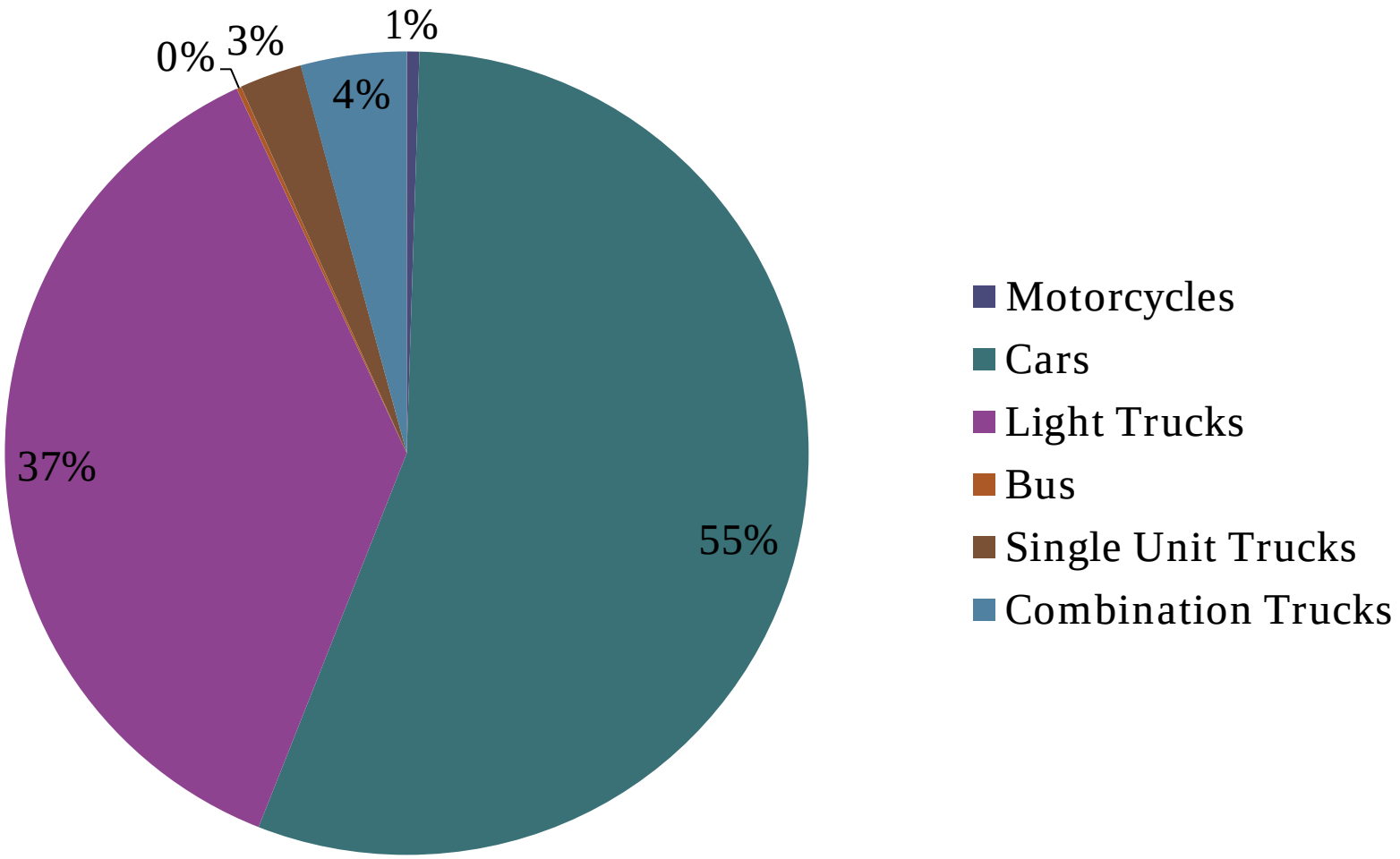
# Age of Fleet: Passenger Cars in OKI Ohio Counties – 2010



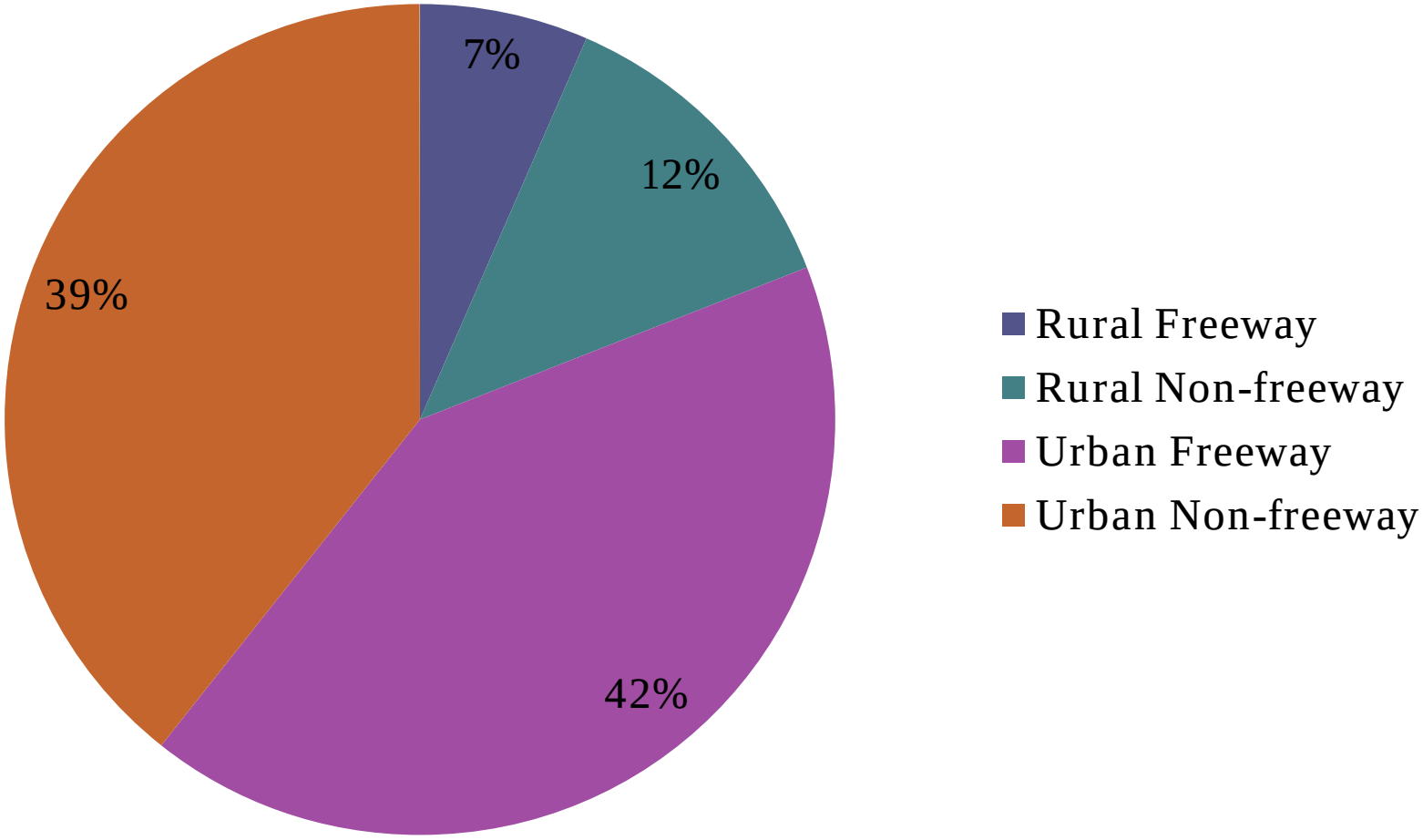
# Age of Fleet: Passenger Cars in OKI Ohio Counties – 2010 (MOVES) and 2004 (MOBILE)



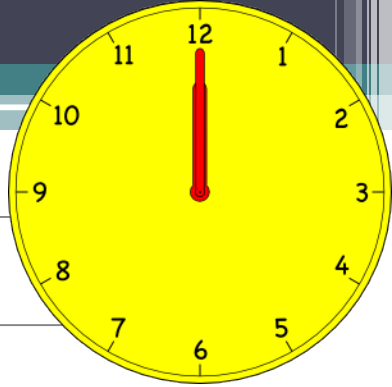
# Percent of VMT by Vehicle Type – uses MOVES Default Mileage Rates

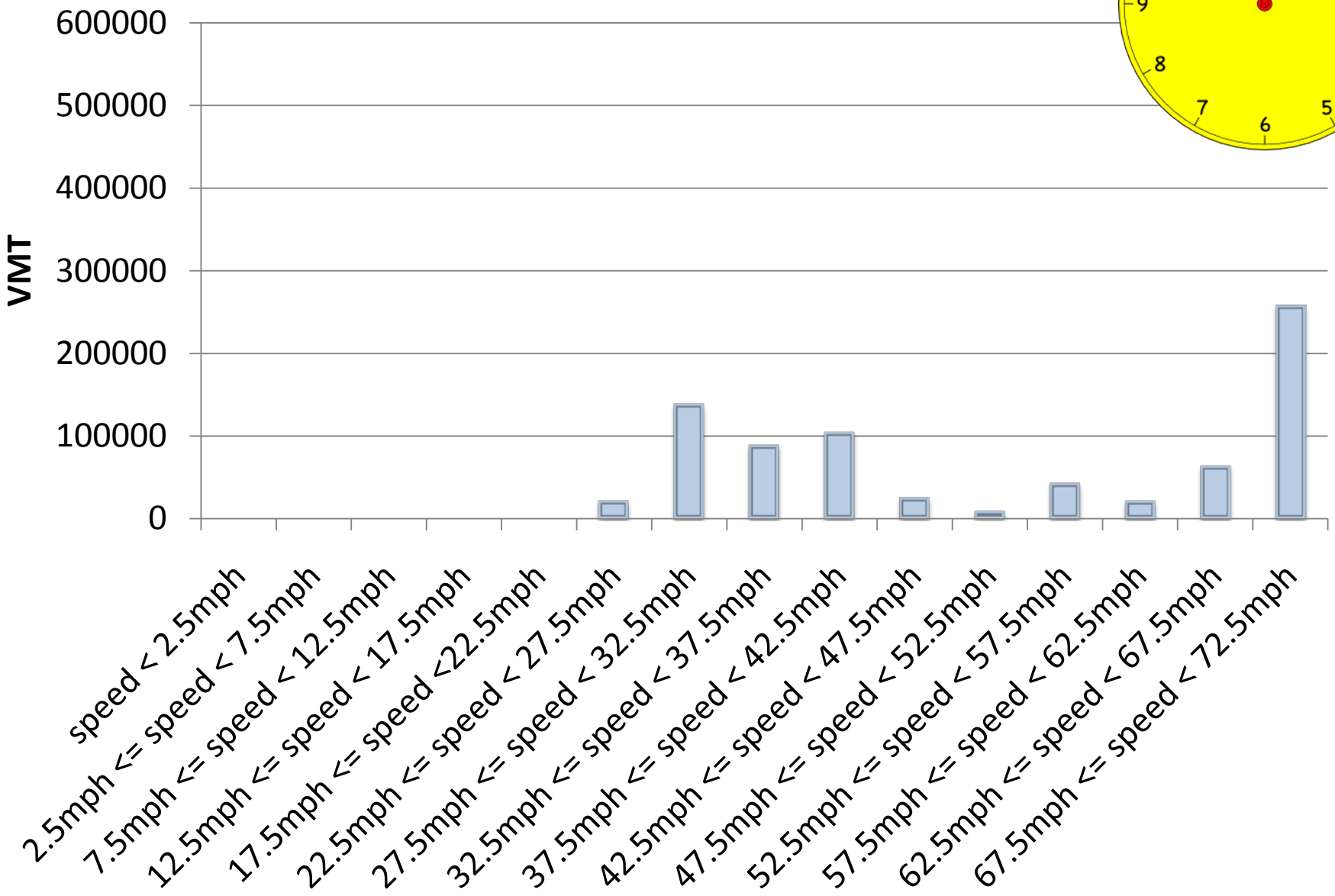


# Percent VMT by Road Type – OKI Travel Model

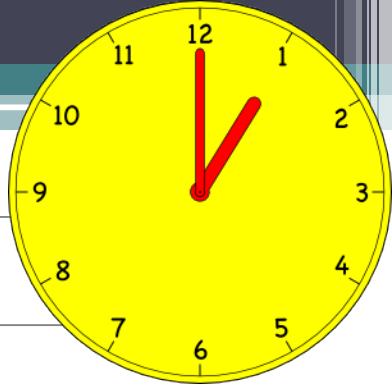


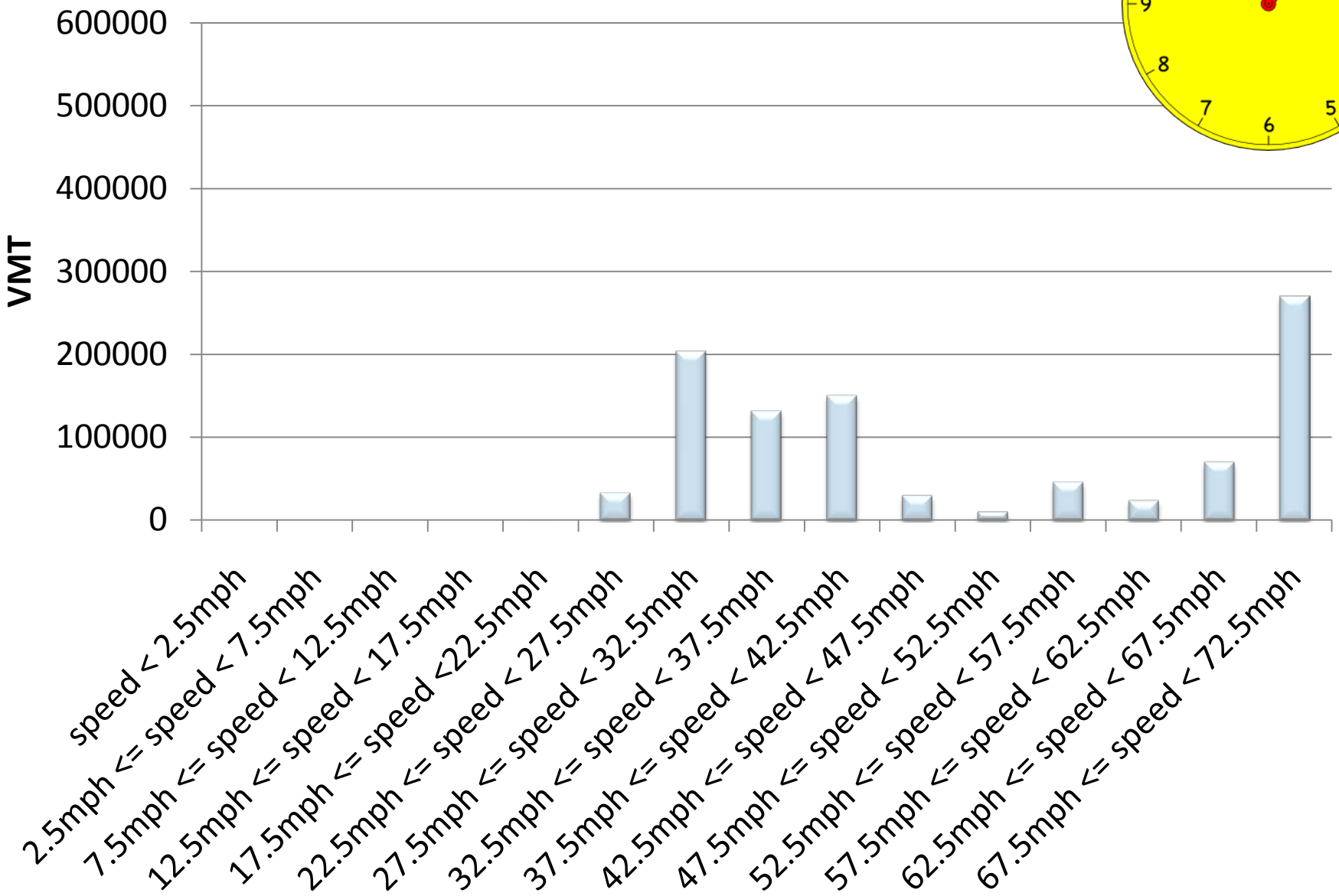
# VMT by Average Speed



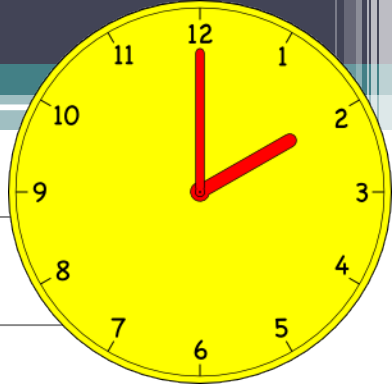


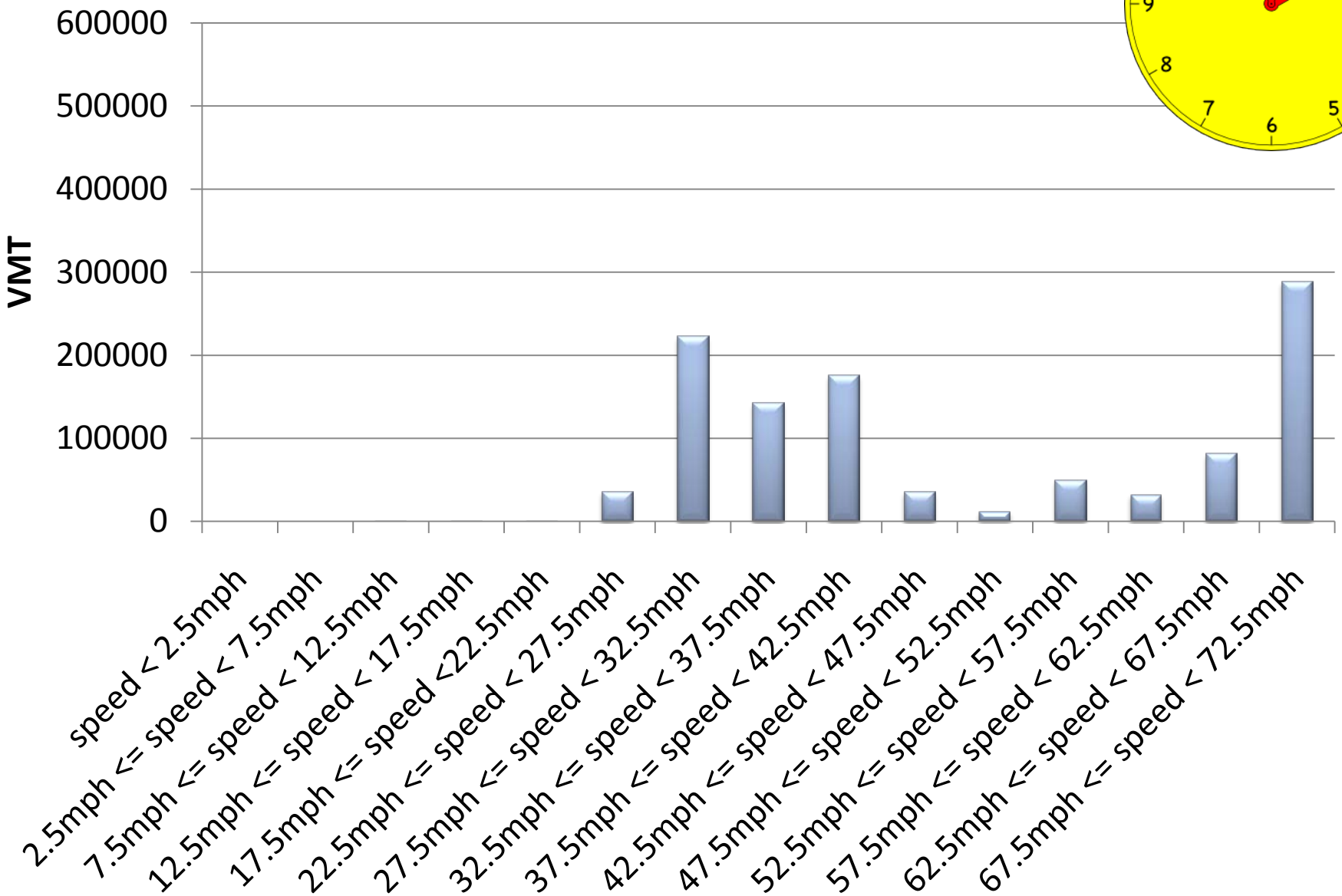
# VMT by Average Speed



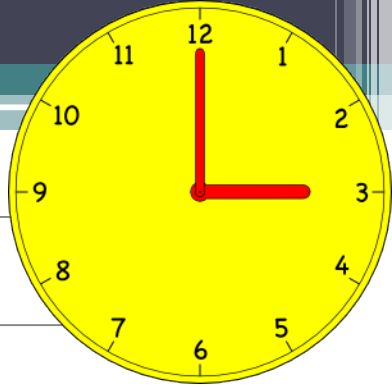


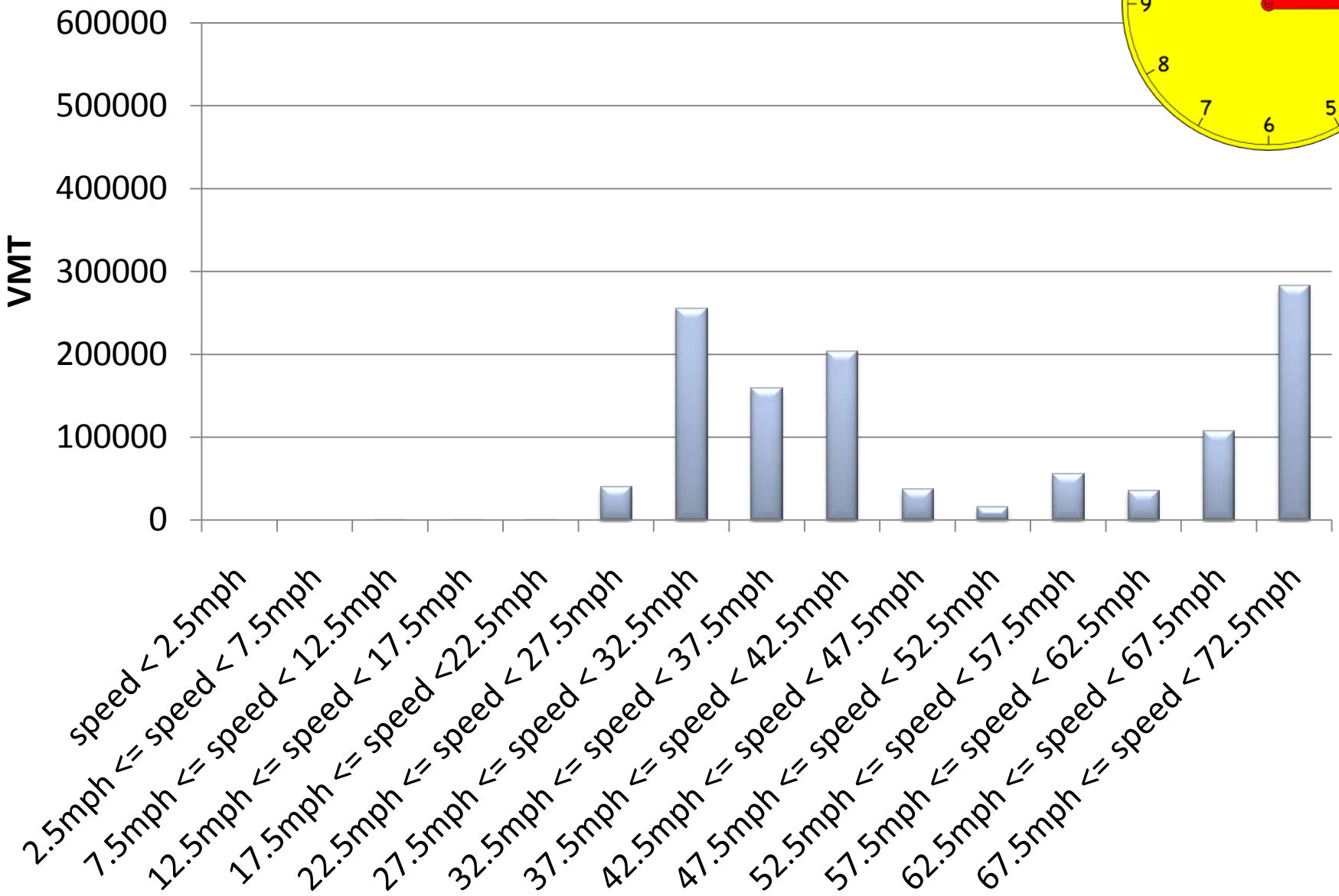
# VMT by Average Speed





# VMT by Average Speed





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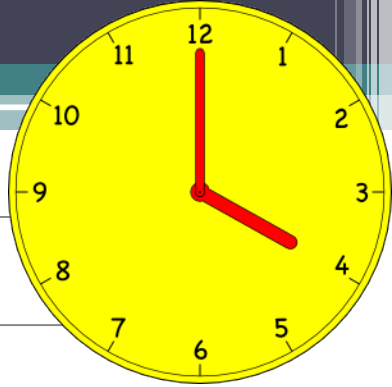
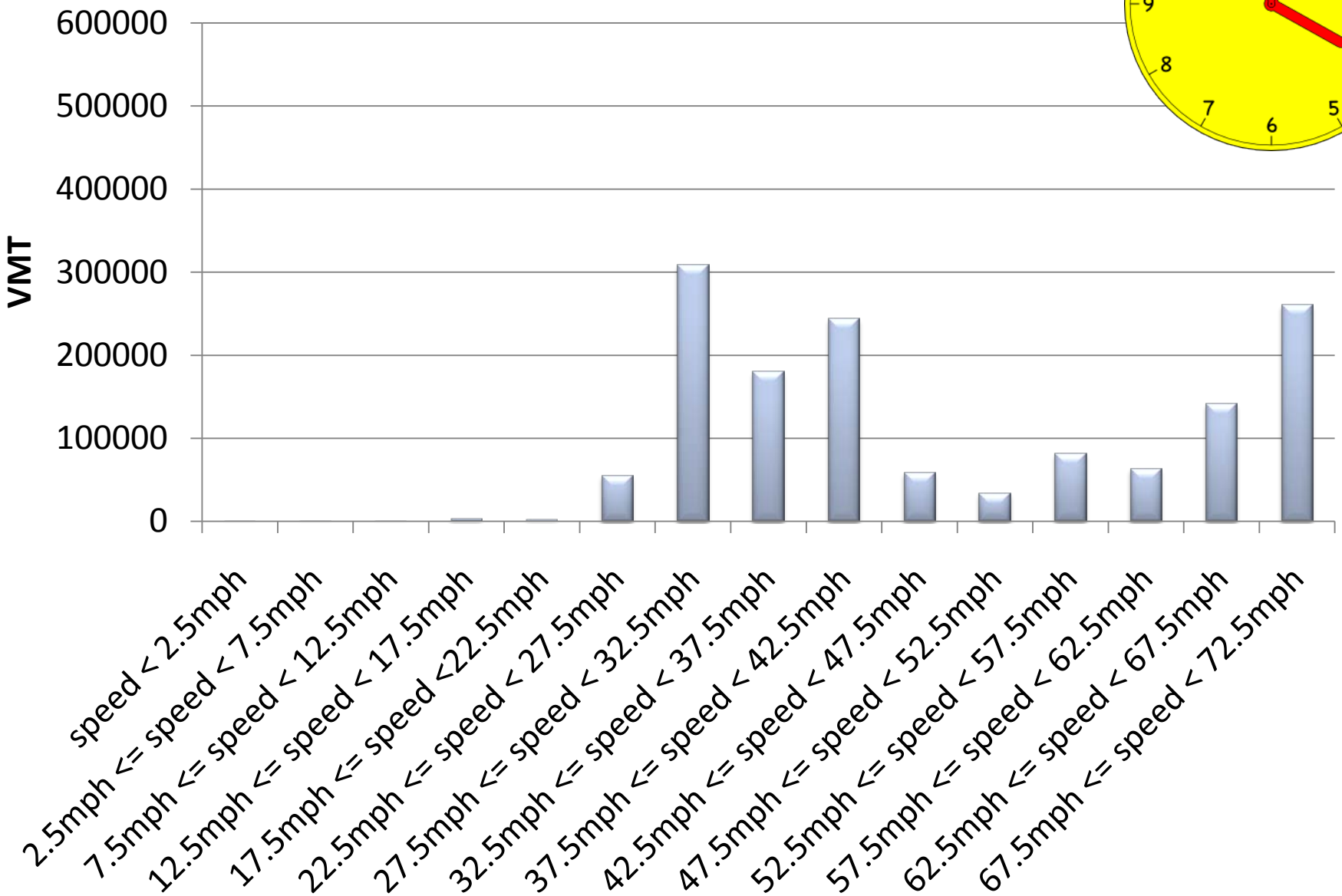
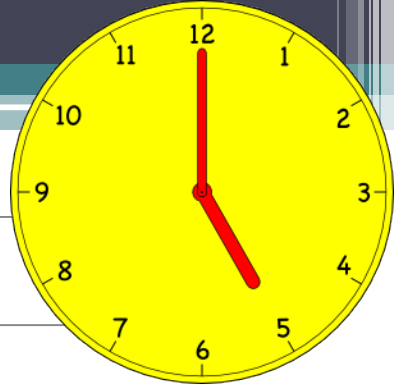
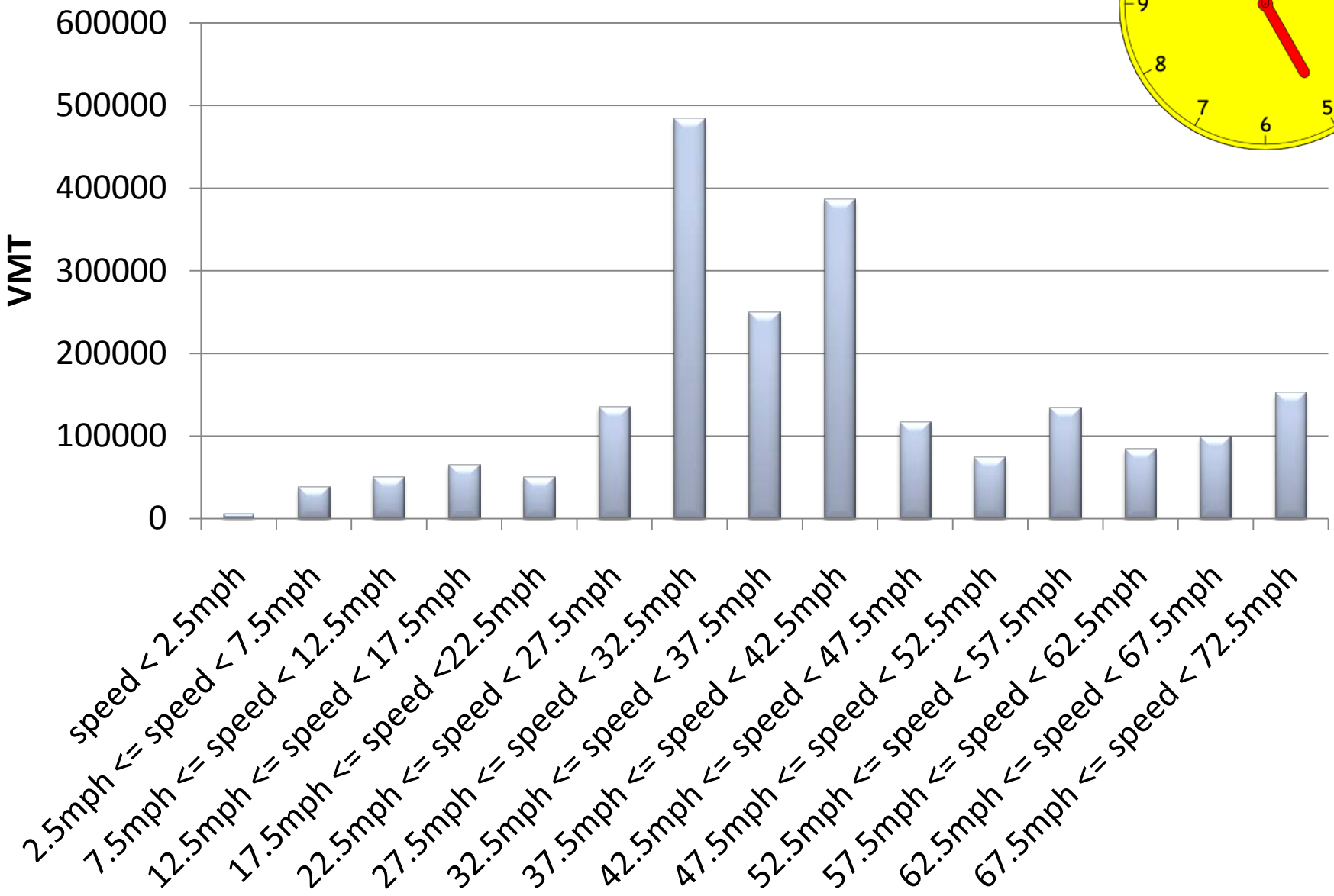


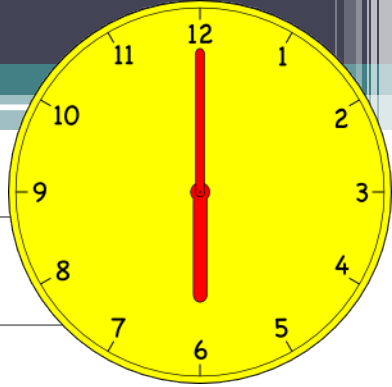


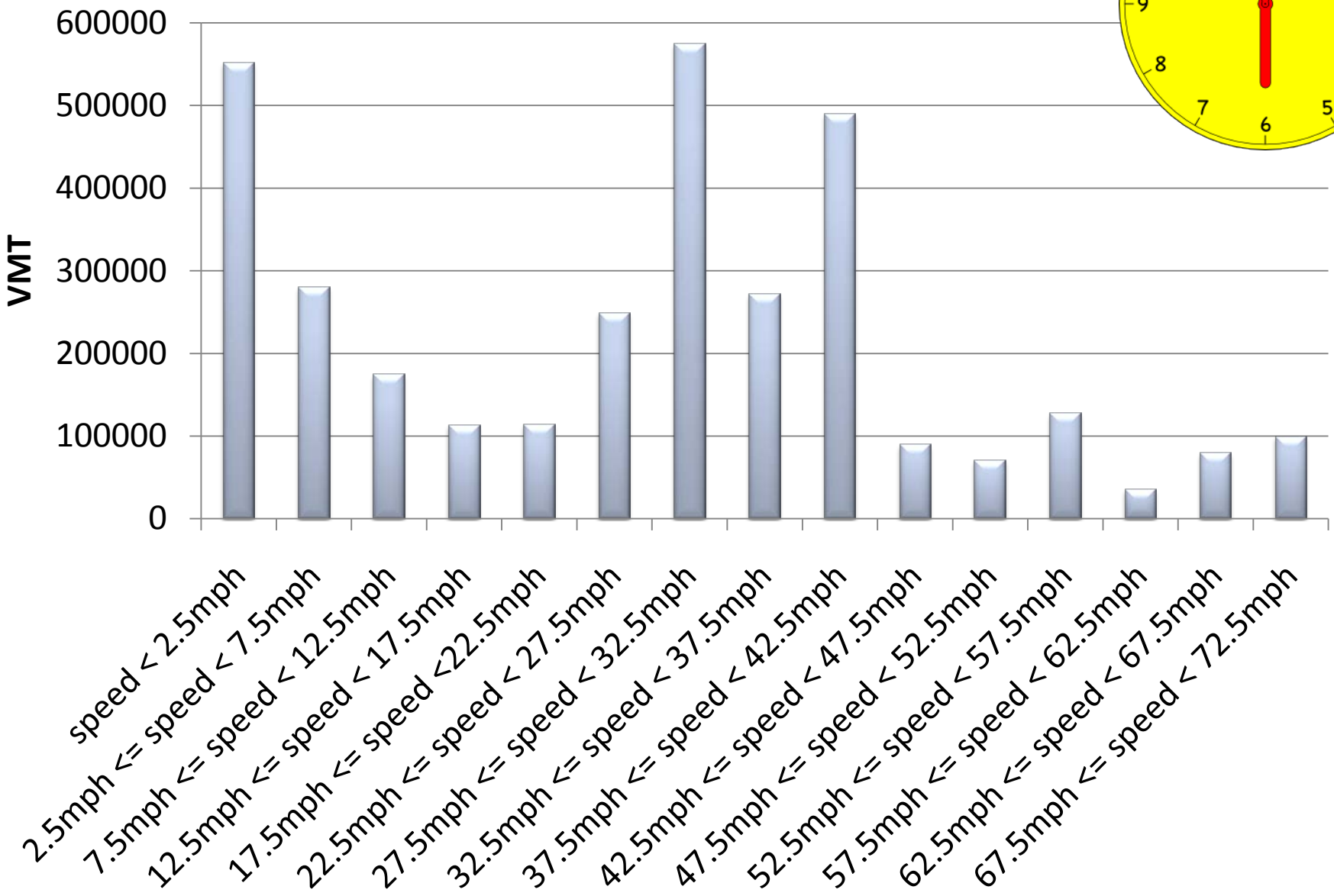
# VMT by Average Speed



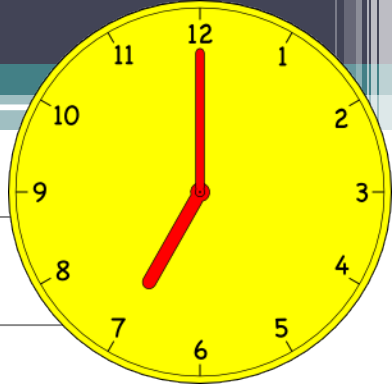


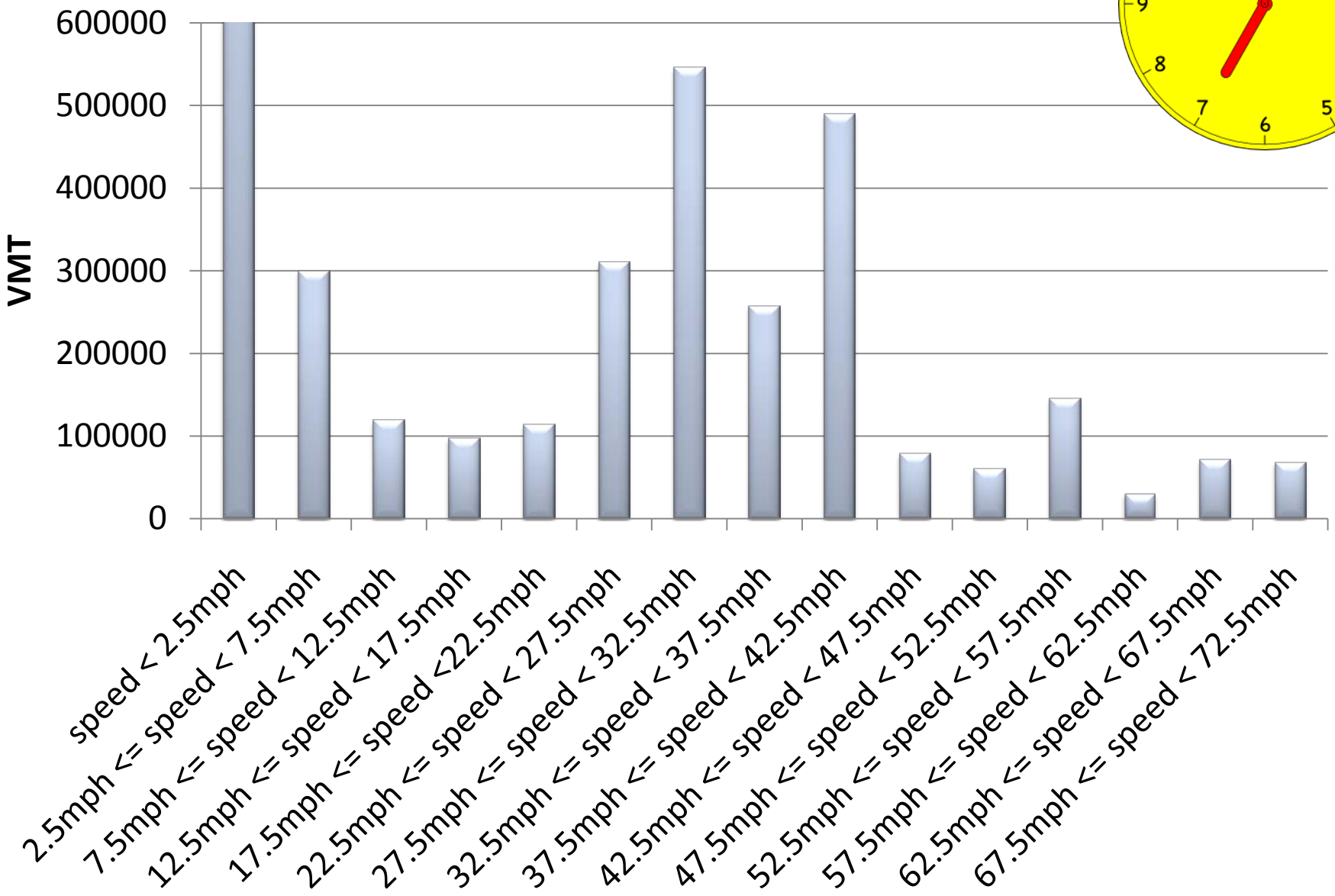
# VMT by Average Speed





# VMT by Average Speed





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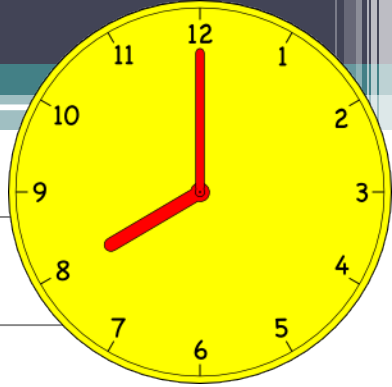

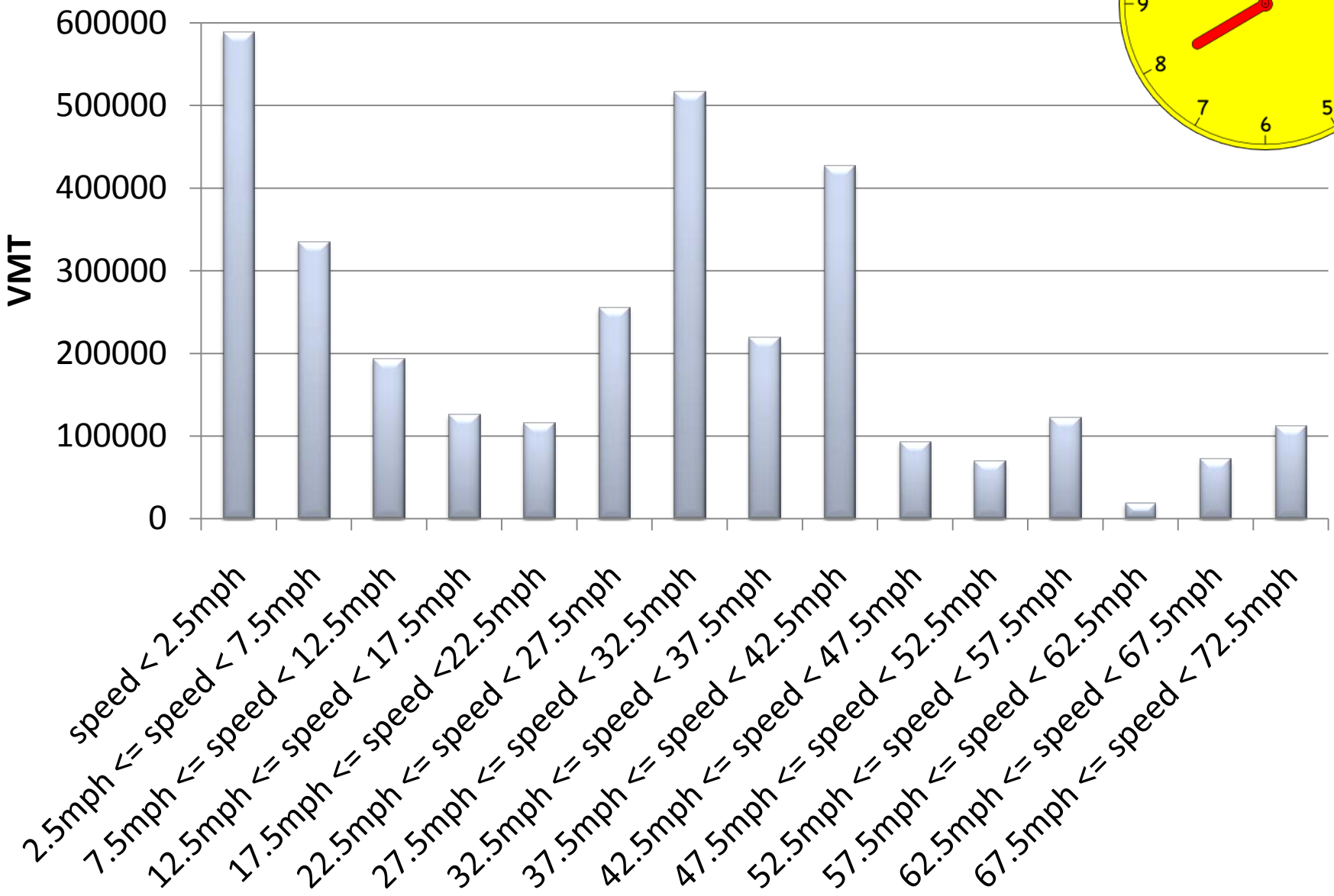

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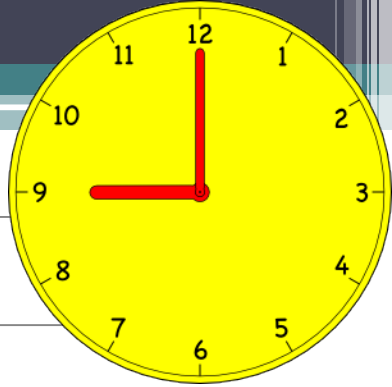

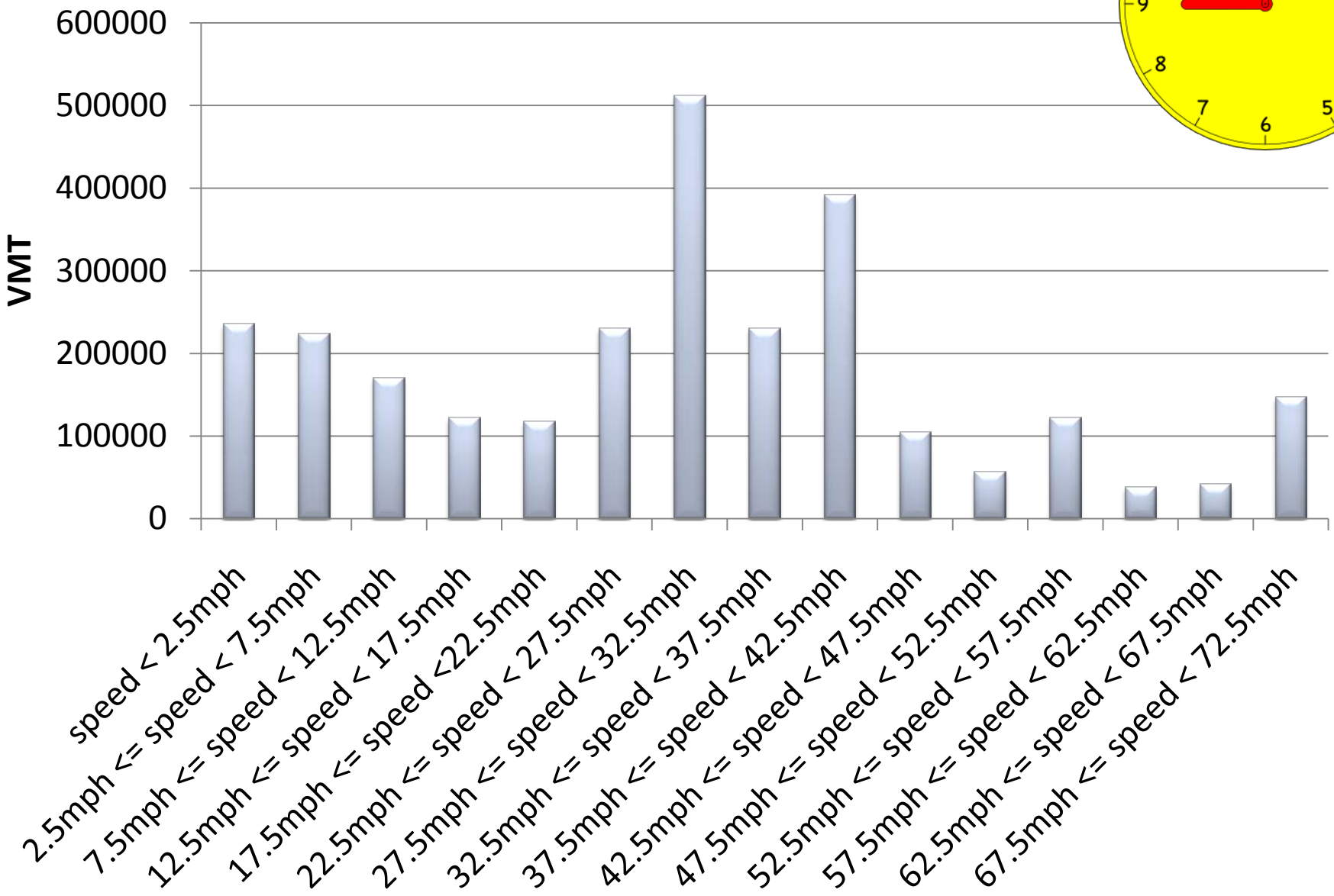

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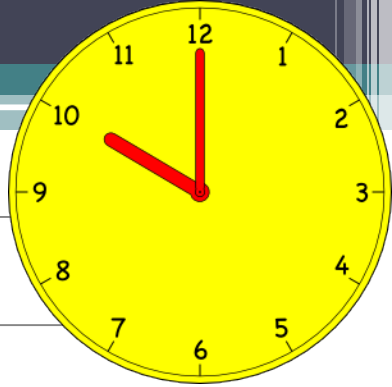

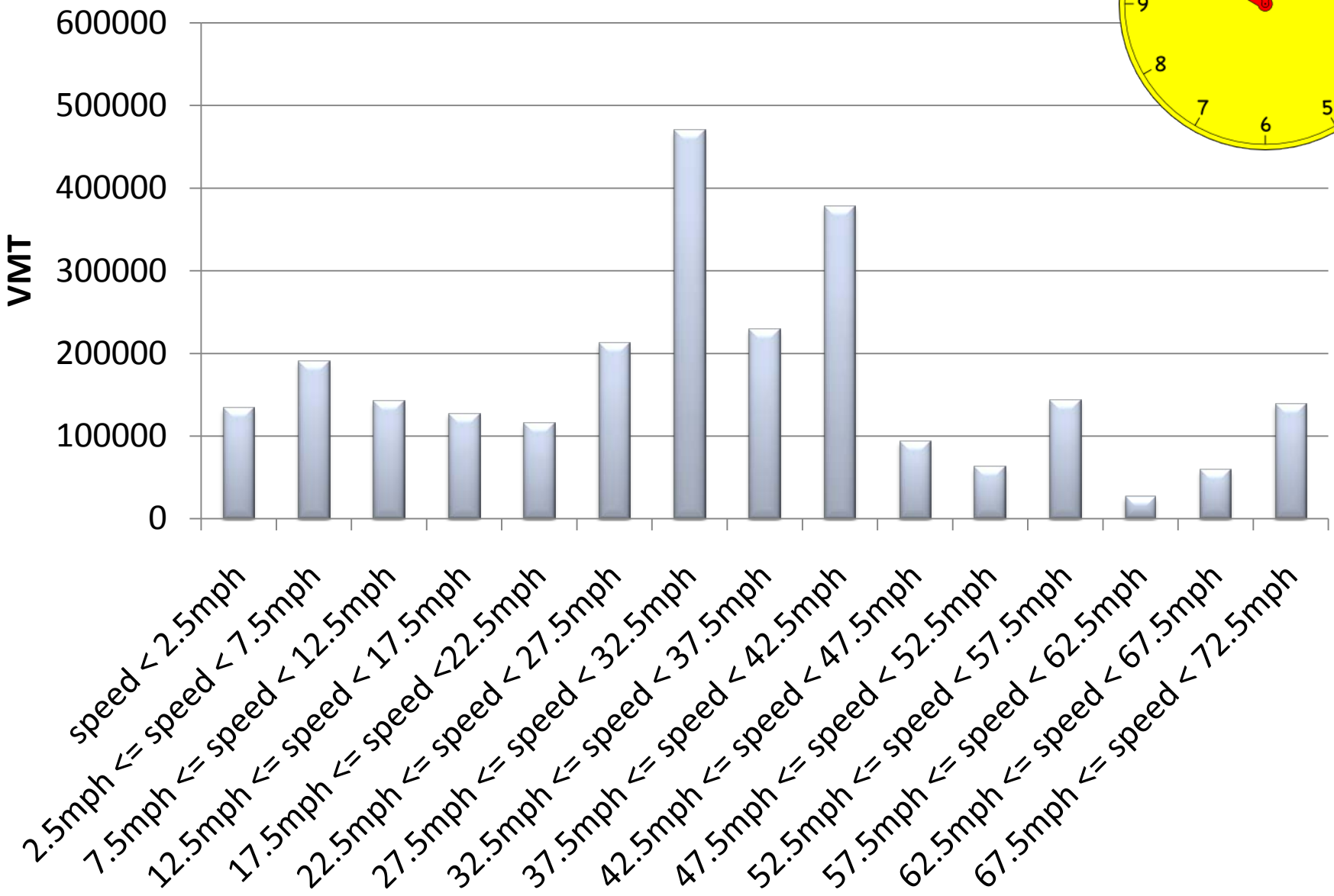

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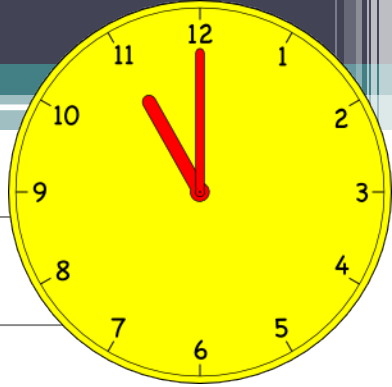

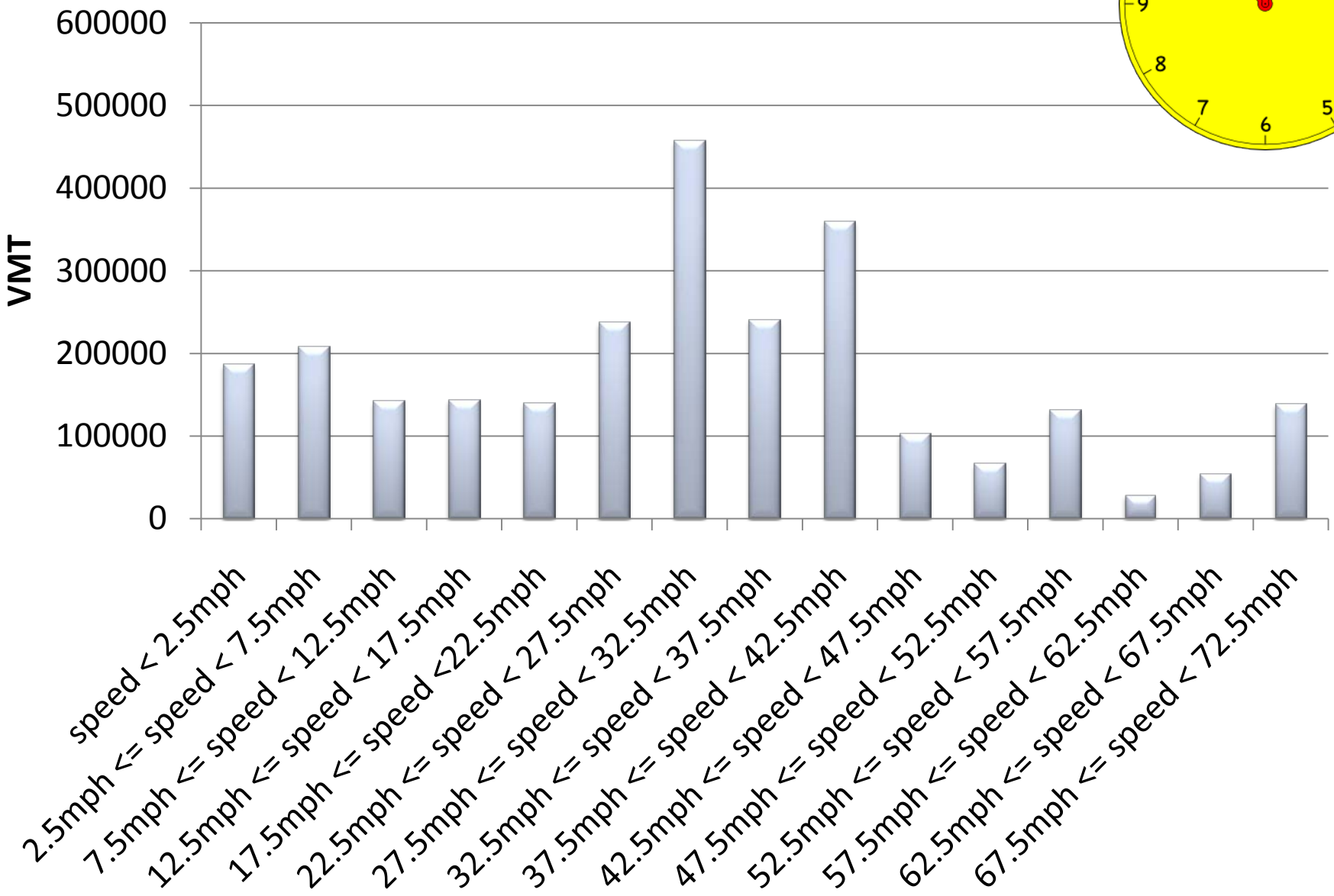

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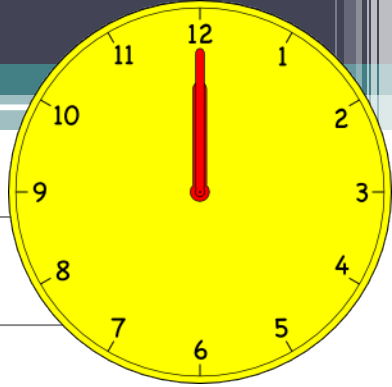

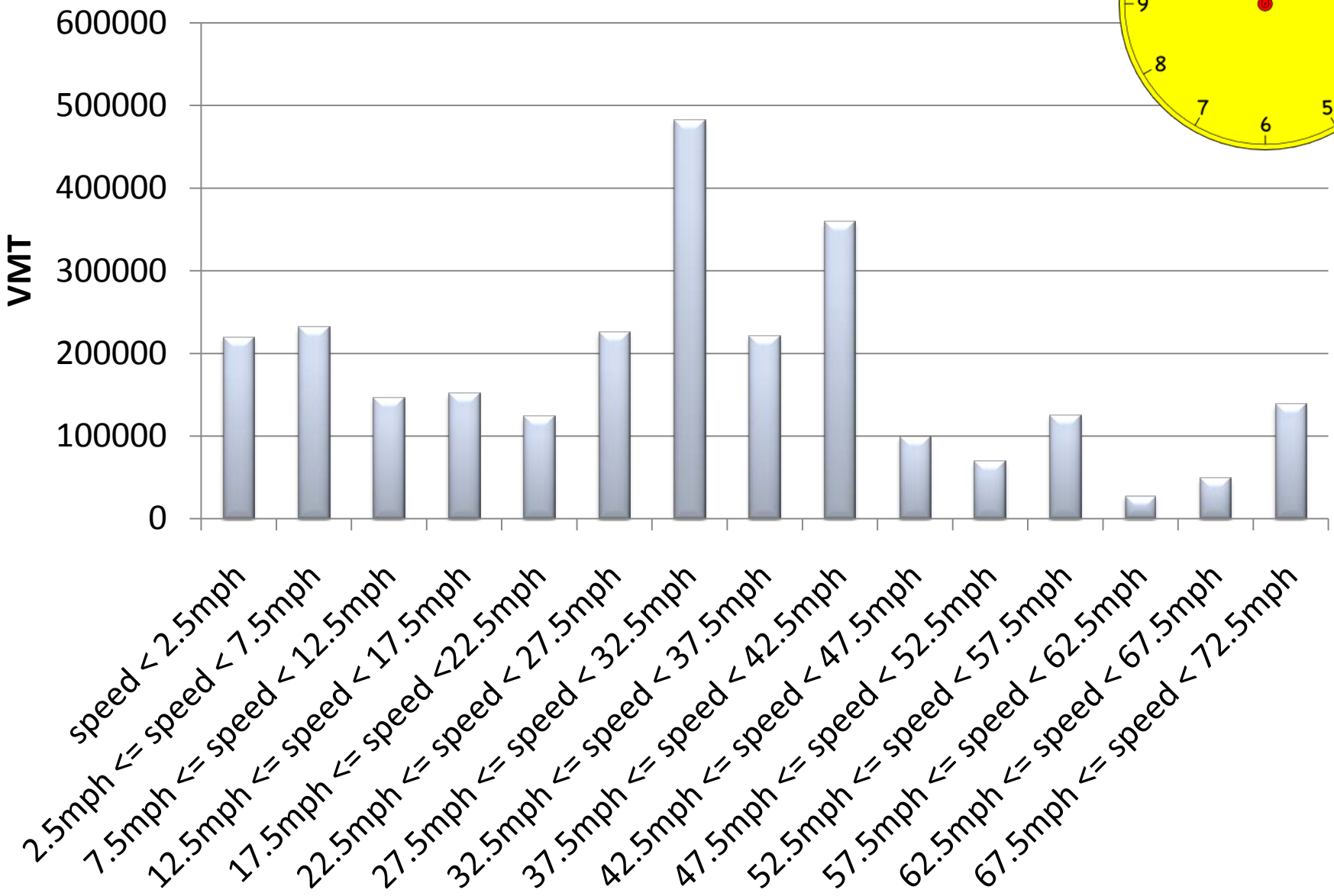

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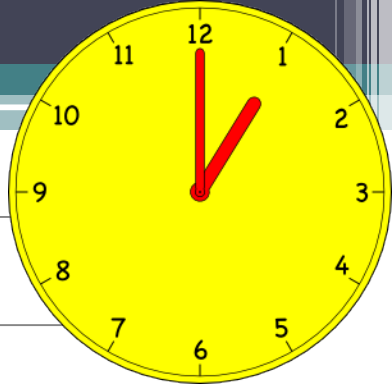

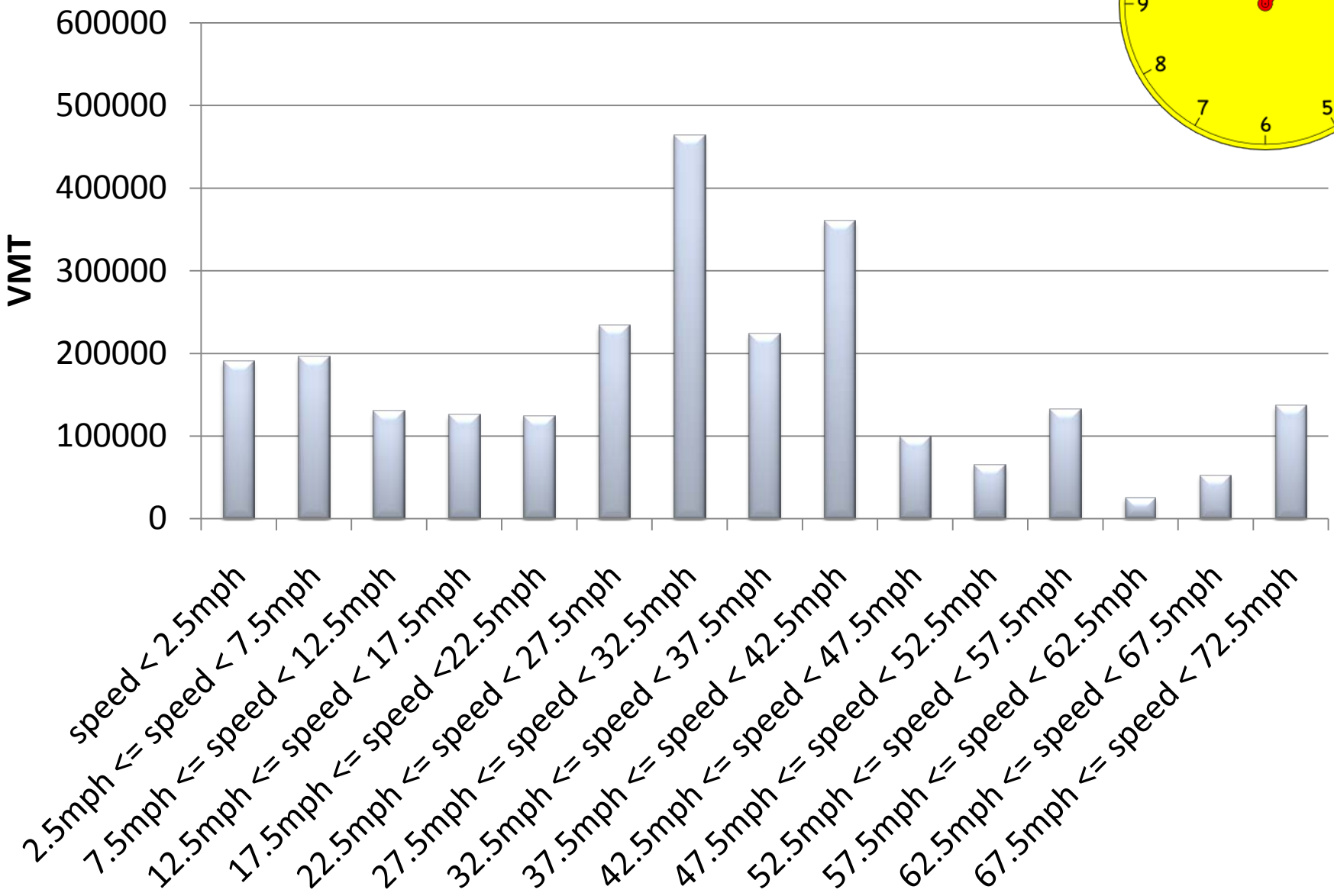

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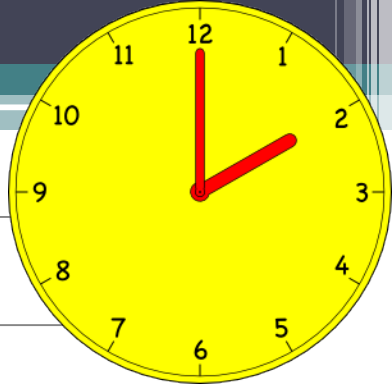

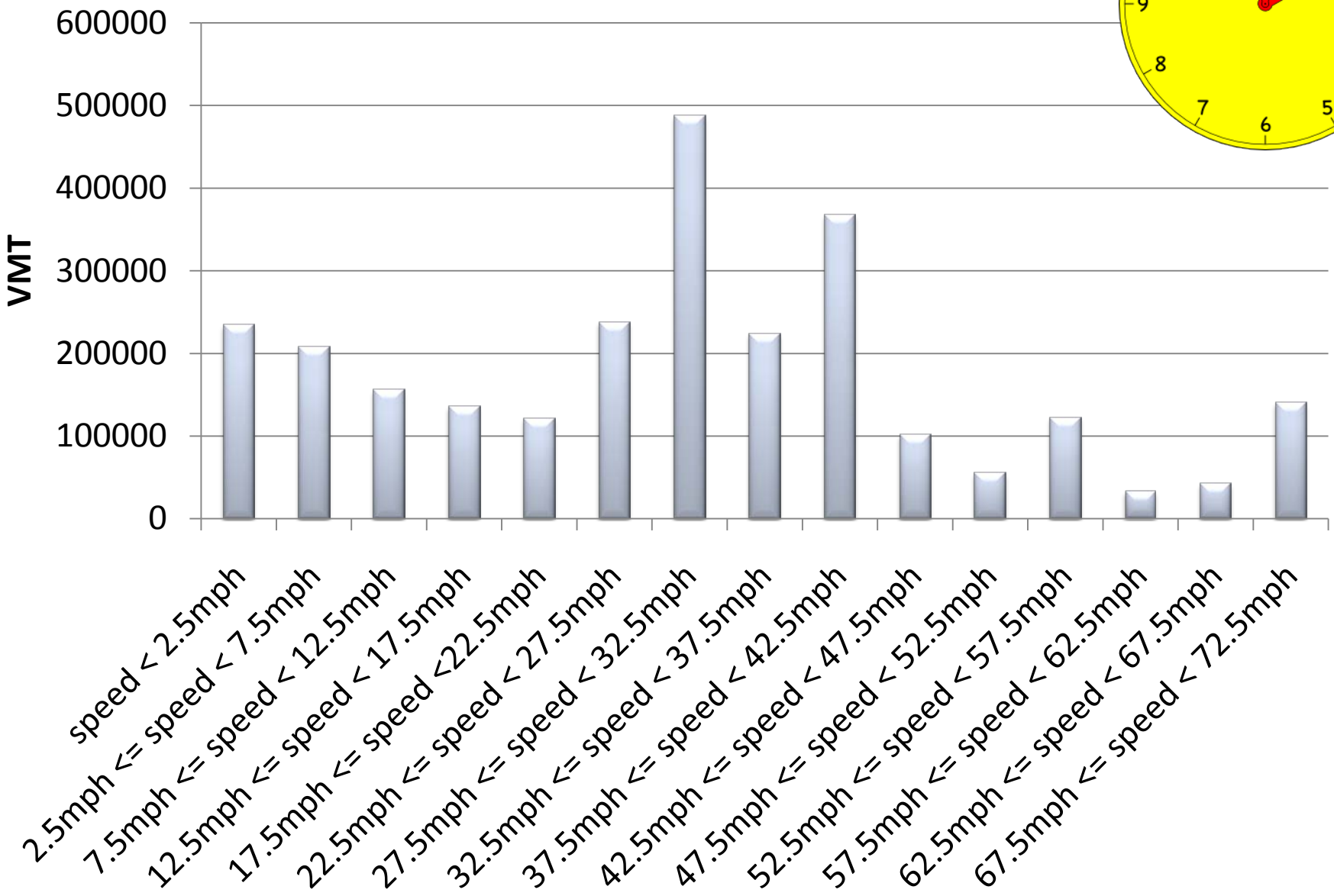

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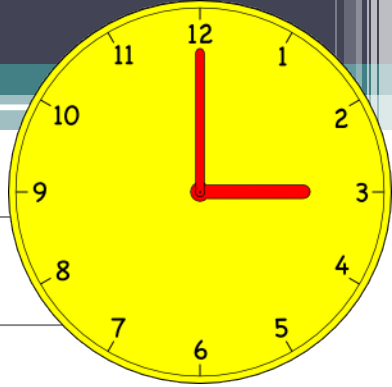

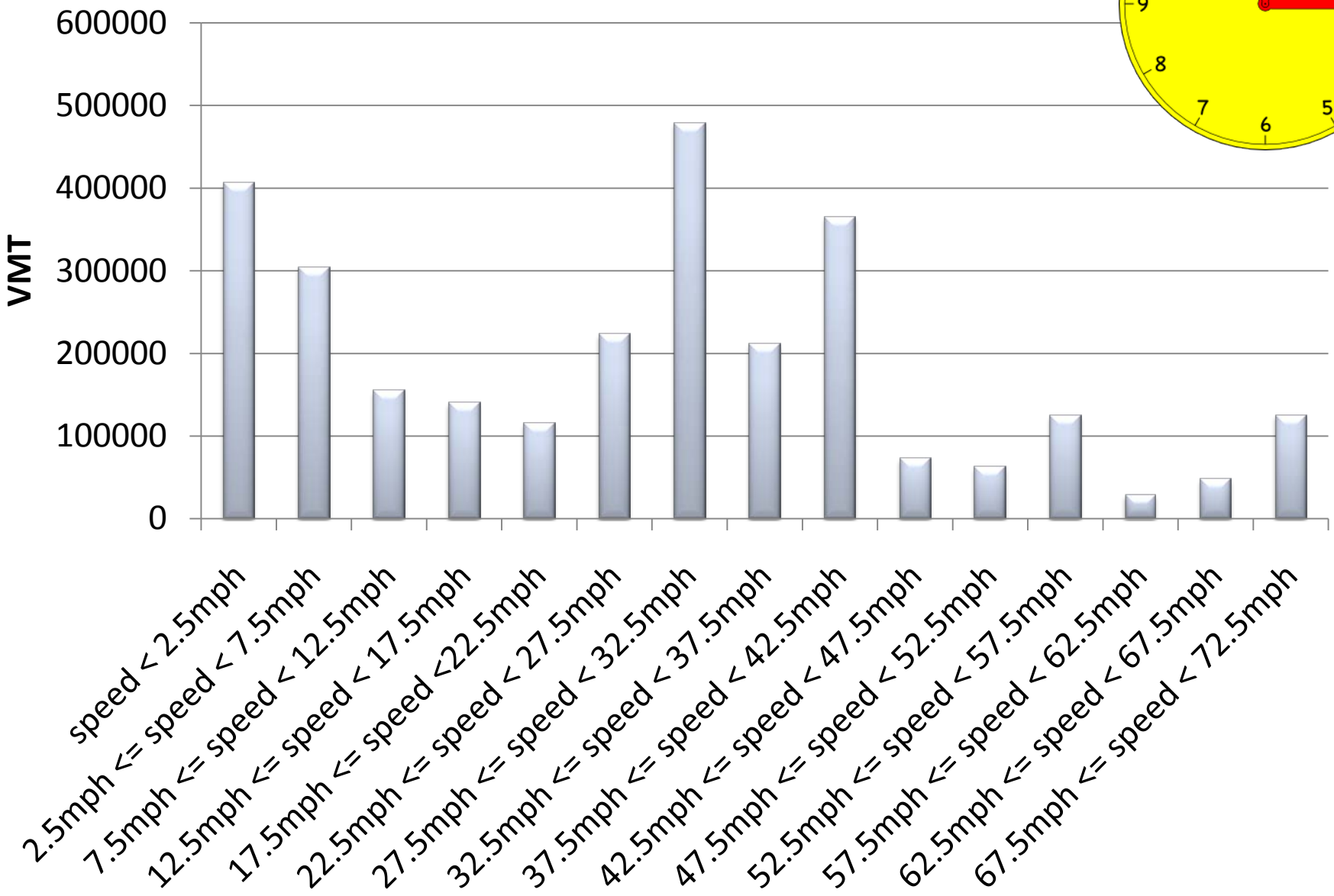

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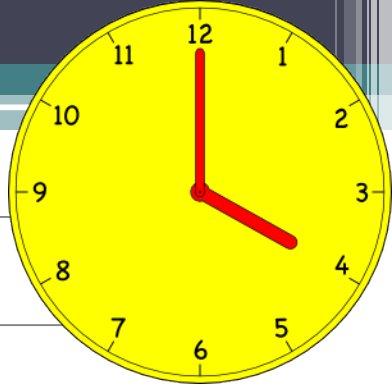

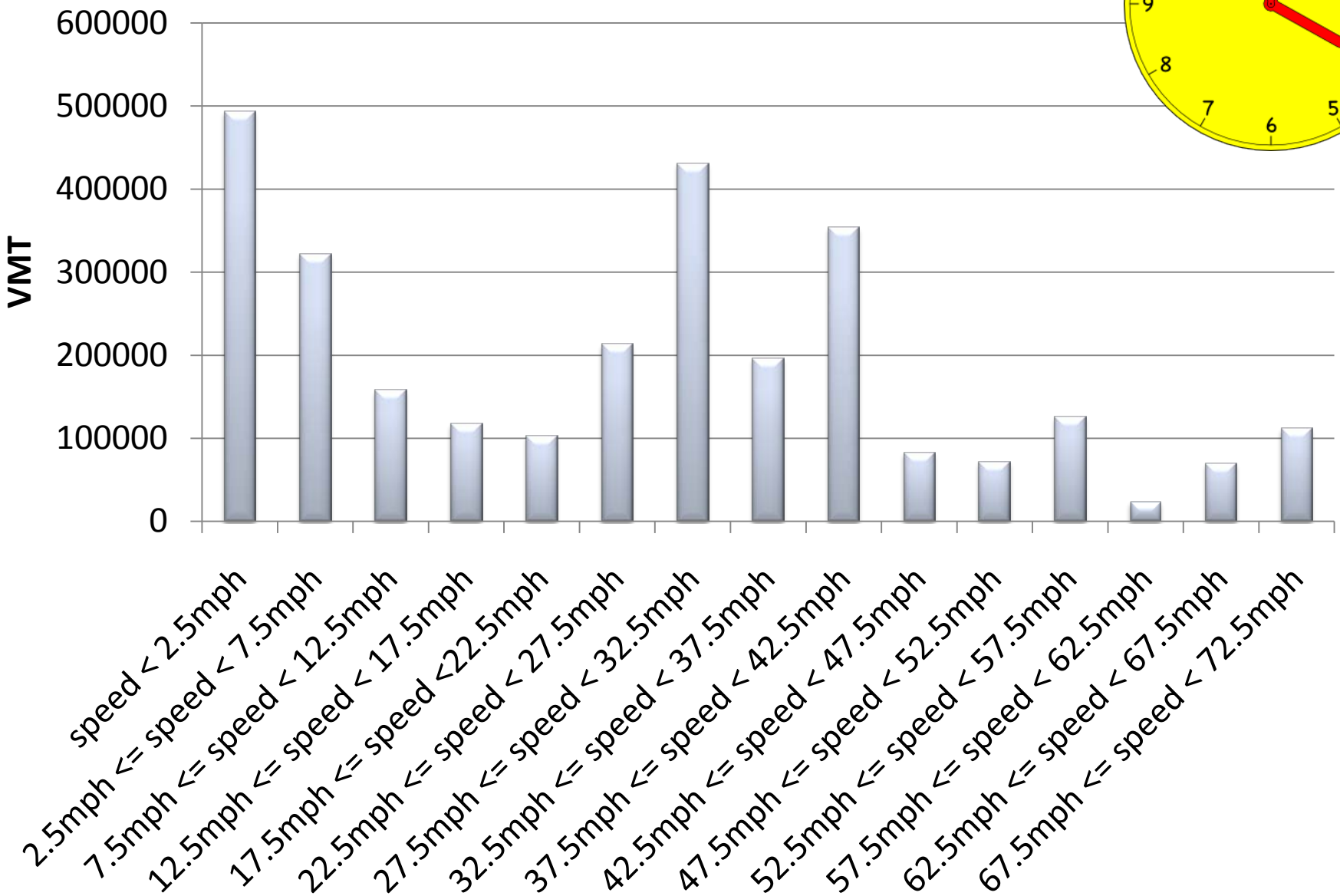

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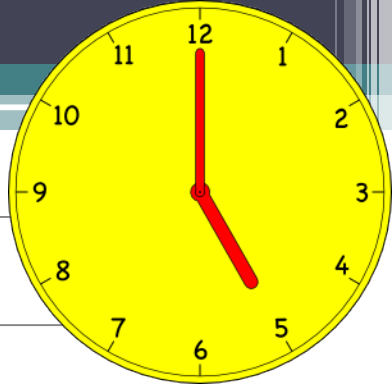

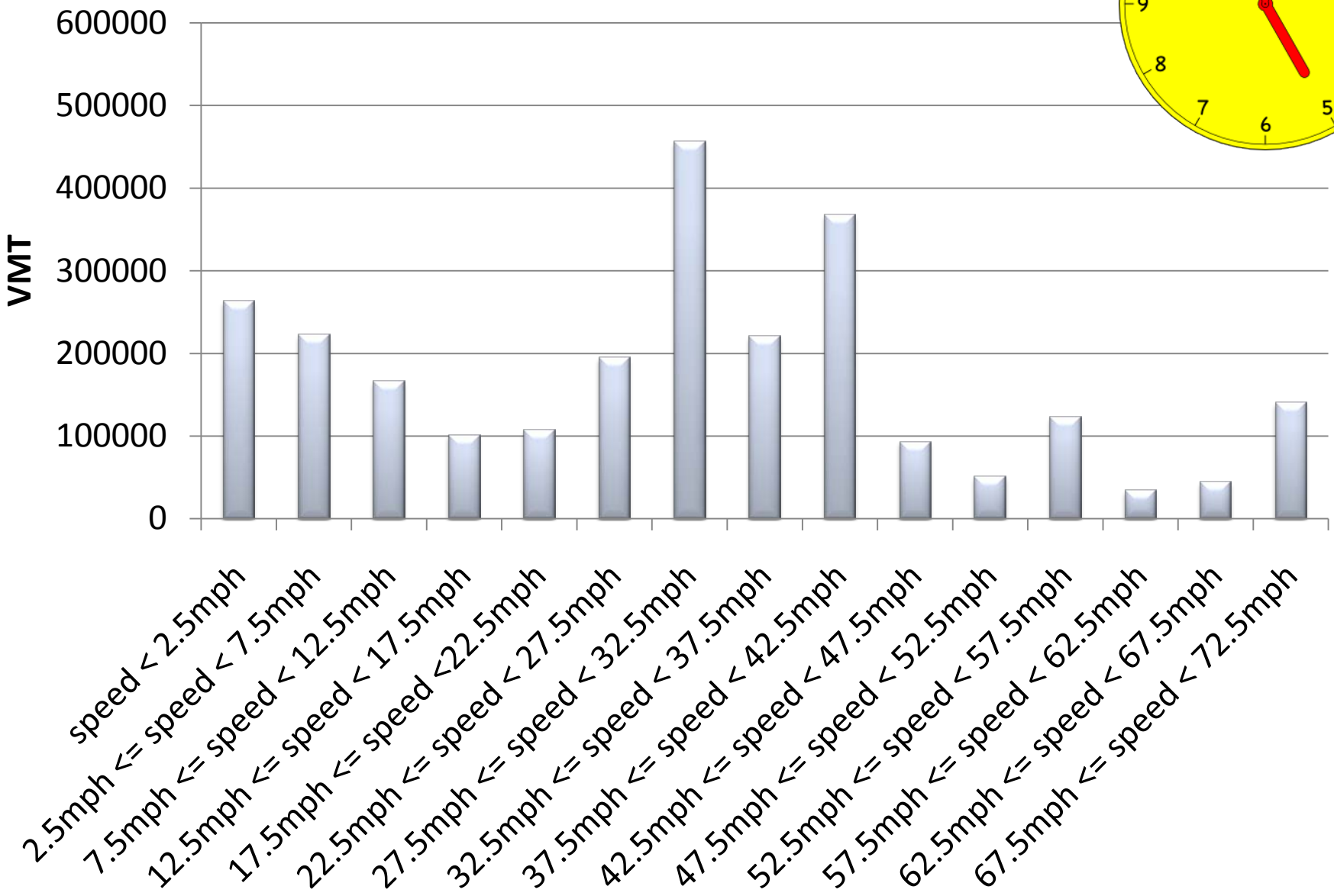

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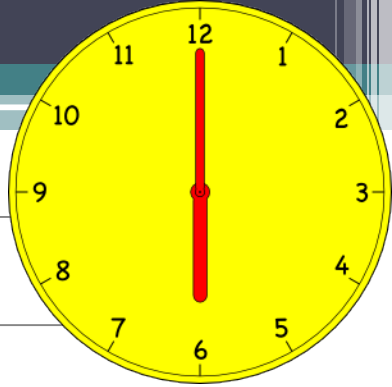

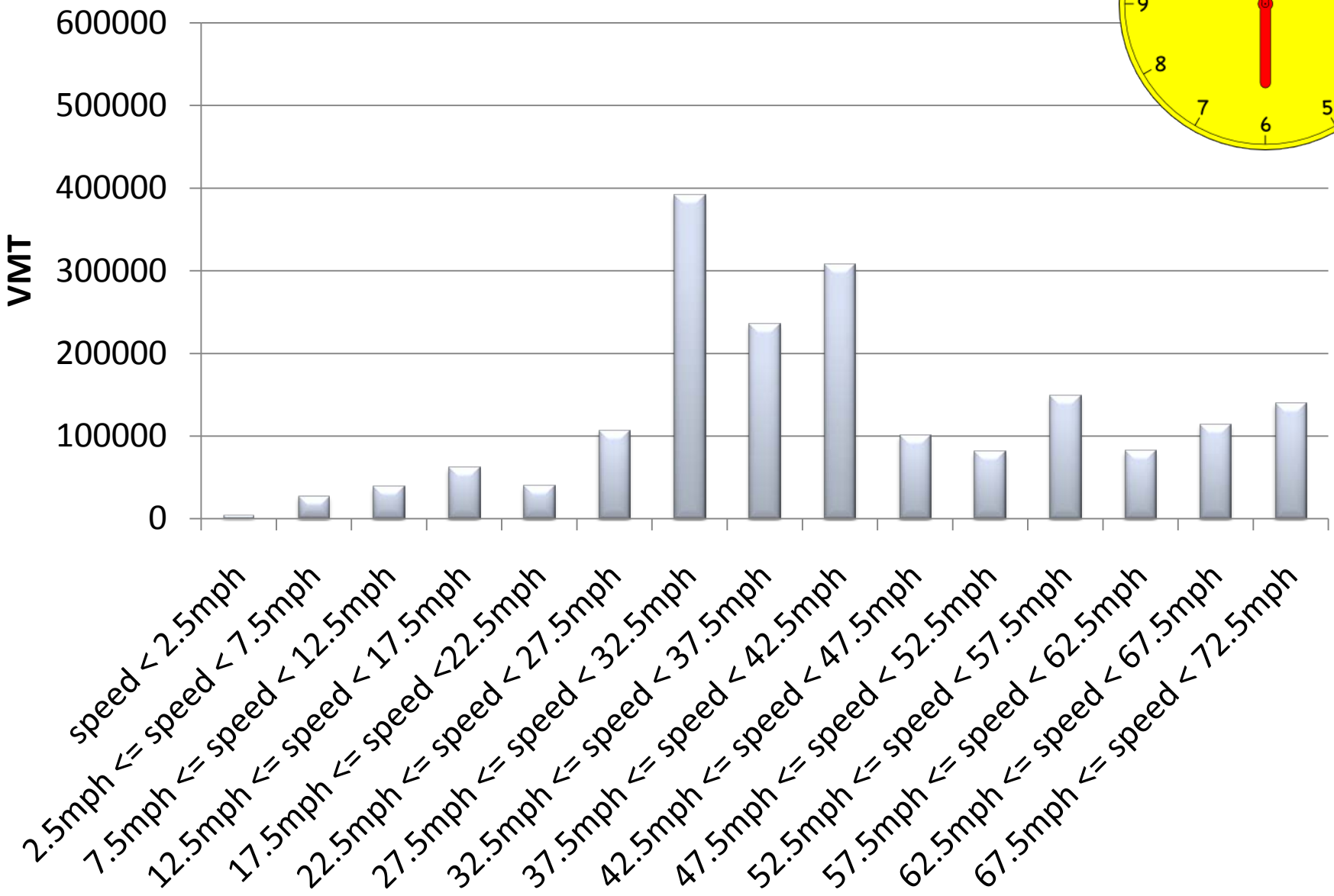

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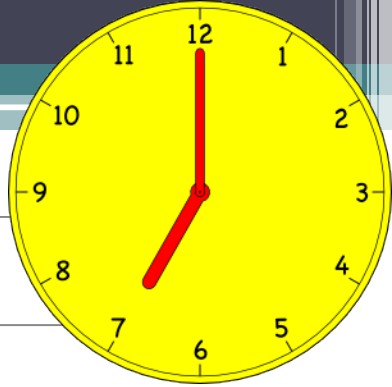

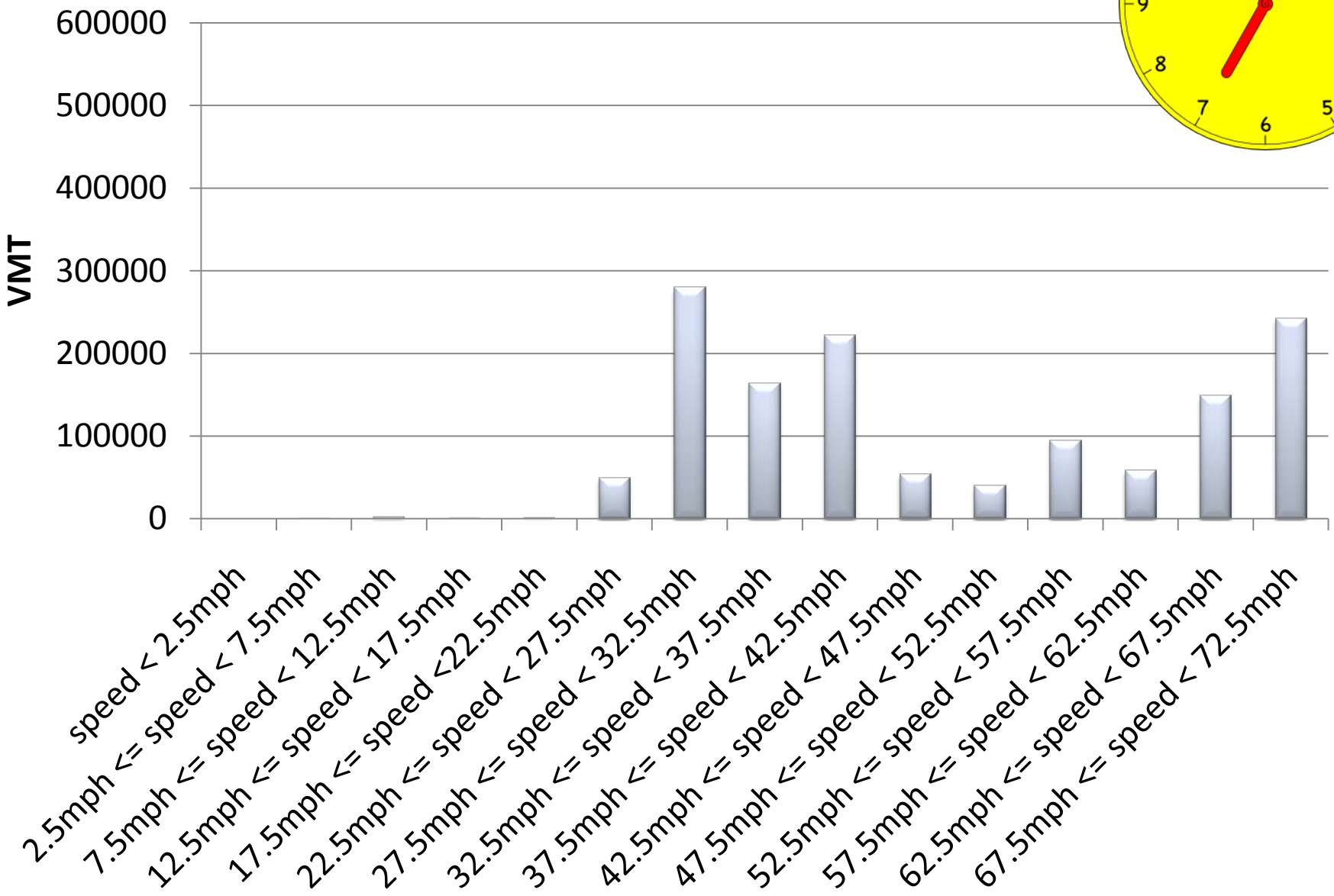

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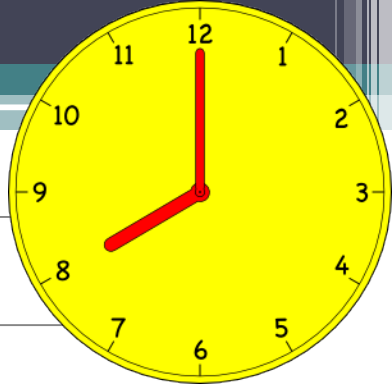

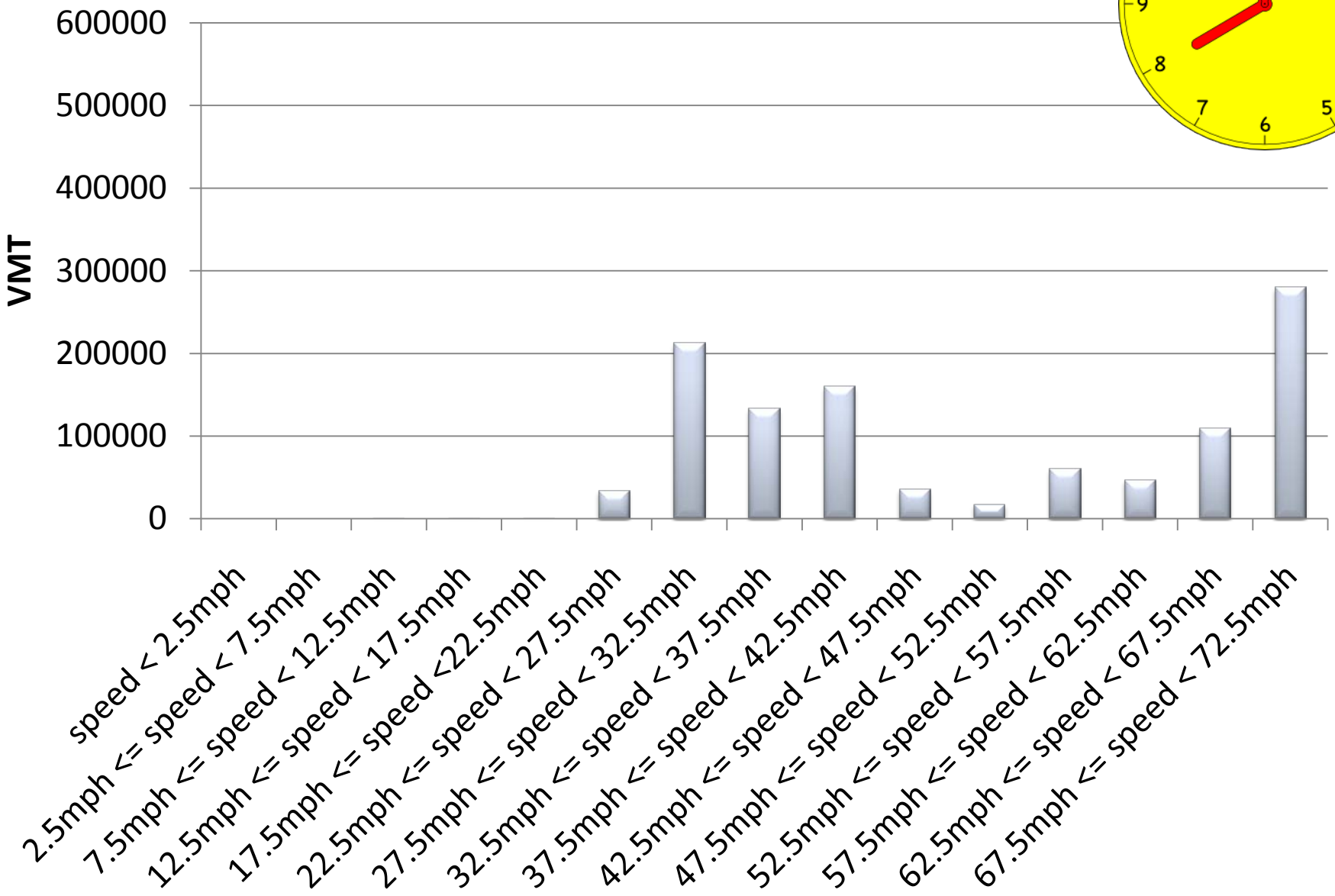

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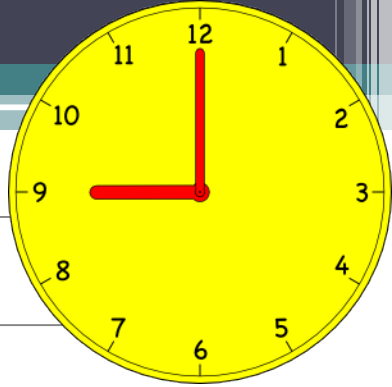


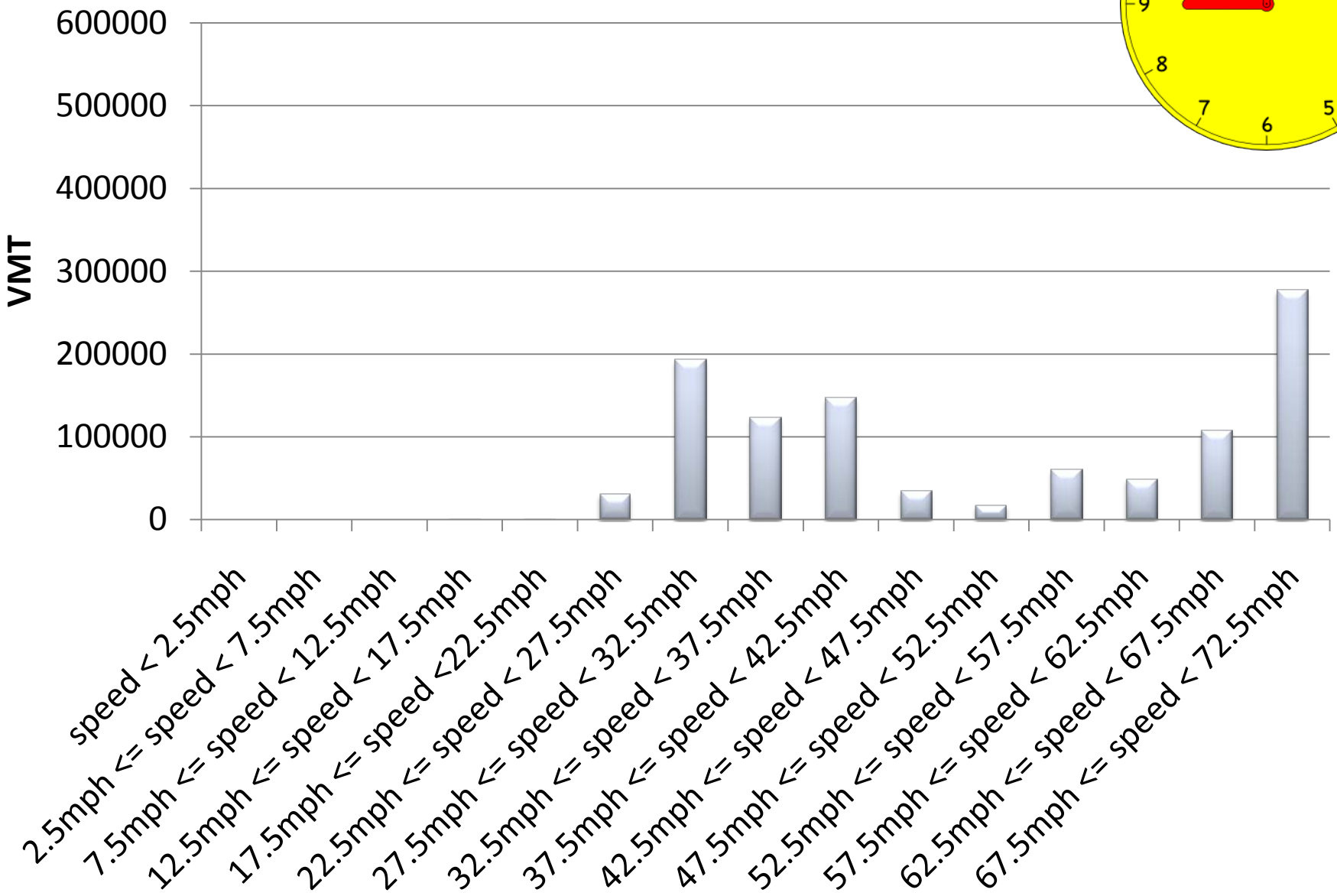

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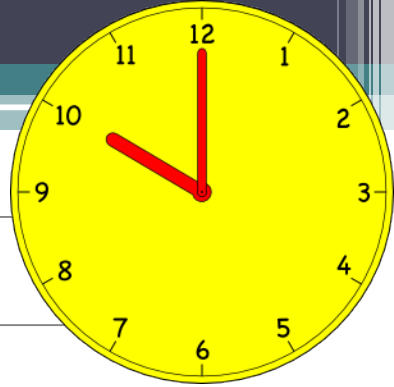
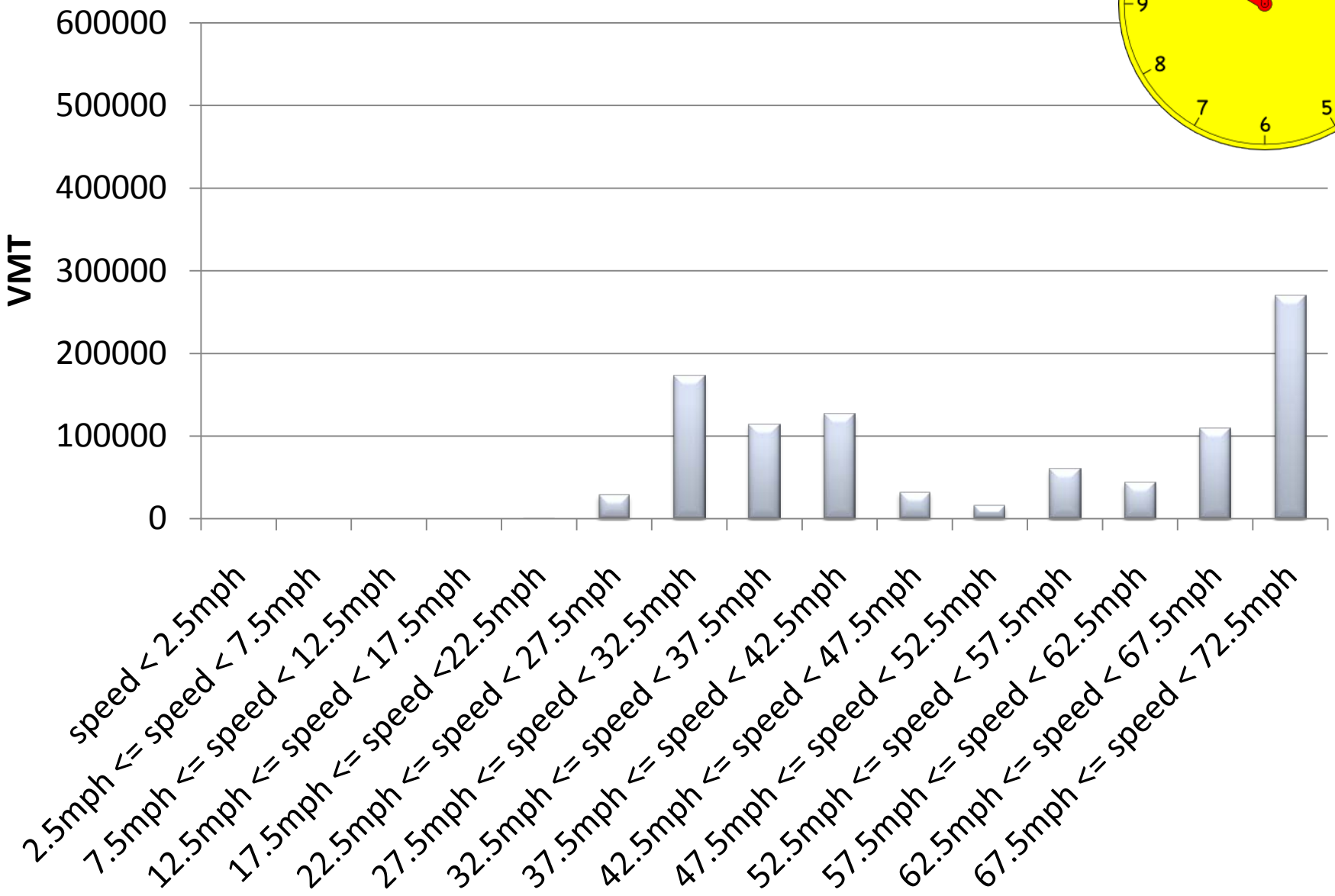
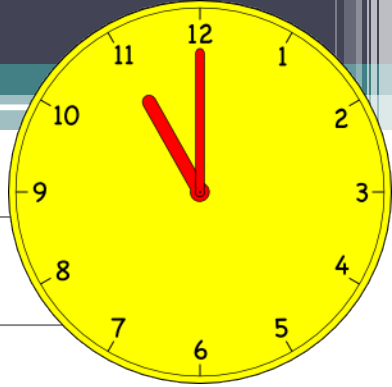
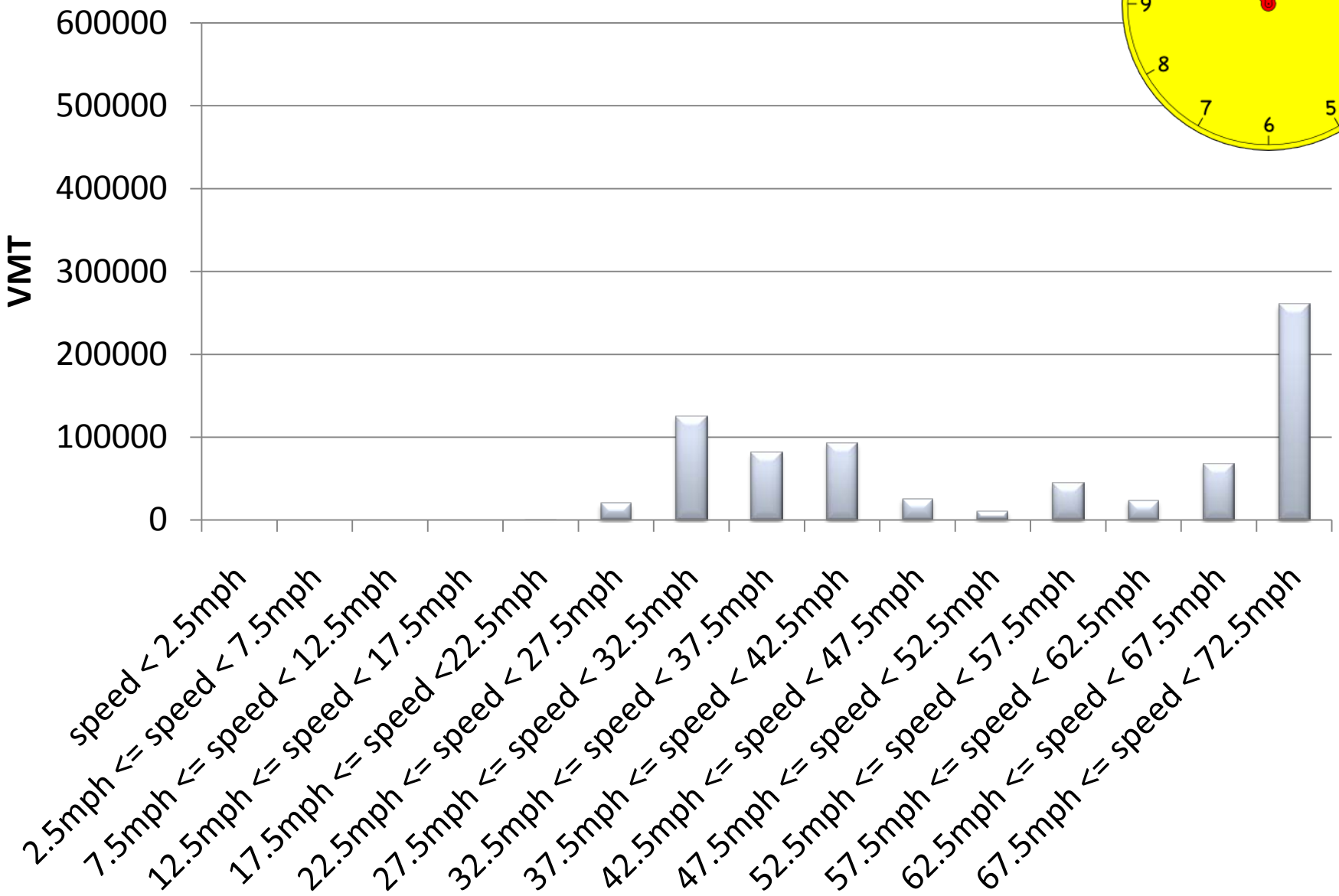




# VMT by Average Speed



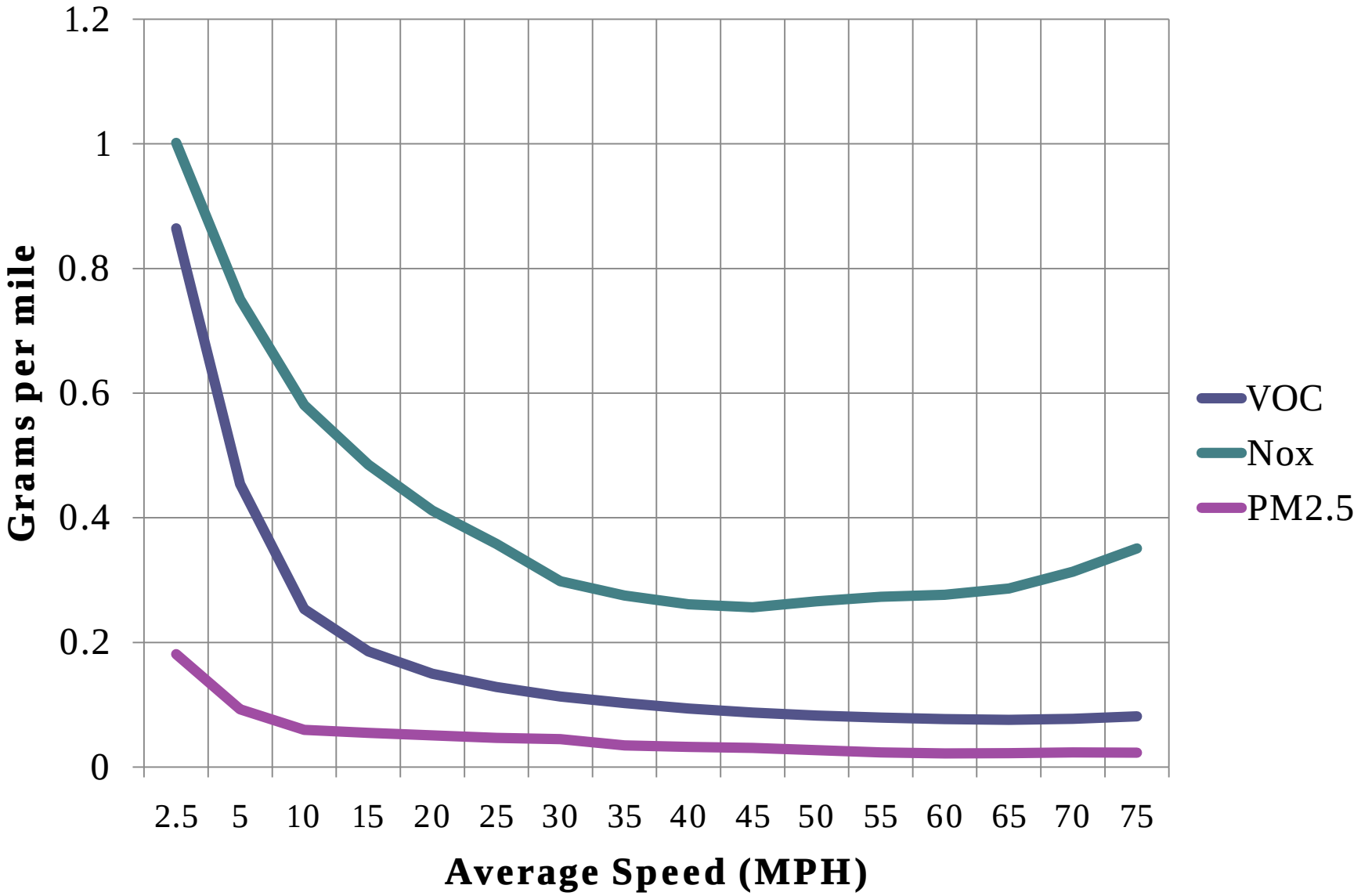


# MOVES Output and Post-Processing

# Emission Rate Tables

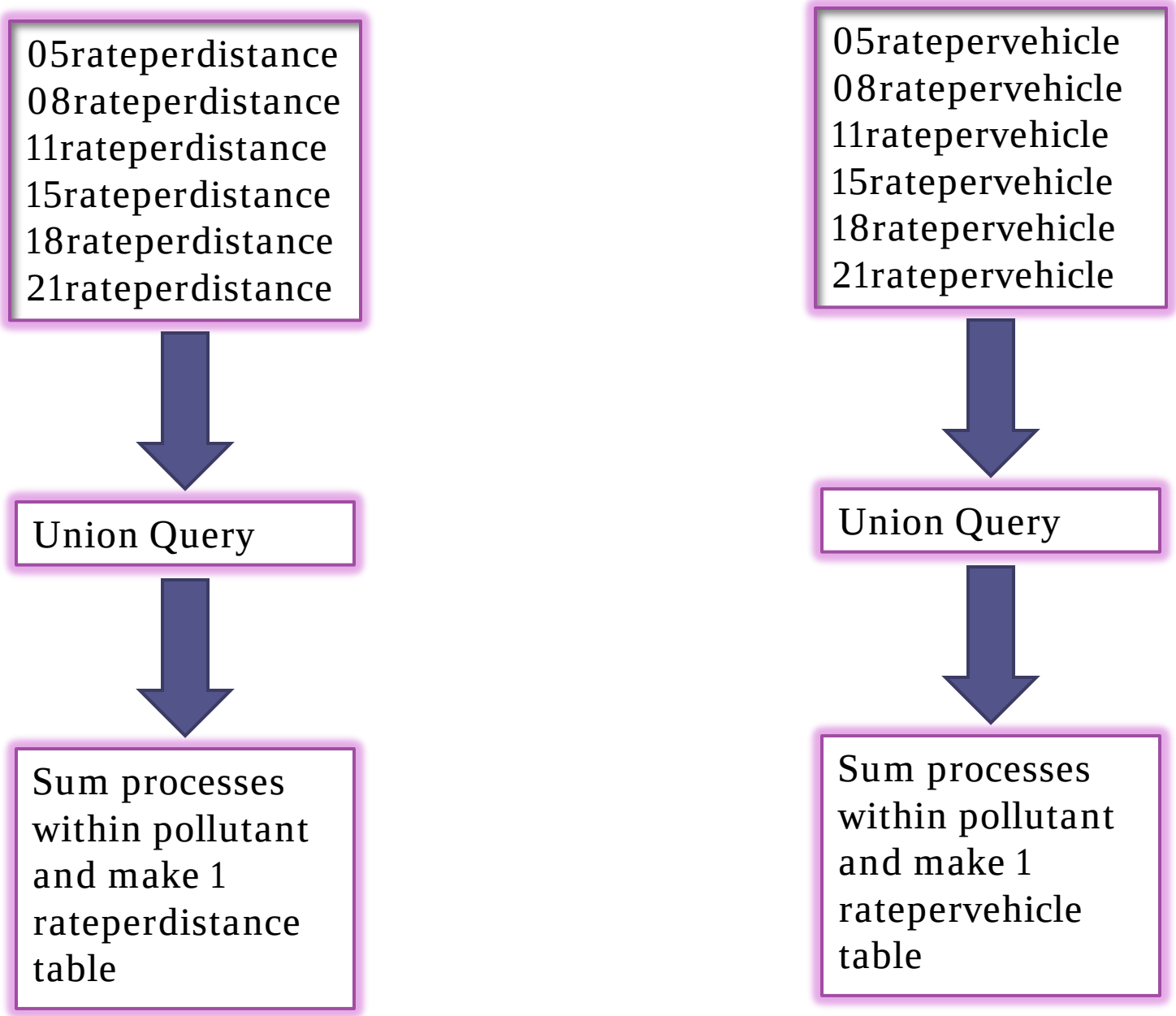
- Rate per Distance
  - Running exhaust, brakewear, tirewear
  - Grams per mile (unit setting in runspec)
  - Rate for each year, hour, source (vehicle) type, road type, speed bin, pollutant and process
- Rate per Vehicle
  - Start and idle exhaust
  - Grams per vehicle population
  - Rate for each year, hour, vehicle type, pollutant and process
- Rate per Profile
  - Evaporative emissions when vehicles are stationary and engine off (VOC's and hydrocarbons only)
  - Grams per vehicle population
  - Rate for each year, hour, vehicle type, pollutant and process

# MOVES
## Running Emissions by Speed



# Using Rate Tables

- MOVES native format is SQL
- Use MS Access, SQL Query browser or other database
- Access: Create ODBC connection and import rate tables
  - 24 rate tables for PM2.5 SIP: 2 domains, 6 analysis years, 2 types of rates (distance and vehicle, no evaporative)
  - Run union query for each rate type
  - Sum rates for all processes within pollutant type
    - Result - 1 rate per distance table and 1 rate per vehicle table


05rateperdistance
08rateperdistance
11rateperdistance
15rateperdistance
18rateperdistance
21rateperdistance
Union Query
Sum processes within pollutant and make 1 rateperdistance table
05ratepervehicle
08ratepervehicle
11ratepervehicle
15ratepervehicle
18ratepervehicle
21ratepervehicle
Union Query
Sum processes within pollutant and make 1 ratepervehicle table

# Distance-Based Emissions : Create VMT Table

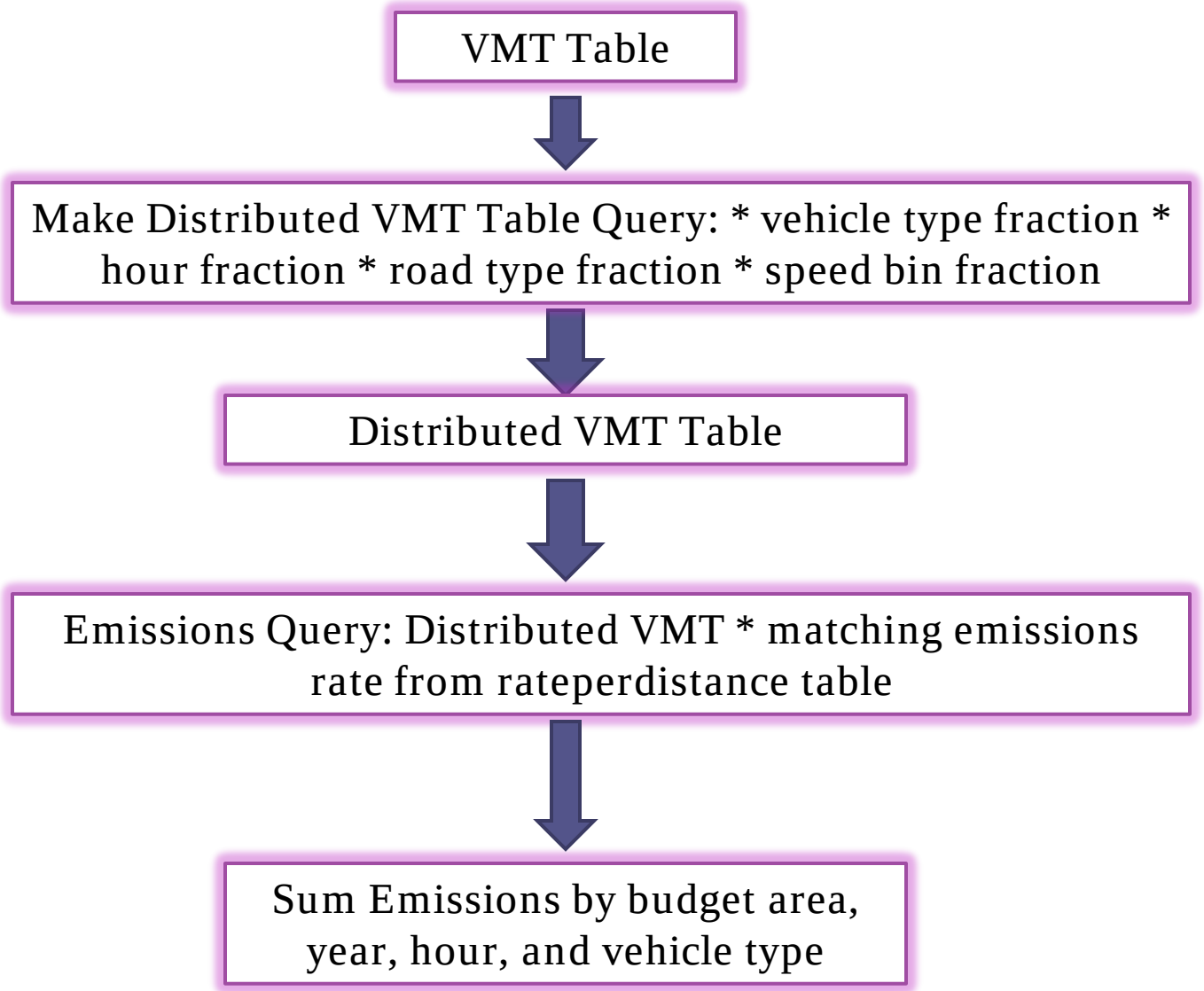
- Table of VMT by domain and analysis year; import from Travel Demand Model
- Distribute VMT by source type, hour, road type and speed bin.

# VMT Table

| budgetID | yearID | Daily VMT | Summer VMT | Annual VMT |
|---|---|---|---|---|
| Kentucky Portion of NA Area | 2005 | 10,138,077 | 10,805,746 | 3,289,109,246 |
| Kentucky Portion of NA Area | 2008 | 10,343,458 | 11,036,353 | 3,425,339,551 |
| Kentucky Portion of NA Area | 2011 | 10,855,202 | 11,592,187 | 3,587,796,233 |
| Kentucky Portion of NA Area | 2015 | 11,955,024 | 12,735,488 | 3,931,385,794 |
| Kentucky Portion of NA Area | 2018 | 12,661,272 | 13,436,728 | 4,163,203,491 |
| Kentucky Portion of NA Area | 2021 | 130,42,657 | 13,874,855 | 4,286,834,417 |
| Ohio/Indiana Portion of NA Area | 2005 | 40,857,926 | 43,229,591 | 13,541,310,549 |
| Ohio/Indiana Portion of NA Area | 2008 | 41,777,597 | 44,257,788 | 14,015,740,949 |
| Ohio/Indiana Portion of NA Area | 2011 | 42,978,171 | 45,565,916 | 14,383,512,129 |
| Ohio/Indiana Portion of NA Area | 2015 | 44,399,285 | 47,028,020 | 14,830,438,318 |
| Ohio/Indiana Portion of NA Area | 2018 | 46,441,595 | 49,192,864 | 15,513,686,243 |
| Ohio/Indiana Portion of NA Area | 2021 | 47,849,498 | 50,682,449 | 15,521,900,856 |

| VMT Distribution | Source |
| --- | --- |
| Hourly | 24-hour traffic counts. By road type |
| Road type (5 types) | Travel Demand Model – By domain, year, sourcetype. Identical distribution for all ST except default for combination trucks. Off-network (roadtype 1 = 0) |
| Average Speed (16 bins) | Travel Demand Model – By domain, year, road type, hour |
| Source (vehicle) type (13 types) | MOVES default national run for representative county. Source type VMT/Total VMT. |

# Calculate Distance Based Emissions



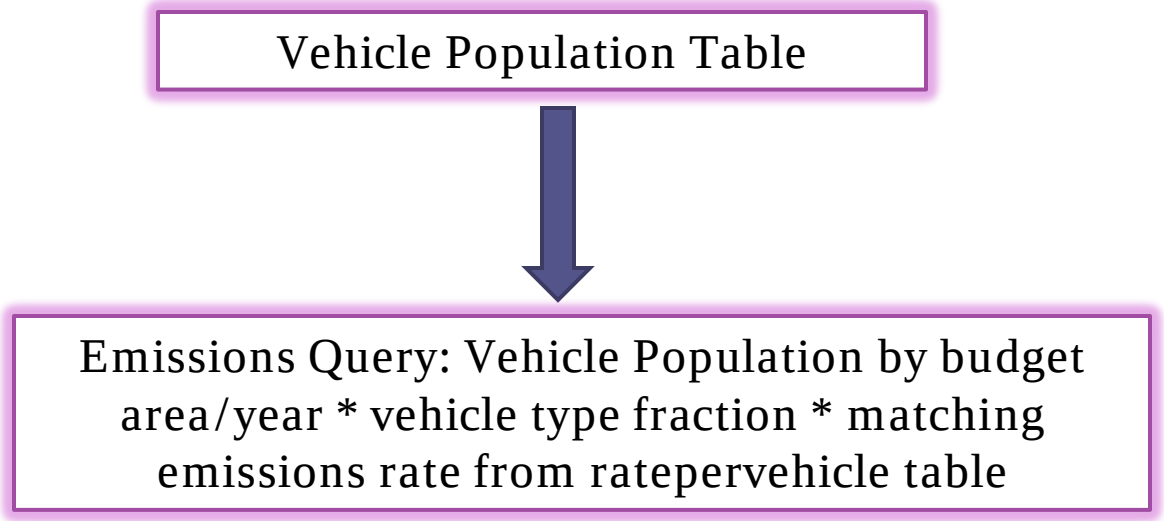
# Vehicle-based Emissions

- Create vehicle population table by year
- Assumption:
  - Vehicle population growth rate = regions household growth rate (o.8% annually)
- MOVES builds the start fraction into the rates
- Multiply by vehicle type population distribution table

# Vehicle Population Table

| budgetID | yearID | SourceTypePopulation |
|---|---|---|
| Kentucky Portion of NA Area | 2005 | 364081 |
| Kentucky Portion of NA Area | 2008 | 375873 |
| Kentucky Portion of NA Area | 2011 | 381911 |
| Kentucky Portion of NA Area | 2015 | 394278 |
| Kentucky Portion of NA Area | 2018 | 403817 |
| Kentucky Portion of NA Area | 2021 | 413587 |
| Ohio/Indiana Portion of NA Area | 2005 | 1754582 |
| Ohio/Indiana Portion of NA Area | 2008 | 1811406 |
| Ohio/Indiana Portion of NA Area | 2011 | 1840505 |
| Ohio/Indiana Portion of NA Area | 2015 | 1900111 |
| Ohio/Indiana Portion of NA Area | 2018 | 1946080 |
| Ohio/Indiana Portion of NA Area | 2021 | 1993161 |

# Calculate Vehicle Based Emissions



# Generate Emissions Report

- Sum distance and vehicle emissions
- Group by budget area, year and pollutant

## Table 1. Mobile Source Emissions for the Cincinnati PM2.5 Nonattainment Area (tons)

**Kentucky Portion of NA Area**

| Year | Pollutant Name | DailyEmissions | AnnualEmissions |
|---|---|---|---|
| **2005** | Vehicle Population: 364,081 Daily VMT: 9,621,110 Annual VMT: 3,289,109,202 | | |
| | **Oxides of Nitrogen** | 39.10 | 13,496.54 |
| | **Primary Exhaust PM2.5 - Total** | 1.36 | 466.23 |
| | **Primary PM2.5 - Brakewear Particulate** | 0.16 | 54.04 |
| | **Primary PM2.5 - Tirewear Particulate** | 0.05 | 17.52 |
| | **Sulfur Dioxide (SO2)** | 0.12 | 41.46 |
| **2008** | Vehicle Population: 375,873 Daily VMT: 9,991,179 Annual VMT: 3,425,339,505 | | |
| | **Oxides of Nitrogen** | 37.91 | 13,114.20 |
| | **Primary Exhaust PM2.5 - Total** | 1.64 | 562.84 |
| | **Primary PM2.5 - Brakewear Particulate** | 0.18 | 62.10 |
| | **Primary PM2.5 - Tirewear Particulate** | 0.06 | 20.70 |
| | **Sulfur Dioxide (SO2)** | 0.12 | 42.74 |
| **2011** | Vehicle Population: 381,911 Daily VMT: 10,490,143 Annual VMT: 3,587,796,186 | | |
| | **Oxides of Nitrogen** | 29.33 | 10,141.52 |
| | **Primary Exhaust PM2.5 - Total** | 1.19 | 407.74 |
| | **Primary PM2.5 - Brakewear Particulate** | 0.20 | 68.38 |
| | **Primary PM2.5 - Tirewear Particulate** | 0.07 | 22.68 |
| | **Sulfur Dioxide (SO2)** | 0.13 | 45.36 |
| **2015** | Vehicle Population: 394,278 Daily VMT: 11,495,496 Annual VMT: 3,931,385,741 | | |
| | **Oxides of Nitrogen** | 20.18 | 6,996.21 |
| | **Primary Exhaust PM2.5 - Total** | 0.78 | 267.30 |
| | **Primary PM2.5 - Brakewear Particulate** | 0.23 | 77.94 |
| | **Primary PM2.5 - Tirewear Particulate** | 0.08 | 25.88 |
| | **Sulfur Dioxide (SO2)** | 0.15 | 50.50 |
| **2018** | Vehicle Population: 403,817 Daily VMT: 12,173,549 Annual VMT: 4,163,203,435 | | |
| | **Oxides of Nitrogen** | 15.78 | 5,480.81 |
| | **Primary Exhaust PM2.5 - Total** | 0.59 | 202.15 |
| | **Primary PM2.5 - Brakewear Particulate** | 0.27 | 91.15 |
| | **Primary PM2.5 - Tirewear Particulate** | 0.09 | 30.09 |
| | **Sulfur Dioxide (SO2)** | 0.16 | 56.28 |
| **2021** | Vehicle Population: 413,587 Daily VMT: 12,534,236 Annual VMT: 4,286,834,360 | | |
| | **Oxides of Nitrogen** | 12.75 | 4,435.96 |
| | **Primary Exhaust PM2.5 - Total** | 0.43 | 146.79 |
| | **Primary PM2.5 - Brakewear Particulate** | 0.28 | 96.84 |
| | **Primary PM2.5 - Tirewear Particulate** | 0.09 | 31.74 |
| | **Sulfur Dioxide (SO2)** | 0.17 | 58.63 |

| Year | Pollutant Name | DailyEmissions | AnnualEmissions |
|---|---|---|---|

**Ohio/Indiana Portion of NA Area**

**2005** Vehicle Population: 1,754,582 Daily VMT: 39,564,030 Annual VMT: 13,541,324,003

| | | |
|---|---|---|
| **Oxides of Nitrogen** | 168.89 | 58,423.36 |
| **Primary Exhaust PM2.5 - Total** | 5.74 | 1,979.63 |
| **Primary PM2.5 - Brakewear Particulate** | 0.65 | 223.20 |
| **Primary PM2.5 - Tirewear Particulate** | 0.20 | 69.67 |
| **Sulfur Dioxide (SO2)** | 0.48 | 165.35 |

**2008** Vehicle Population: 1,811,406 Daily VMT: 40,858,751 Annual VMT: 14,015,754,874

| | | |
|---|---|---|
| **Oxides of Nitrogen** | 148.02 | 51,357.02 |
| **Primary Exhaust PM2.5 - Total** | 4.85 | 1,675.04 |
| **Primary PM2.5 - Brakewear Particulate** | 0.80 | 273.84 |
| **Primary PM2.5 - Tirewear Particulate** | 0.25 | 85.37 |
| **Sulfur Dioxide (SO2)** | 0.54 | 185.13 |

**2011** Vehicle Population: 1,840,505 Daily VMT: 42,044,841 Annual VMT: 14,383,526,419

| | | |
|---|---|---|
| **Oxides of Nitrogen** | 135.95 | 47,061.53 |
| **Primary Exhaust PM2.5 - Total** | 5.54 | 1,904.61 |
| **Primary PM2.5 - Brakewear Particulate** | 0.85 | 290.00 |
| **Primary PM2.5 - Tirewear Particulate** | 0.27 | 91.52 |
| **Sulfur Dioxide (SO2)** | 0.53 | 182.01 |

**2015** Vehicle Population: 1,900,111 Daily VMT: 43,316,281 Annual VMT: 14,830,453,053

| | | |
|---|---|---|
| **Oxides of Nitrogen** | 89.45 | 31,064.21 |
| **Primary Exhaust PM2.5 - Total** | 3.57 | 1,227.86 |
| **Primary PM2.5 - Brakewear Particulate** | 0.82 | 280.25 |
| **Primary PM2.5 - Tirewear Particulate** | 0.26 | 90.54 |
| **Sulfur Dioxide (SO2)** | 0.53 | 182.69 |

**2018** Vehicle Population: 1,946,080 Daily VMT: 45,314,292 Annual VMT: 15,513,701,656

| | | |
|---|---|---|
| **Oxides of Nitrogen** | 70.34 | 24,451.43 |
| **Primary Exhaust PM2.5 - Total** | 2.78 | 958.57 |
| **Primary PM2.5 - Brakewear Particulate** | 0.90 | 307.39 |
| **Primary PM2.5 - Tirewear Particulate** | 0.29 | 99.03 |
| **Sulfur Dioxide (SO2)** | 0.57 | 195.09 |

**2021** Vehicle Population: 1,993,161 Daily VMT: 46,689,707 Annual VMT: 15,521,916,278

| | | |
|---|---|---|
| **Oxides of Nitrogen** | 55.50 | 18,911.05 |
| **Primary Exhaust PM2.5 - Total** | 2.10 | 705.30 |
| **Primary PM2.5 - Brakewear Particulate** | 0.96 | 320.17 |
| **Primary PM2.5 - Tirewear Particulate** | 0.31 | 102.89 |
| **Sulfur Dioxide (SO2)** | 0.60 | 199.14 |

# Advantage of Using Rates

- Use same rates across multiple counties
- Adjust only transportation system inputs (new travel model run)
  - VMT
  - Average speed
  - Road type
- Rerun MOVES on standard cycle (i.e. every 4 years) or when new analysis year required.

# Post-processing Lessons

- RunID's in MOVES rate tables;  Only use max #.
- Improve processing speed.  When distributing VMT, remove records where VMT = 0 (i.e. any fraction = 0)
- Include calculated VMT and vehicle type population in report – should match original.

# General EPA Comments

- More local data is better. Need to justify use of defaults.
- Some concern about calculating annual emissions from one set of annual average temperatures.
- OK to use MOVES for PM and MOBILE for ozone in same conformity analysis (until end of grace period)
- Good practice = Summary table of all RunSpec settings and CDM data sources.

# Contact Information

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