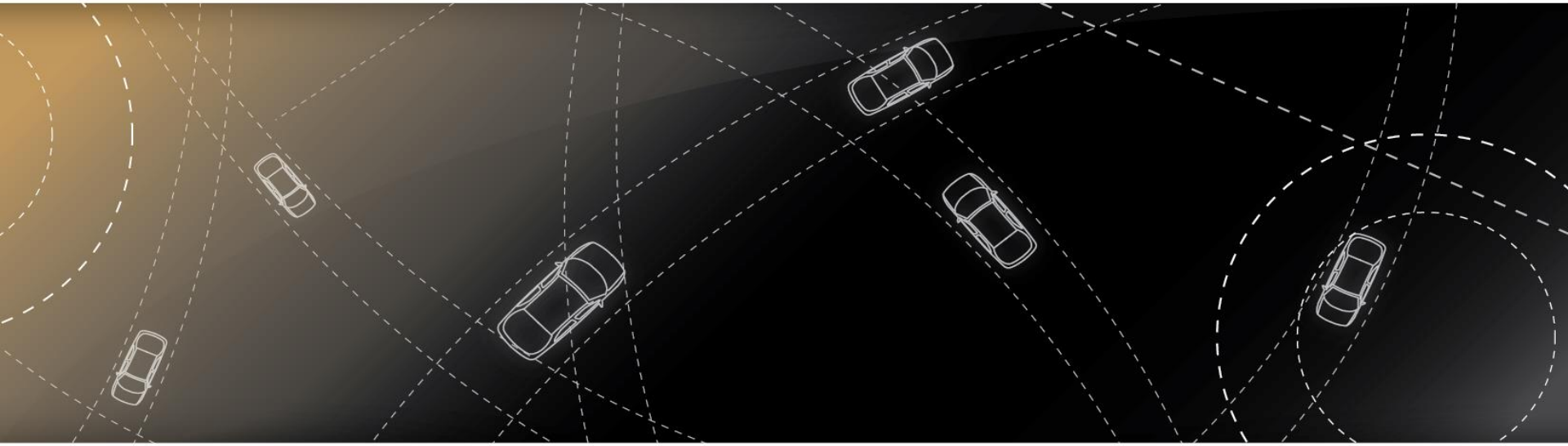
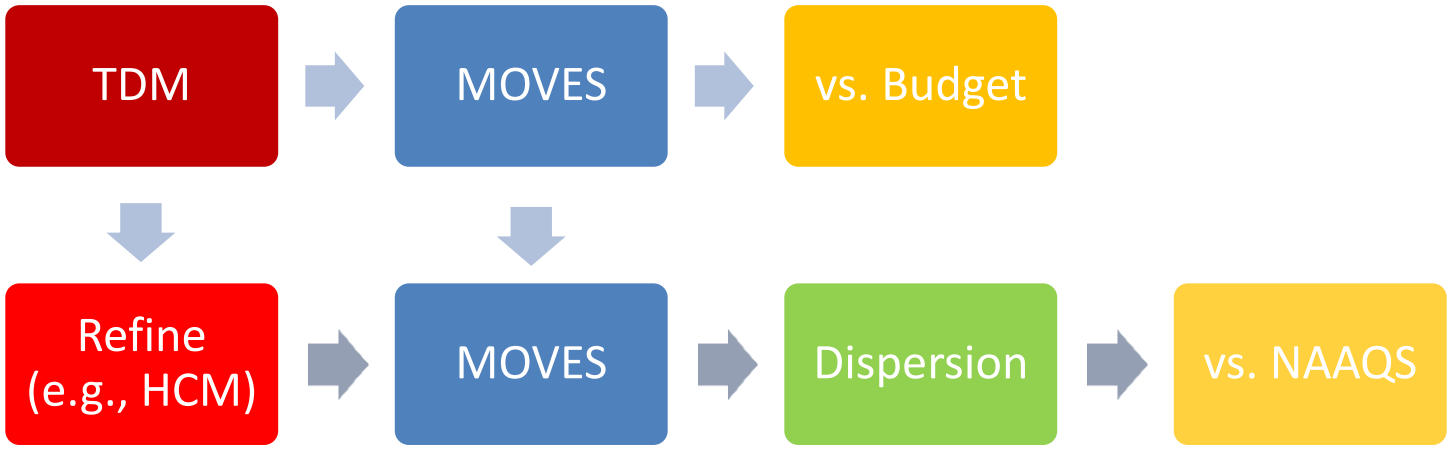


Models Used in Air Quality Analysis

September 15, 2016

Overview

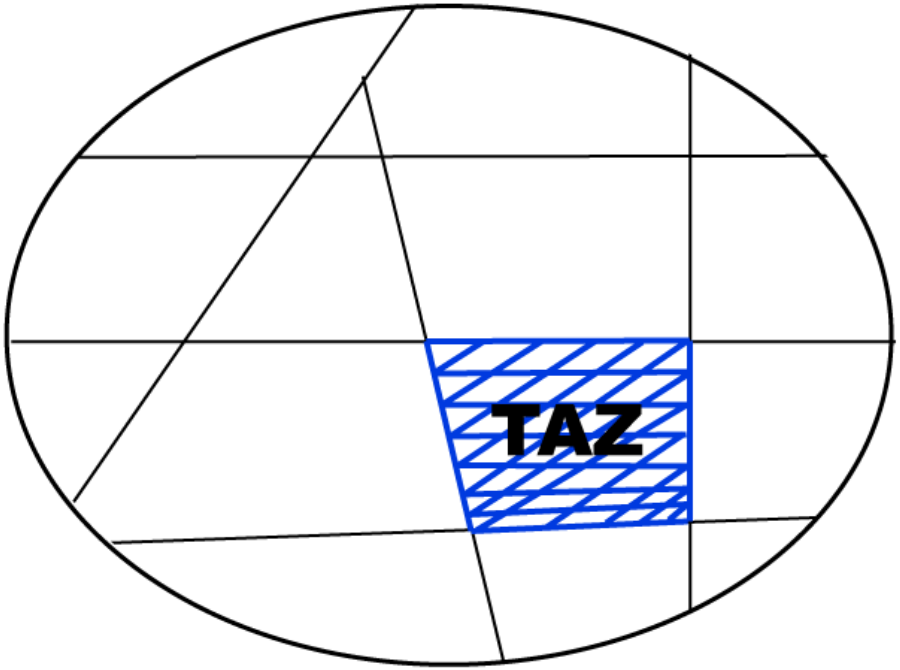
Regional Conformity



Project-Level (Hot-Spot) Conformity

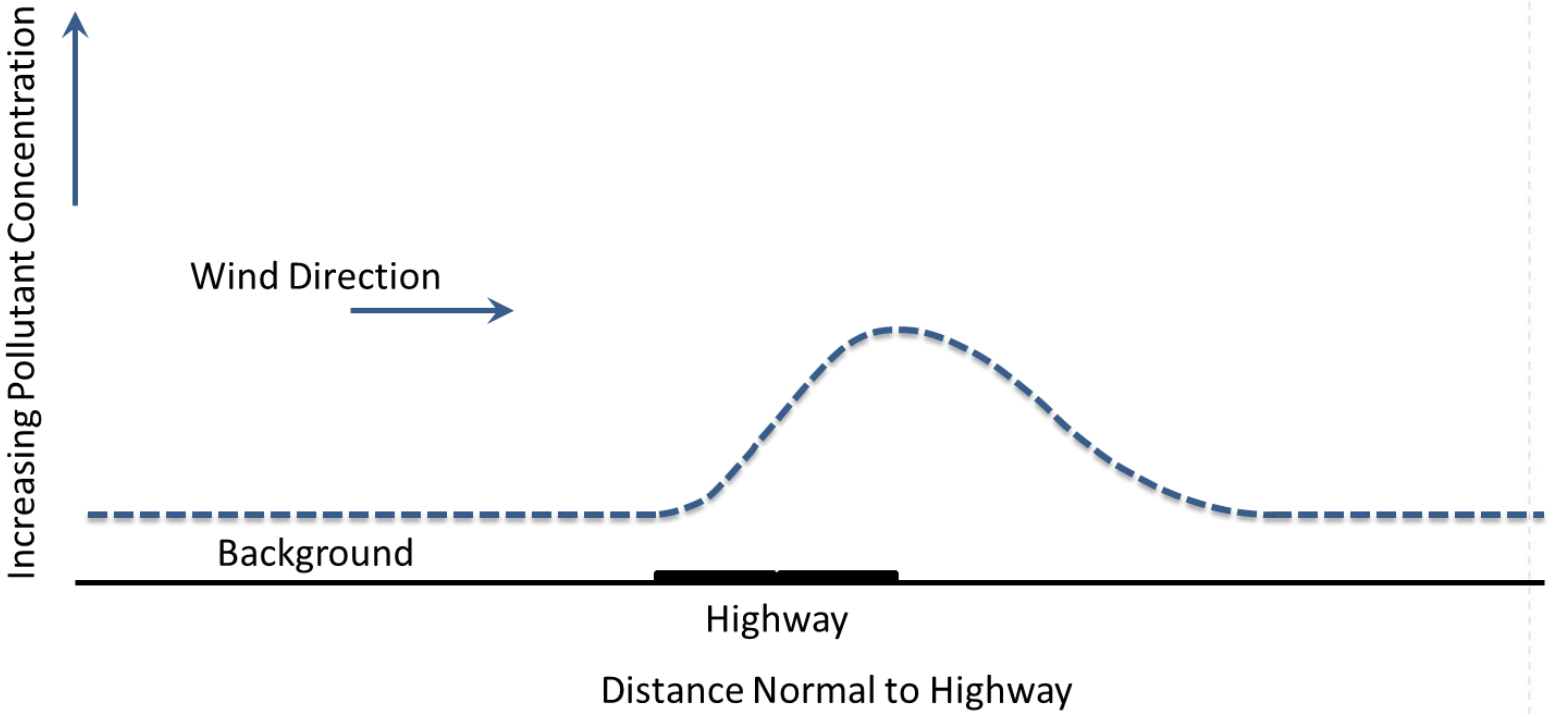
Traffic Considerations- Regional

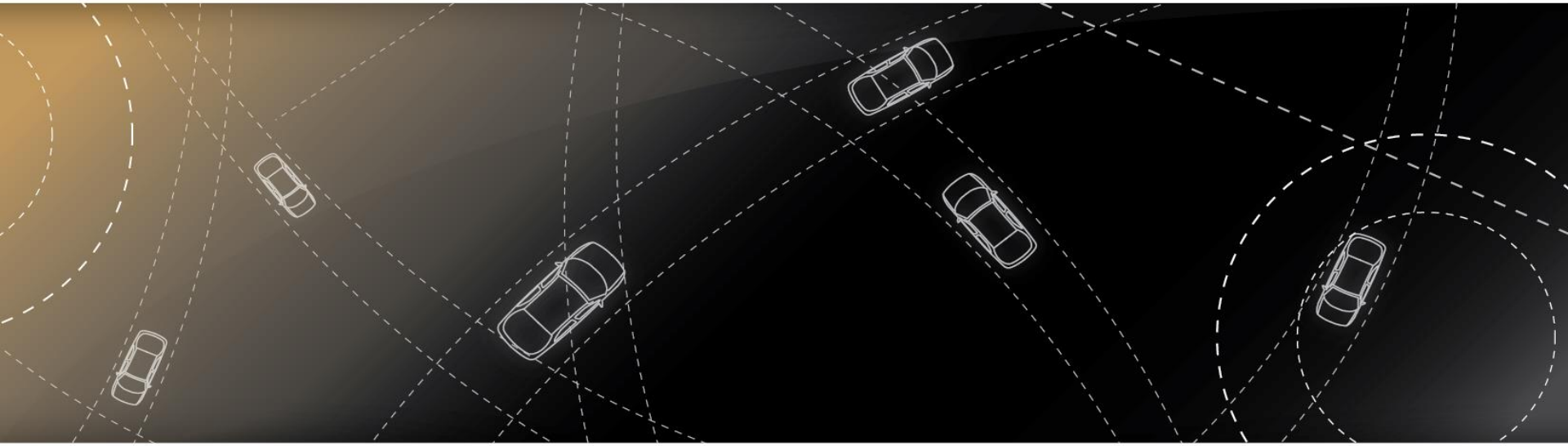
How is an Area Represented in Network Modeling?



Emission Estimation Process

Project Scale – Determining Ambient Concentrations





Models Used in Air Quality Analysis

Transportation Planning and Traffic Engineering

September 15, 2016

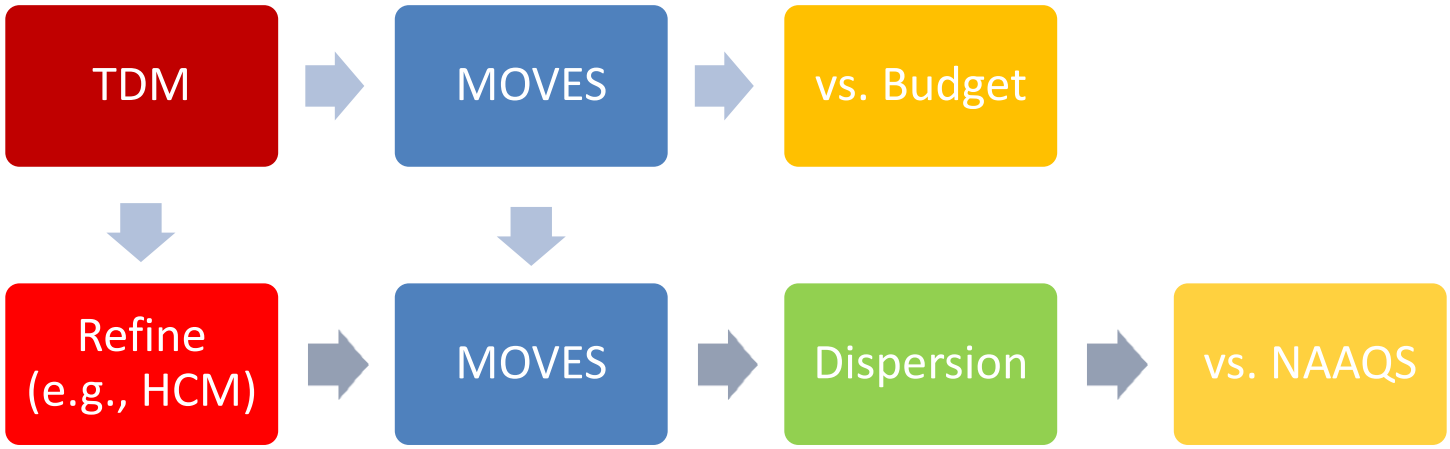
Traffic Considerations

- Training Objectives
  - Introduce Regional Traffic Data Concepts
  - Introduce Project-Level Traffic Concepts
  - Introduce the Role of Traffic Data in Air Quality Studies

A wide array of models and tools can be used. We won't cover any specifically, but look more broadly at the general concepts.

Traffic Considerations- Overview

Regional Conformity



Project-Level (Hot-Spot) Conformity

Traffic Considerations- Overview

- Key Factors
  - Traffic Volumes
  - Vehicle Speeds
- Data Sources
  - Historic Trends
  - Forecast Modeling
- Relationships
  - Exogenous
  - Endogenous

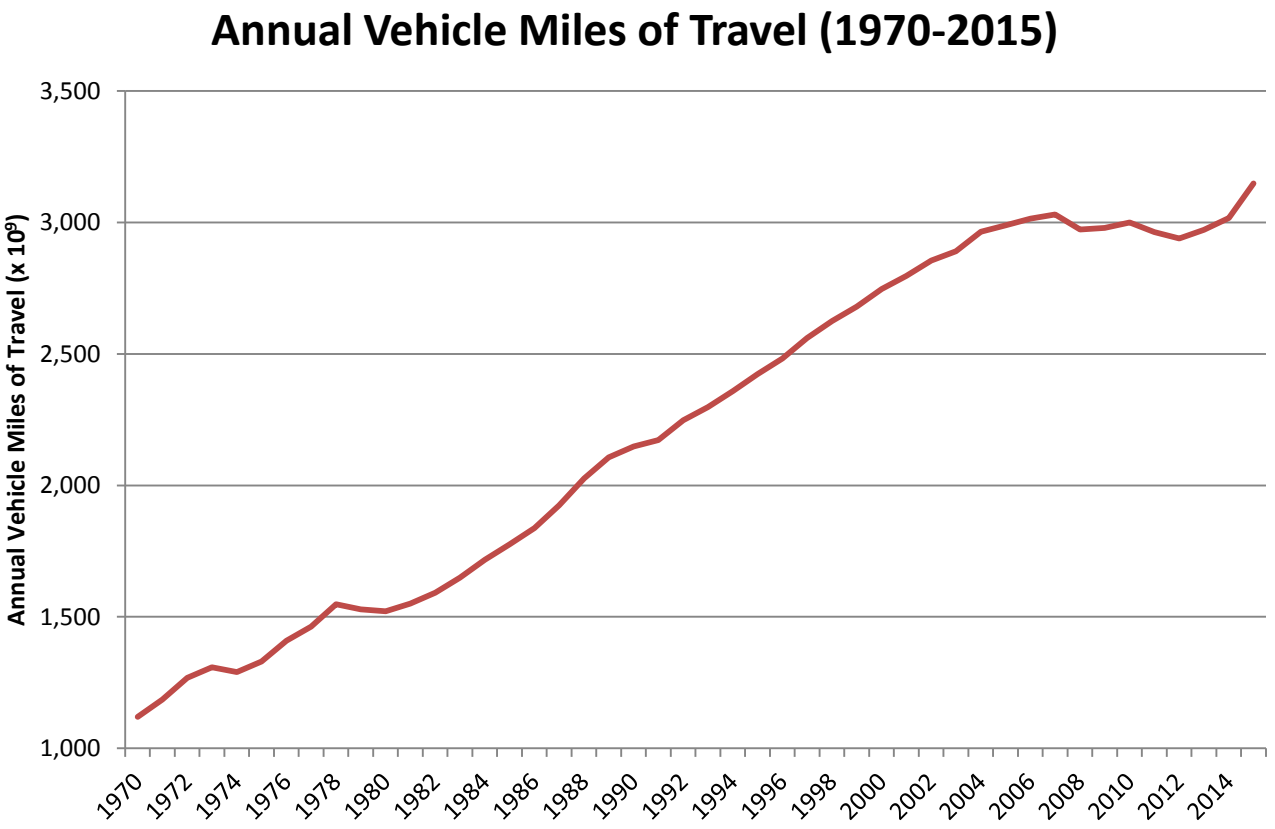
Traffic Considerations- Intro

- How is the traffic?
  - When?
  - Where?



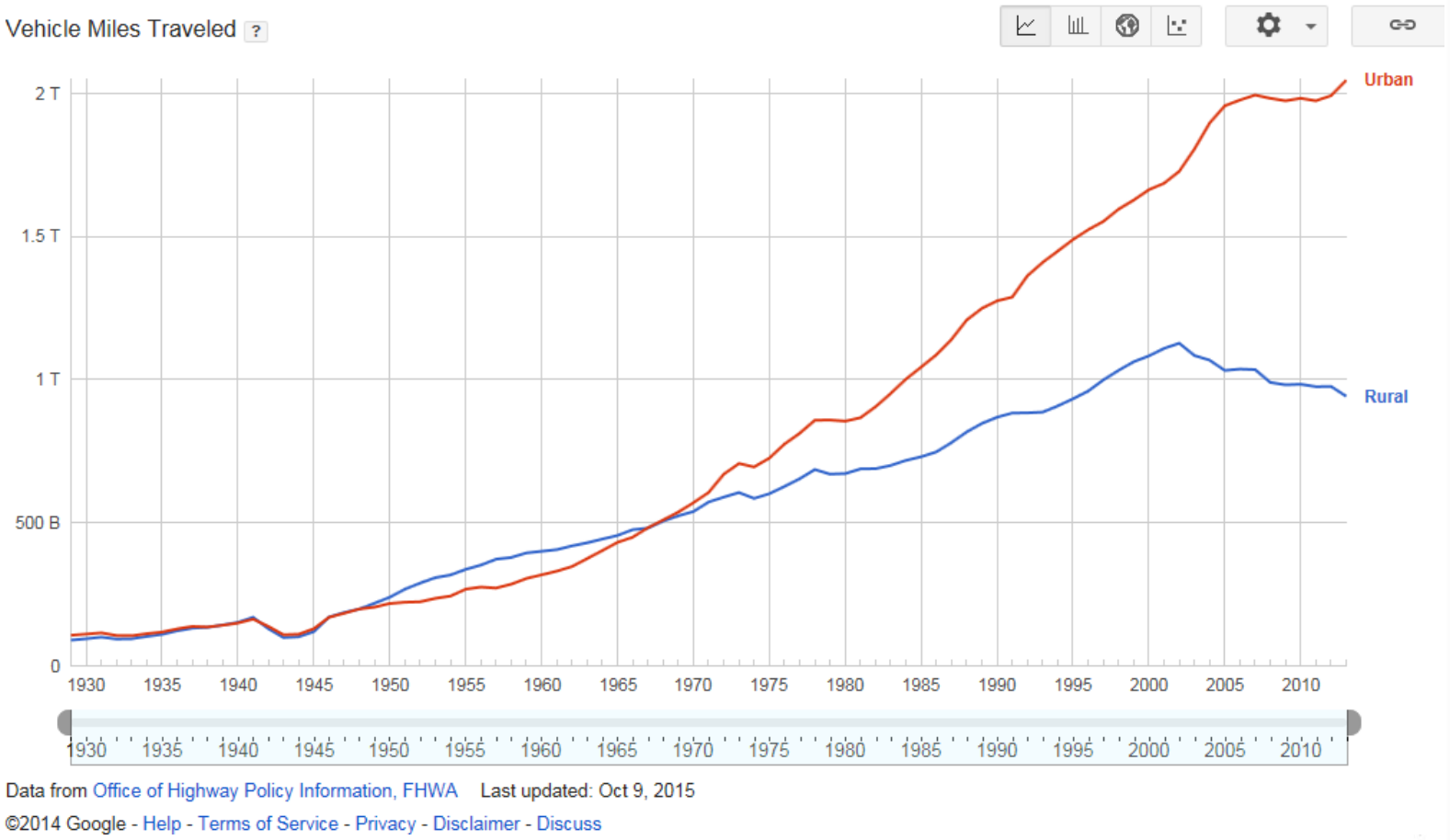
- The answer is a moving target!

Traffic Considerations- Intro



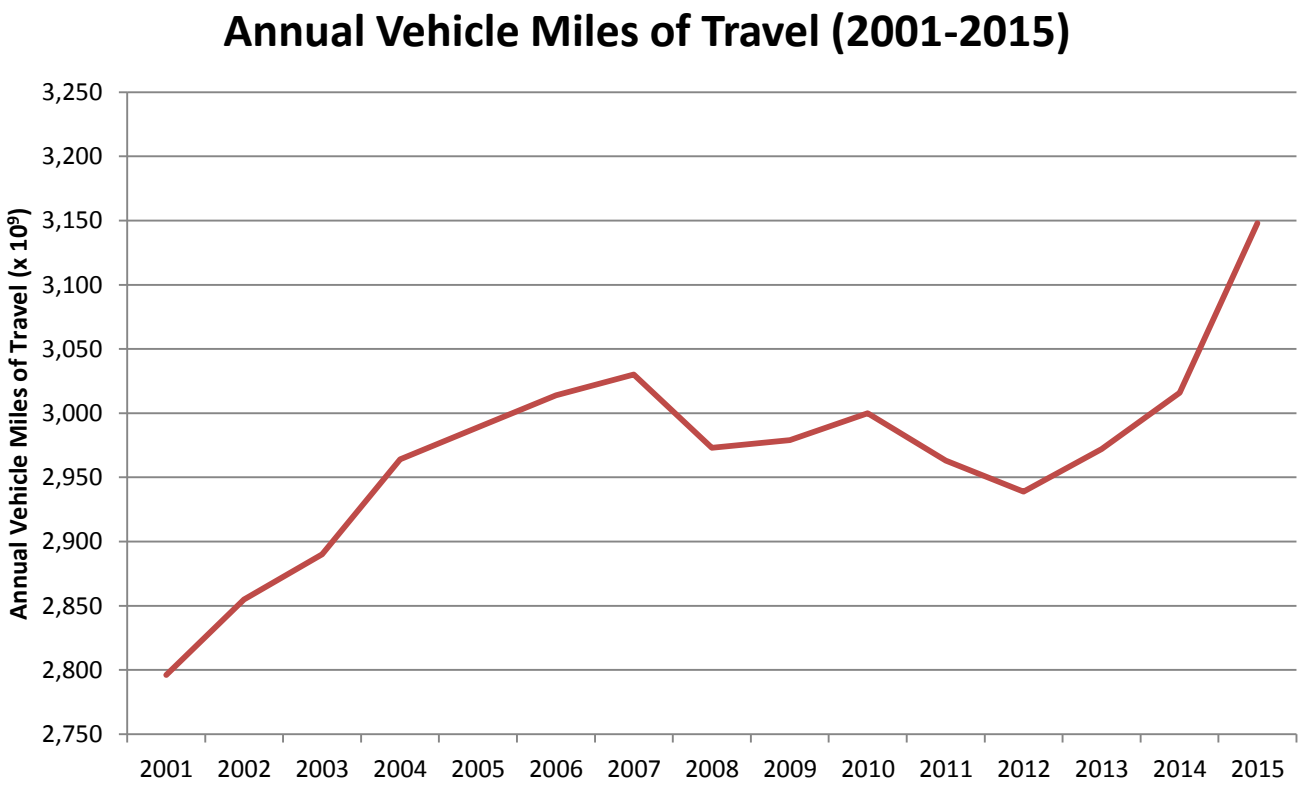
http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Traffic Considerations- Intro



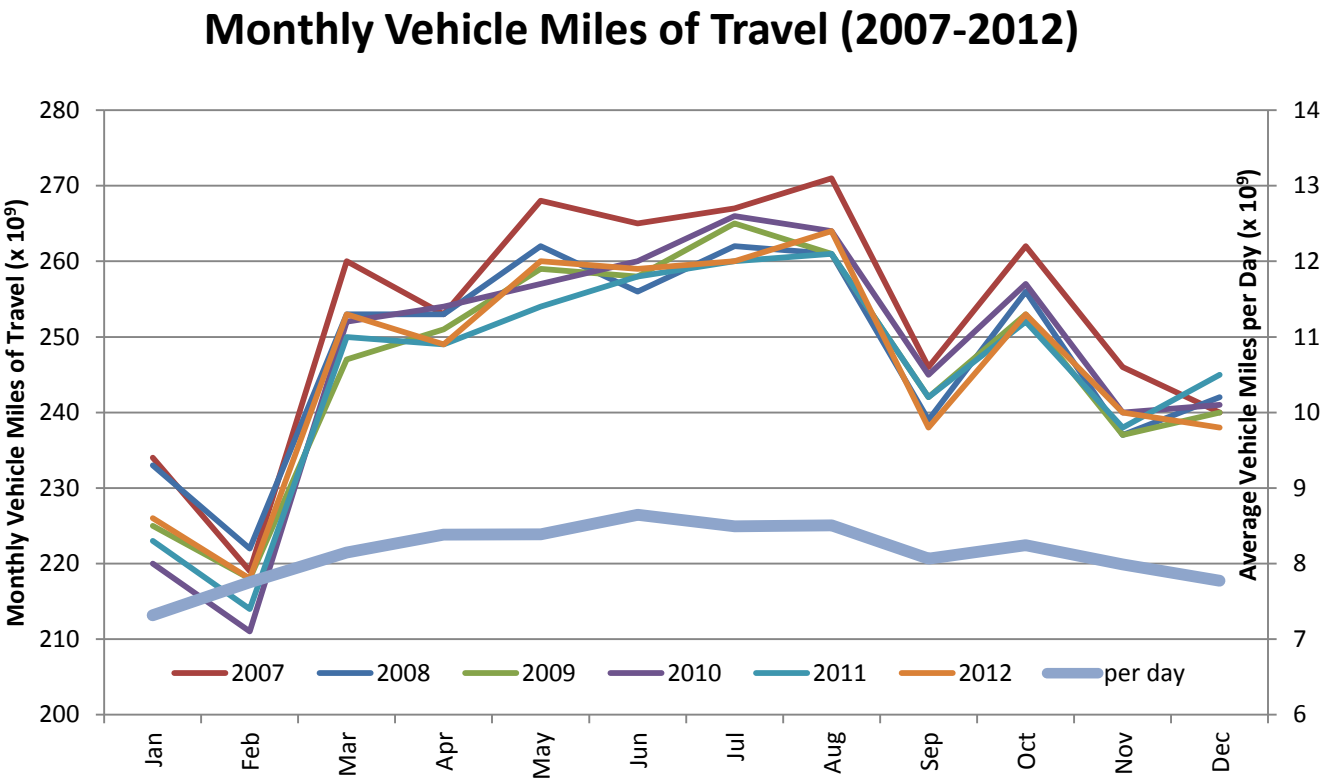
http://www.google.com/publicdata/explore

Traffic Considerations- Intro



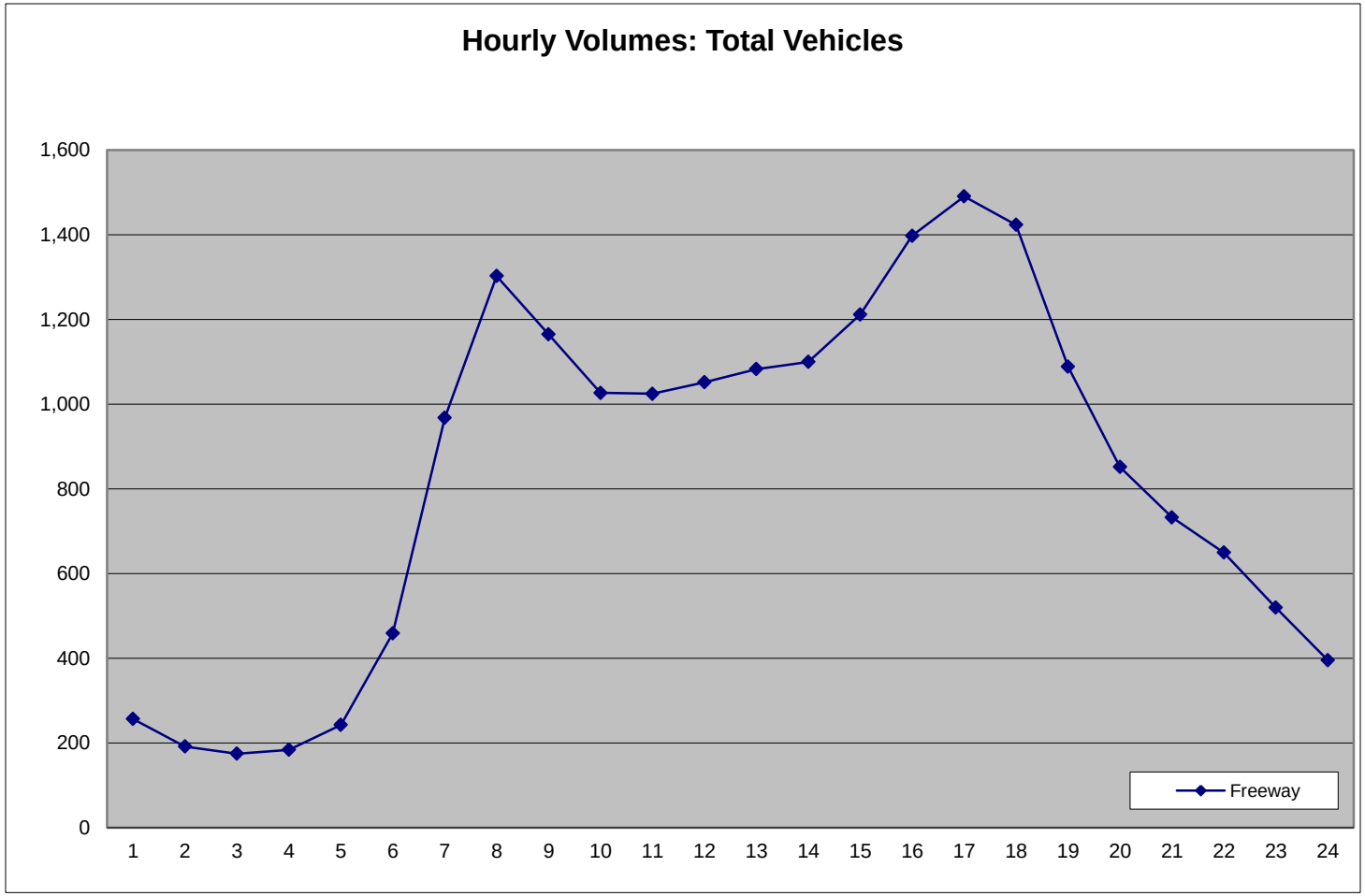
http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

Traffic Considerations- Intro

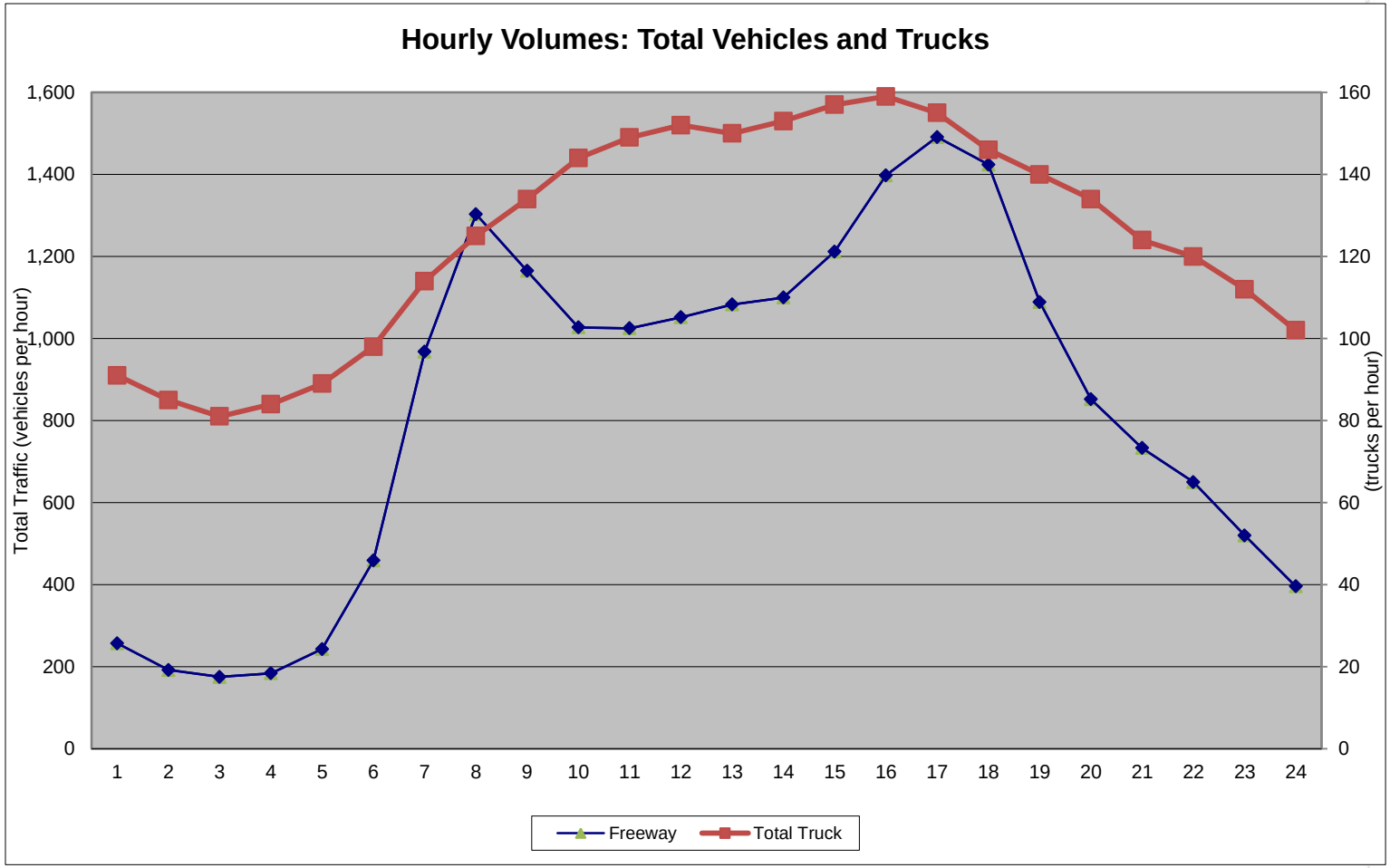


http://www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm

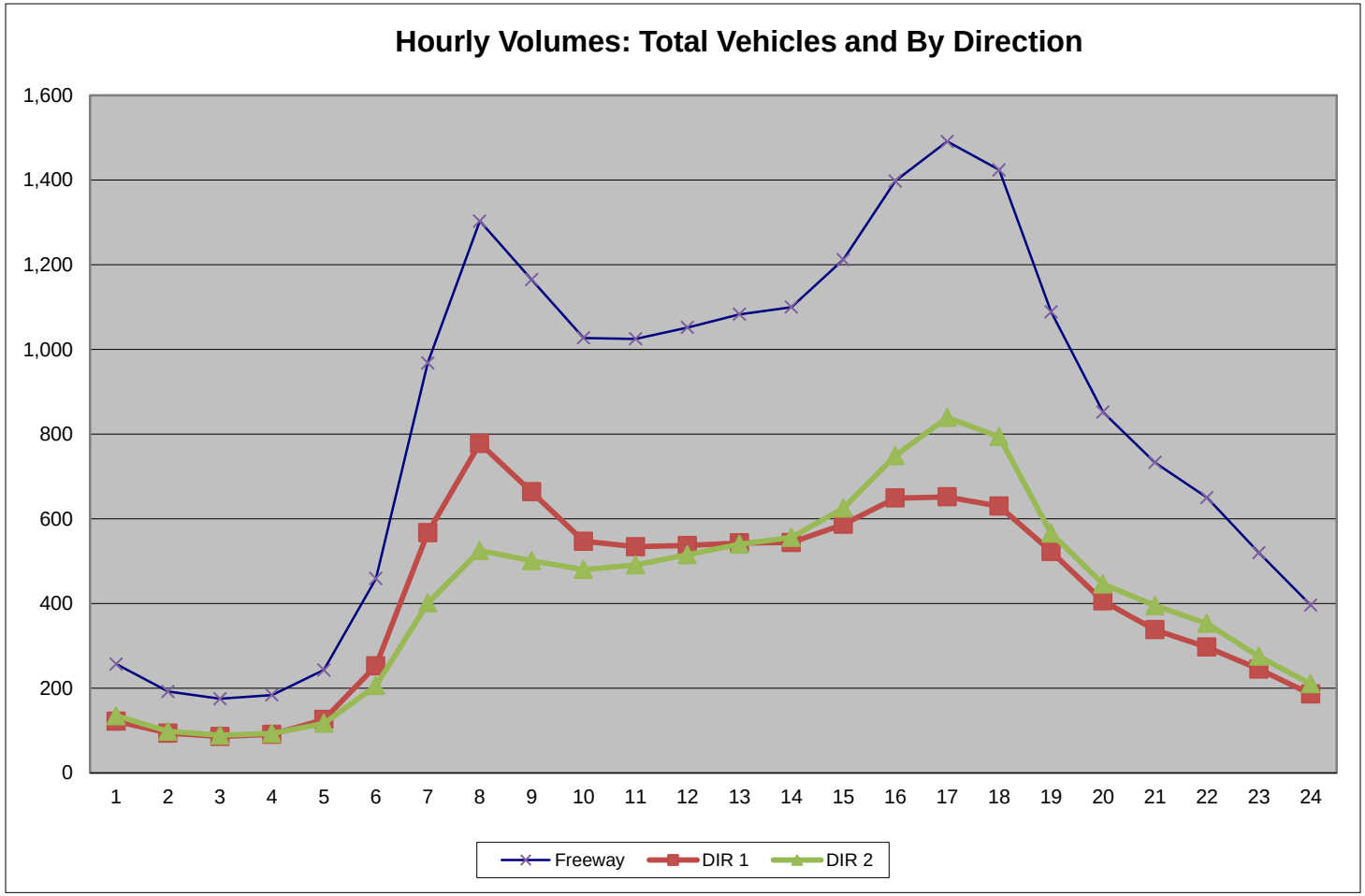
Traffic Considerations- Intro



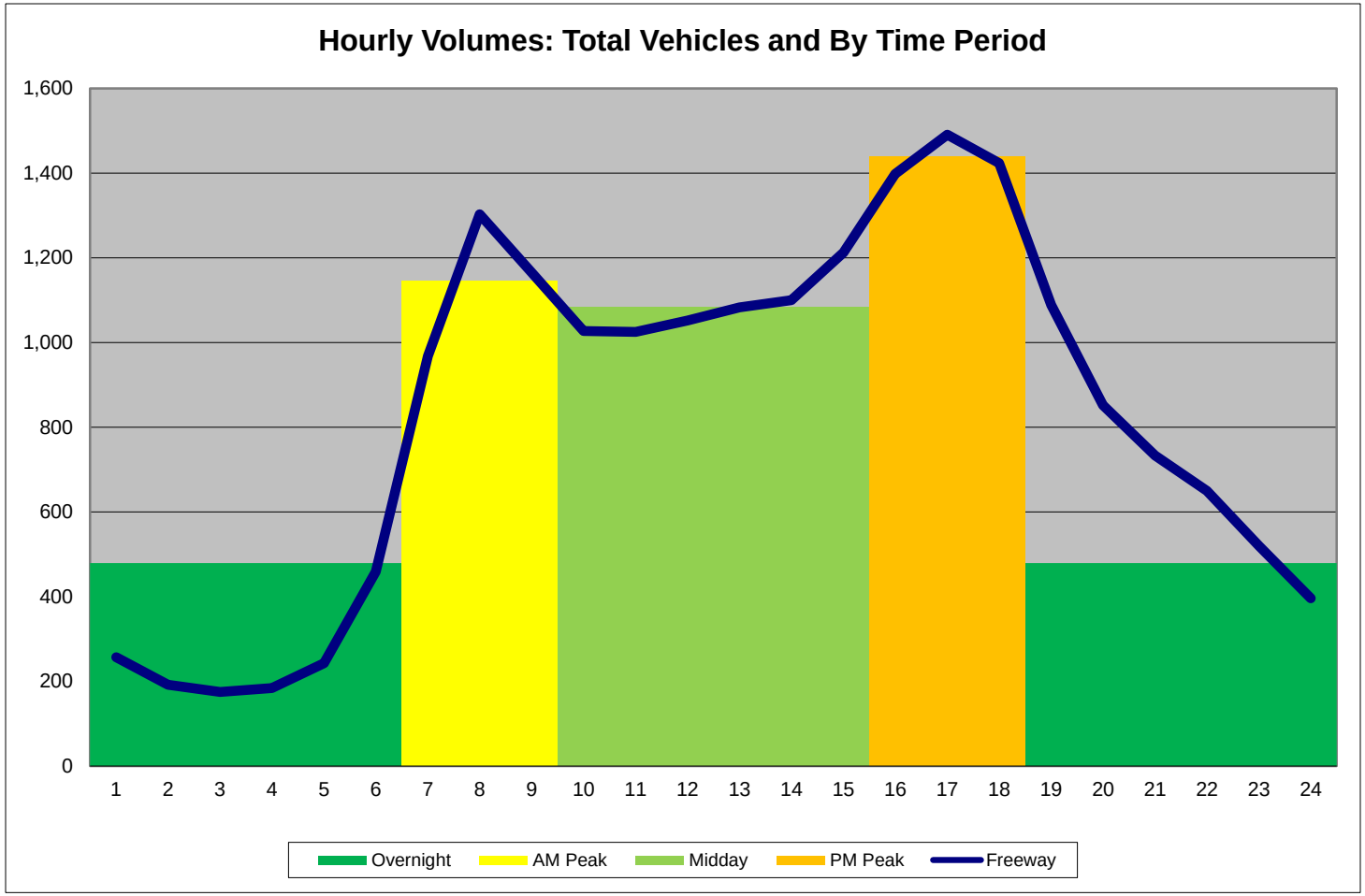
Traffic Considerations- Intro



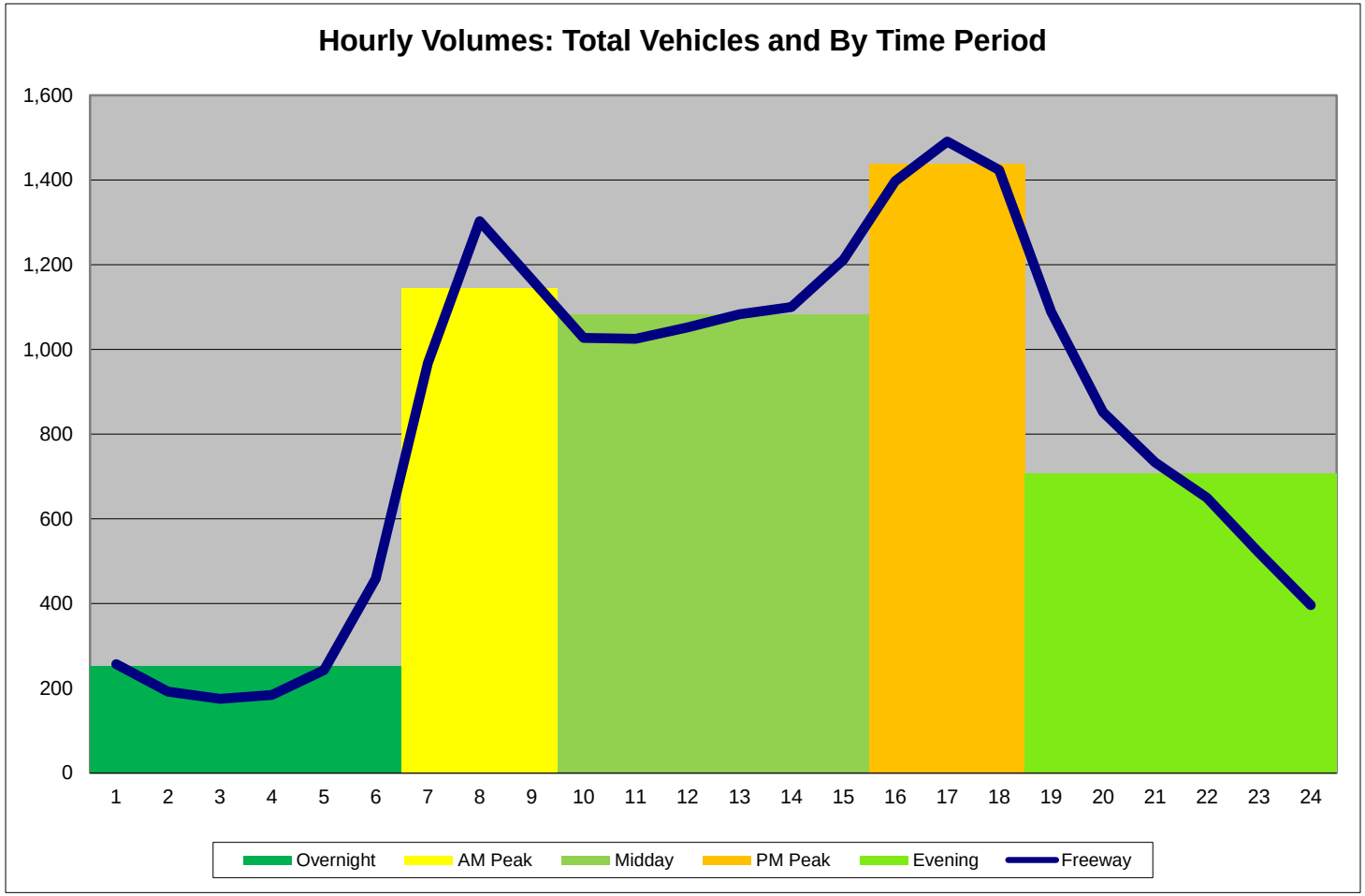
Traffic Considerations- Intro



Traffic Considerations- Intro



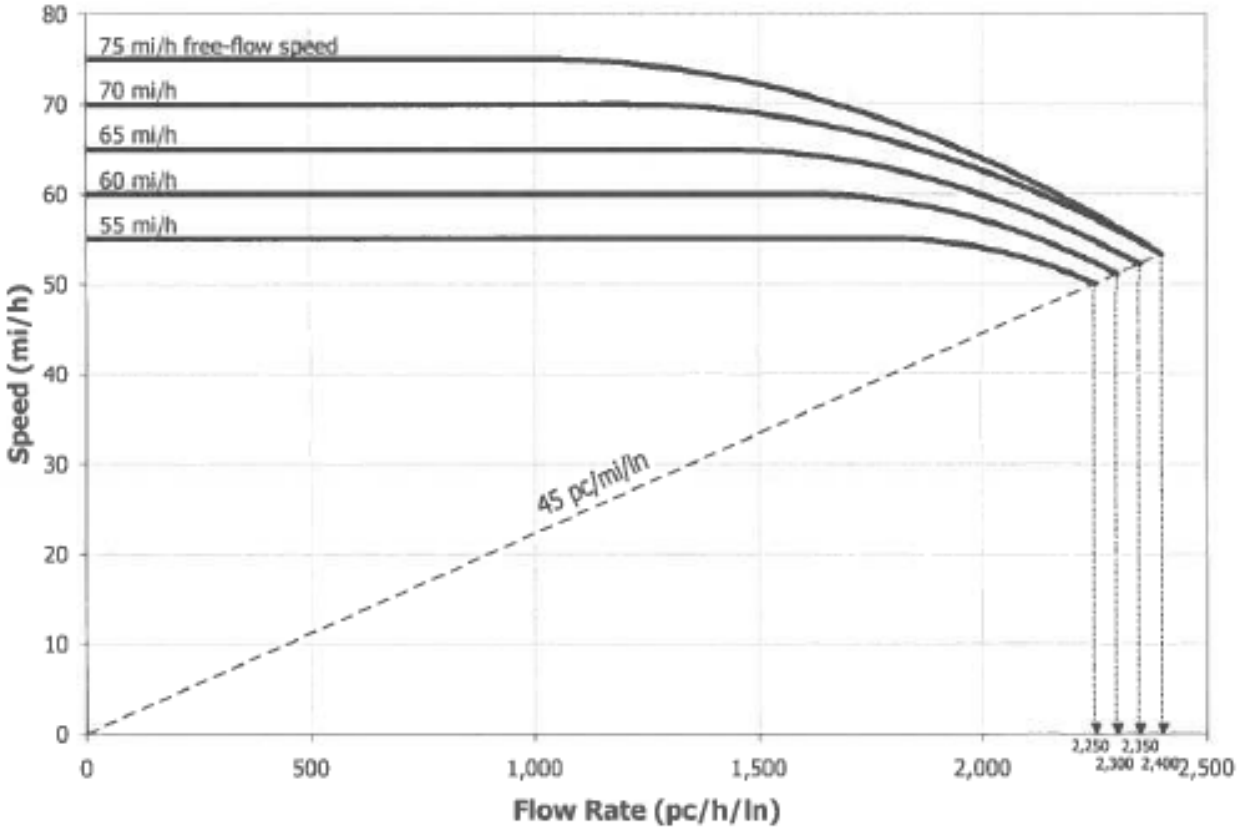
Traffic Considerations- Intro



Traffic Considerations- Intro

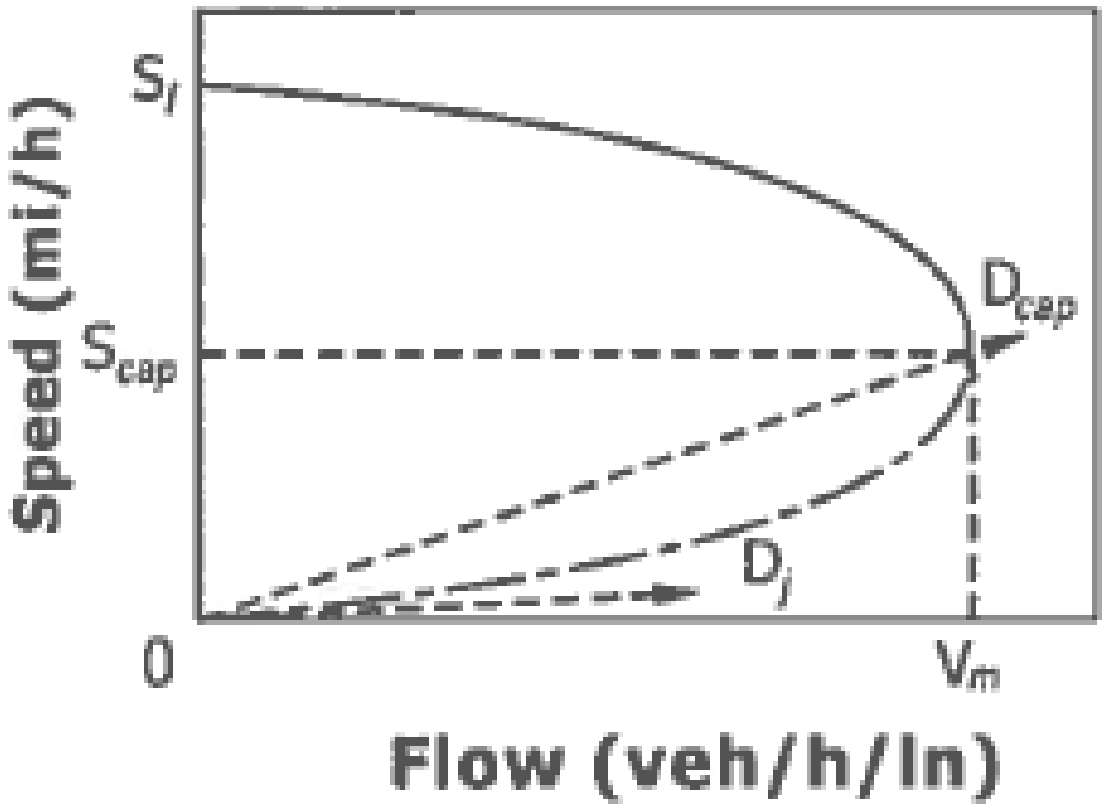
- A Couple Underlying Fundamentals
  - Travel is a “derived demand”
    - People don’t travel just to travel
    - Travel with intention of completing a task at another location (e.g., go to work or shop)
    - Travel is a “cost” of that other task
  - Travel time is a big factor in that cost
    - Speeds are affected by a variety of factors
  - Reliability is a growing concern

Traffic Considerations- Intro



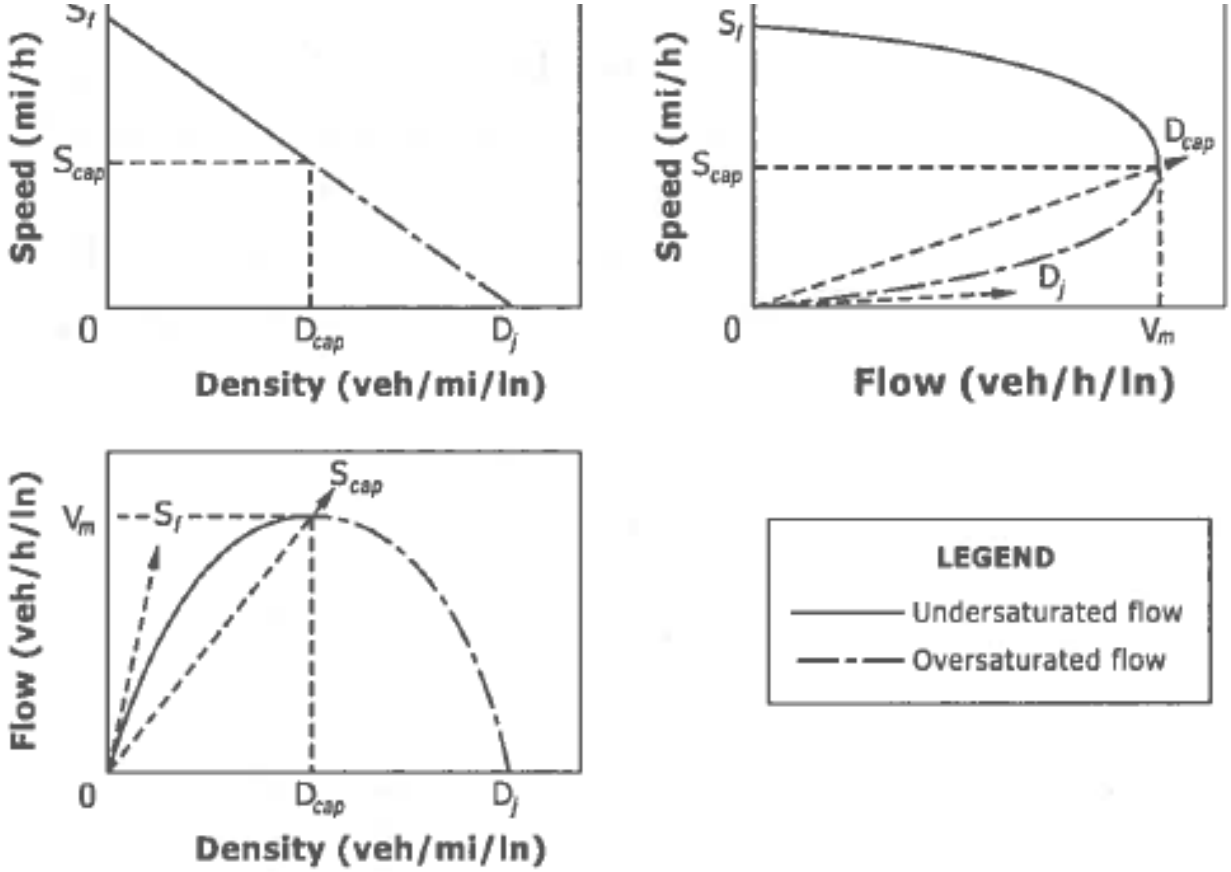
Highway Capacity Manual 2010, Exhibit 11-2

Traffic Considerations- Intro



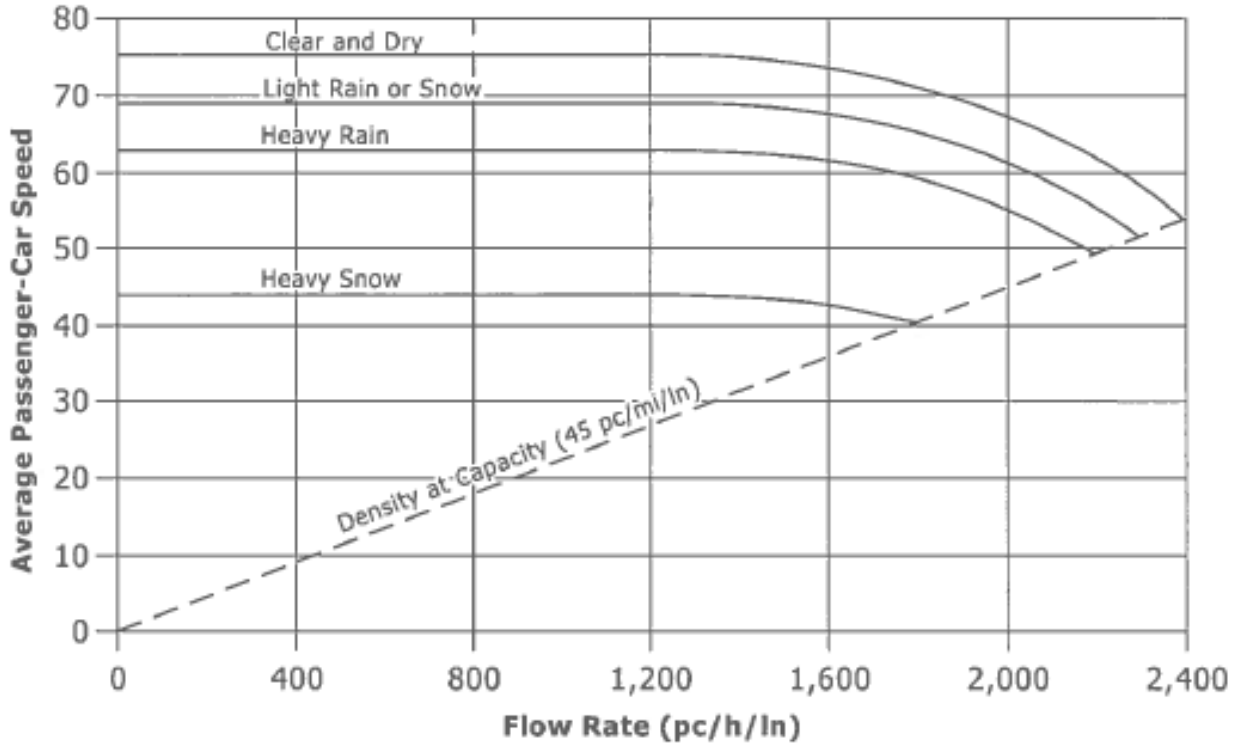
Highway Capacity Manual 2010, Exhibit 4-3

Traffic Considerations- Intro



Highway Capacity Manual 2010, Exhibit 4-3

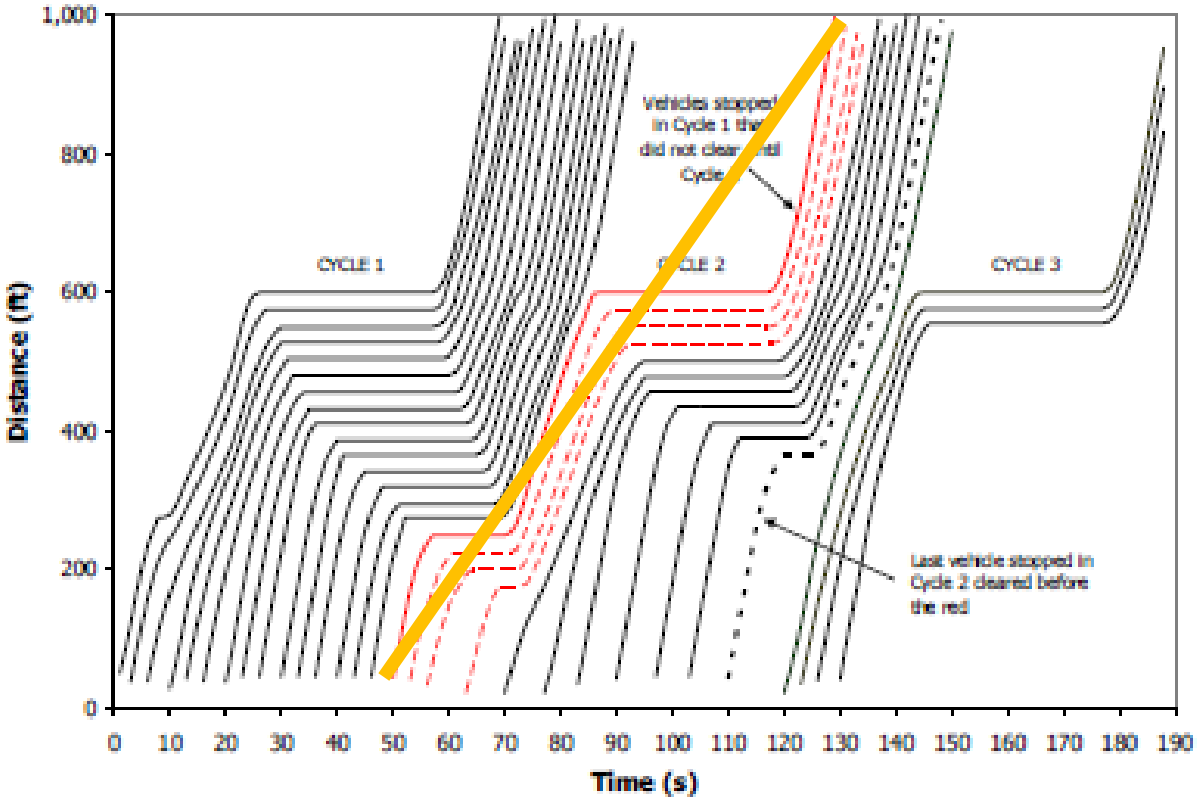
Traffic Considerations- Intro



Note: Free-flow speed = 75 mi/h (base conditions).

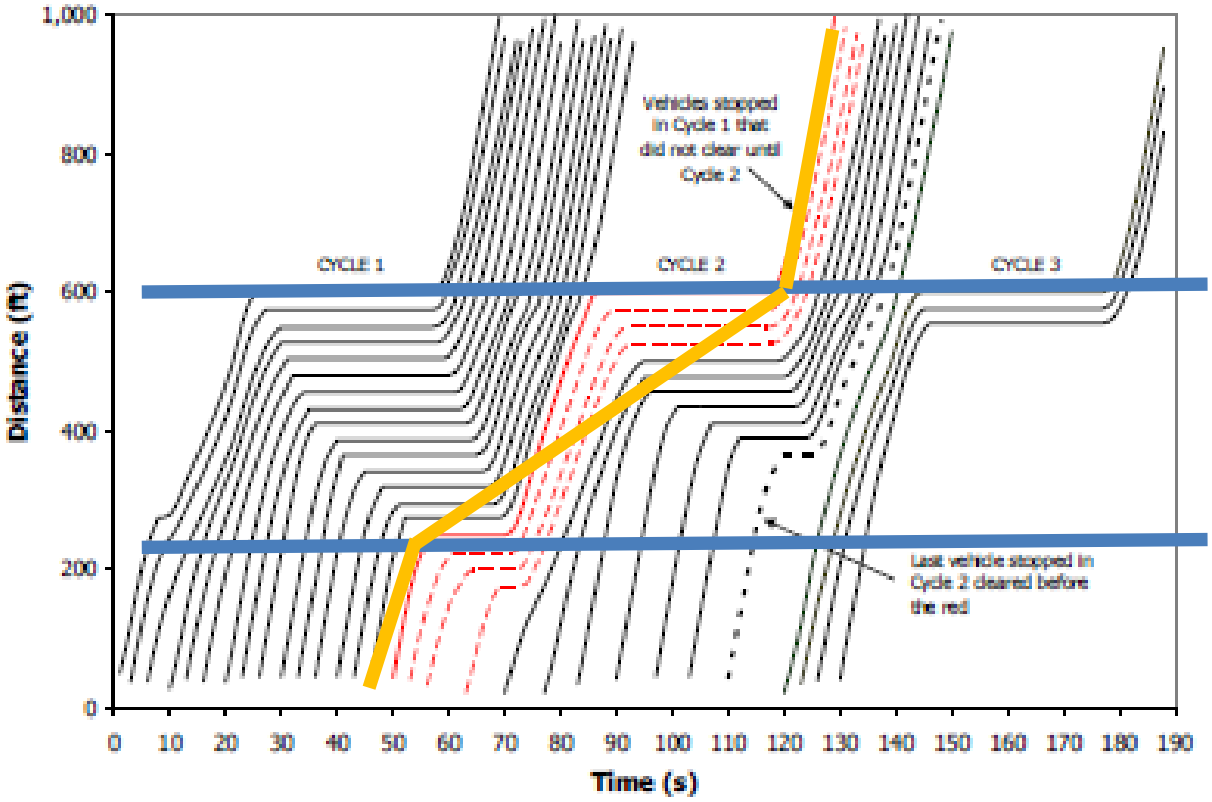
Highway Capacity Manual 2010, Exhibit 10-18

Traffic Considerations- Intro



Highway Capacity Manual 2010, Exhibit 24-5

Traffic Considerations- Intro



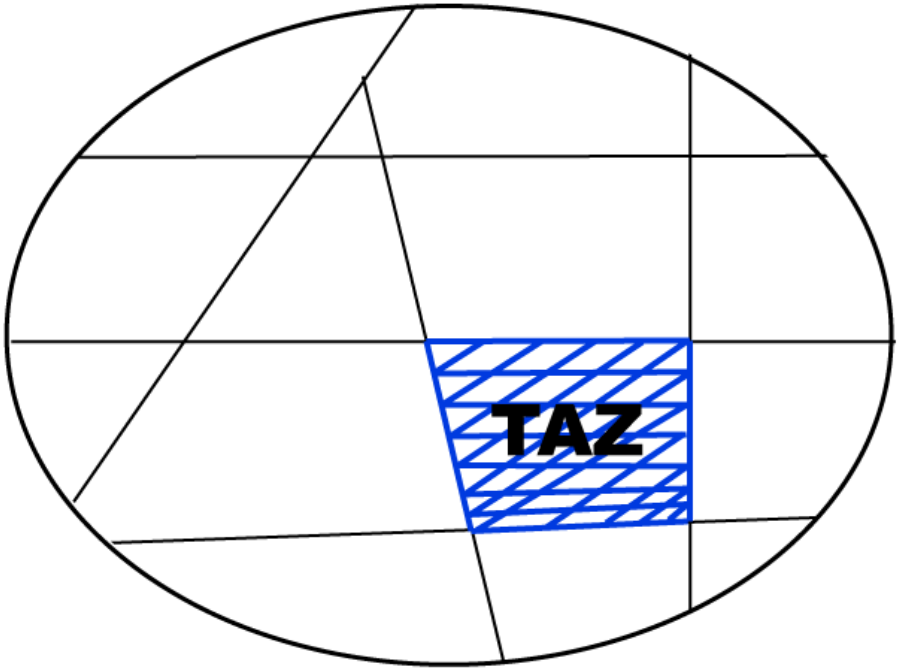
Highway Capacity Manual 2010, Exhibit 24-5

Traffic Considerations- Regional

- In Urban Areas, Metropolitan Planning Organization (MPO) develops a regional Travel Demand Model (TDM)
- The area is divided into Traffic Analysis Zones (TAZs)
  - TAZs contain land use data (homes, jobs)
  - TDM represents travel between TAZs

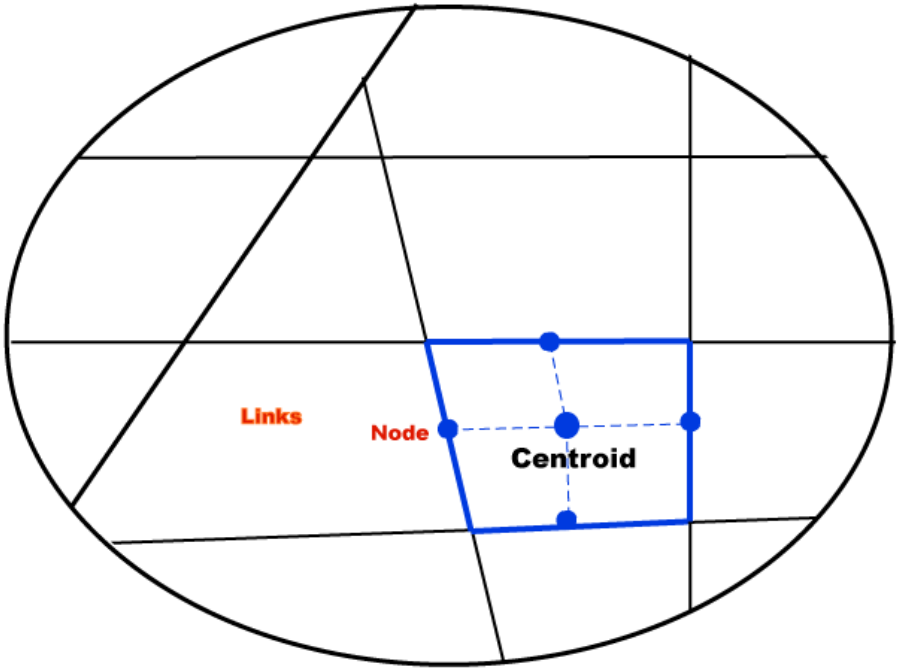
Traffic Considerations- Regional

How is an Area Represented in Network Modeling?



Traffic Considerations- Regional

How is an Area Represented in Network Modeling?



Traffic Considerations- Regional

- Typical TDM Concept: 4 Step Model
  - Trip Generation
  - Trip Distribution
  - Mode Choice
  - Route Assignment
- Model at aggregate level over full area
- Meet network constraints
- Different Model Structures Available

Traffic Considerations- Regional

- In typical application, MPO uses TDM volumes and speeds to complete regional conformity analysis
- Use TDM to assess viability of large scale projects (highway and transit) to set Transportation Improvement Program (TIP) and Long-range Plan
- Plan within financial constraints

Traffic Considerations- Project

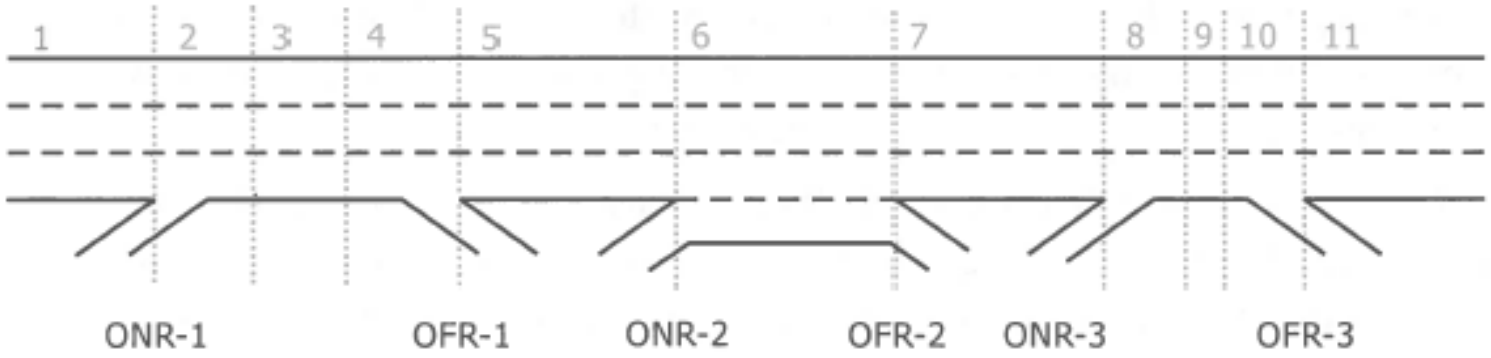
- Regional TDM provides basic volumes
  - Can forecast future year conditions
  - Speeds typically imprecise
  - Do not normally treat intersection delay
  - Still reflect relative congestion effects
- Need project-level analysis for details
  - Typically calculate Levels of Service
    - At intersections and other critical locations

Traffic Considerations- Project

- In looking at a Project, consider:
  - How will it affect where people go?
  - How will it affect who goes by what mode?
  - How will it affect what routes they use?
  - How will it affect their time of travel?
  - How will it affect on-road operations?
  - How will it affect land use & future travel?
- Apply the same considerations for all alternatives

Traffic Considerations- Project

HCM Freeway Example

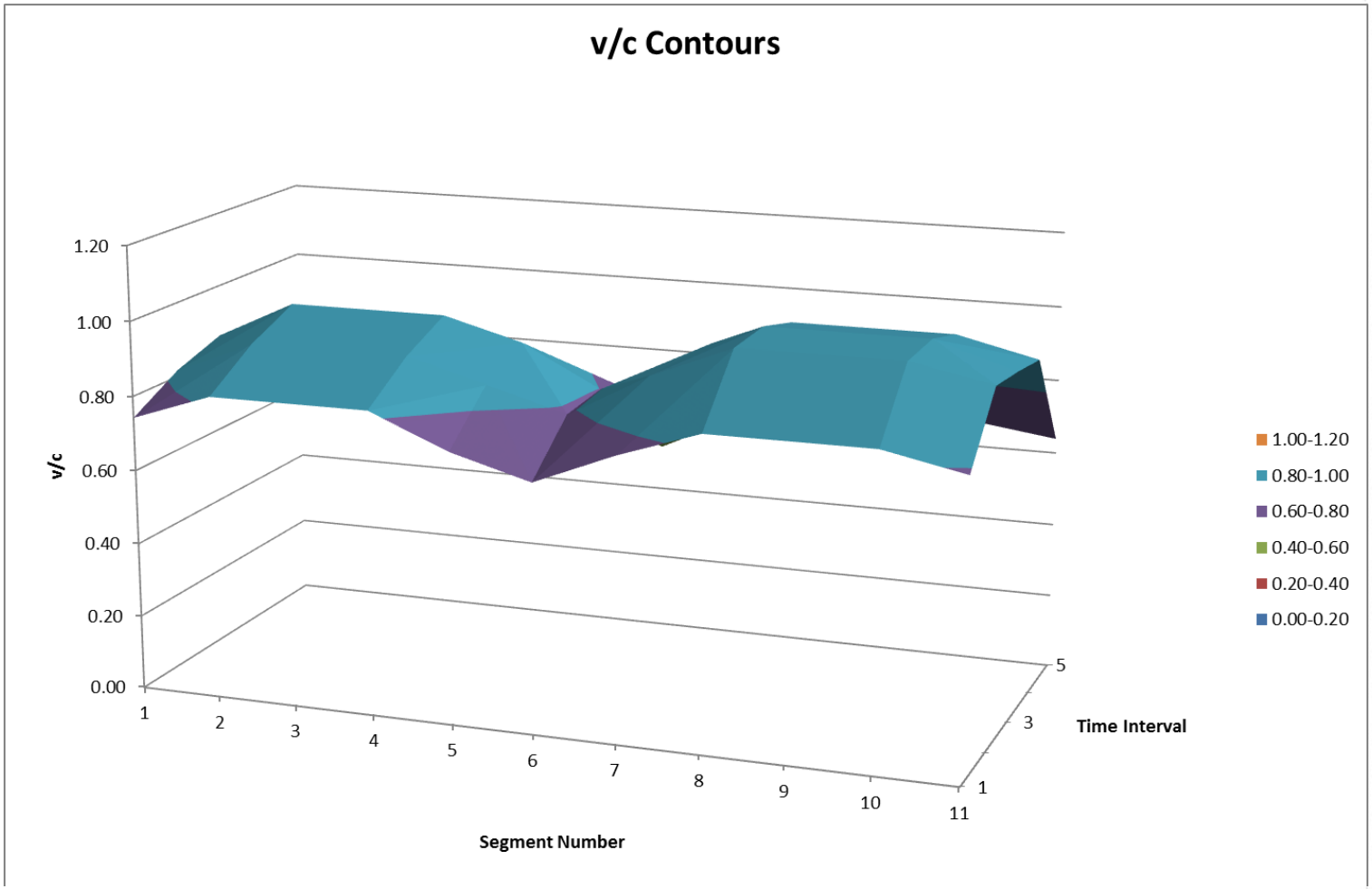


Ref: Highway Capacity Manual 2010, Exhibit 10-25

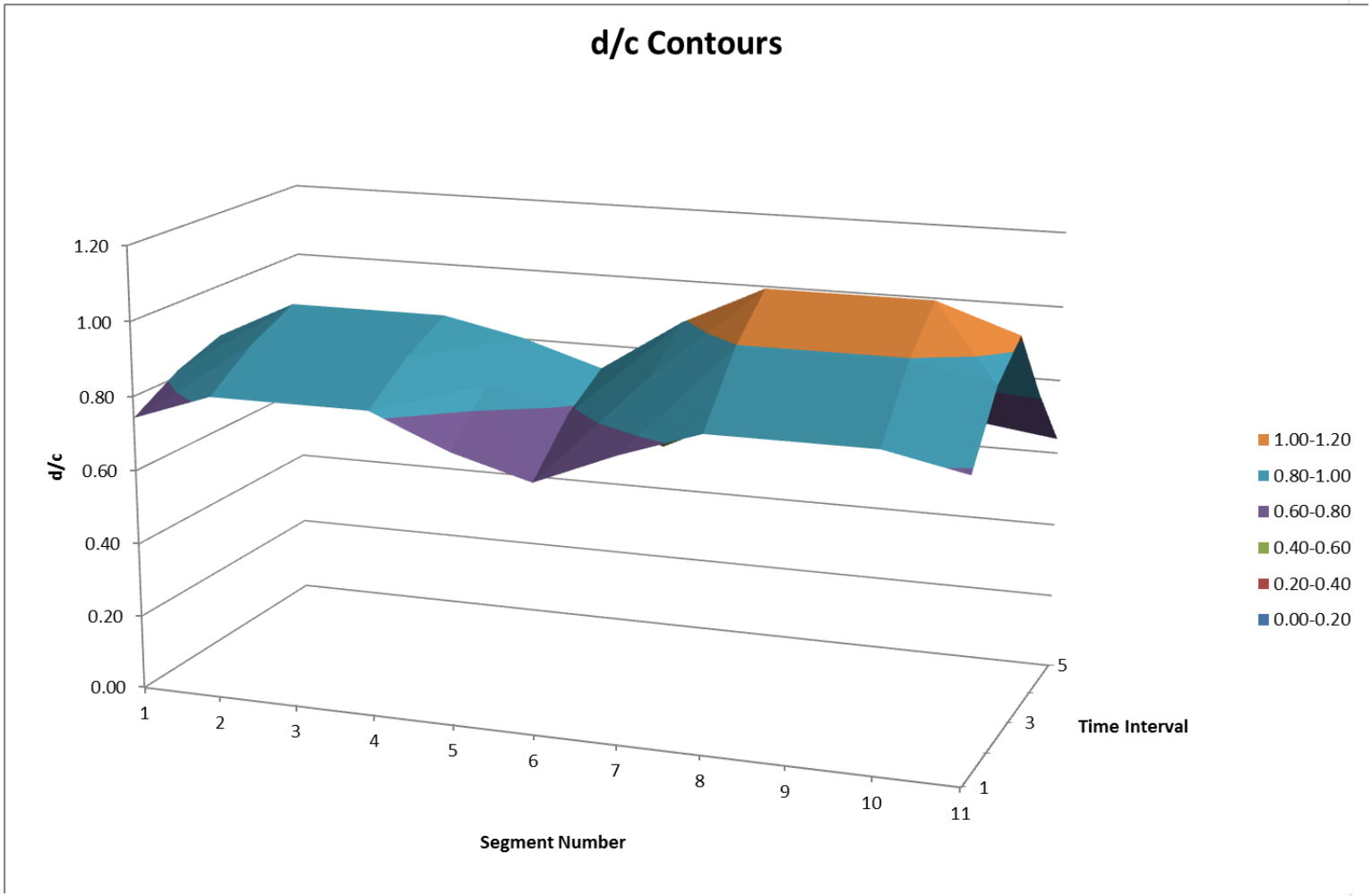
Traffic Considerations- Project

Facility-Level Summary	Release June 25, 2011												
Title	HCM 2010 Ch 10 Ex 2												
Number of ValidTime Intervals	5												
Period Duration (min)	75											SECTION AND PERIOD TOTALS	
SEGMENT NUMBER :	1	2	3	4	5	6	7	8	9	10	11		units
SEGMENT LABEL :	S01	ONR-1	S03	OFR-1	S05	S06	S07	ONR-3	S09	OFR-3	S11		
Input or estimated segment type (B,W,ONR,OFR)	B	ONR	B	OFR	B	W	B	ONR	R	OFR	B		
Segment length (ft)	5280	1500	2280	1500	5280	2640	5280	1140	360	1140	5280	6.00	miles
Number of lanes	3	3	3	3	3	4	3	3	3	3	3		
Free flow speed (mi/hr)	60	60	60	60	60	60	60	60	60	60	60		
Maximum d/c ratio**	0.86	0.97	0.97	0.97	0.92	0.85	0.99	1.10	1.10	1.10	1.02	Oversaturated	
Time interval queueing begins					3	3	3						
Travel time per vehicle (min)	1.02	0.32	0.46	0.31	1.05	0.76	1.22	0.25	0.08	0.23	1.07	6.8	min
VMTD Veh-miles (Demand)	6425.5	1995.7	3033.5	1995.7	6550.0	3649.6	6849.3	1619.0	511.3	1619.0	7098.8	41,348	VMT
VMTV Veh-miles (Volume)	6425.5	1995.7	3033.5	1995.7	6550.0	3649.6	6849.3	1619.0	511.3	1619.0	7098.8	41,348	VMT
VHT travel (hrs)	109.0	38.0	53.5	35.9	114.5	93.0	139.3	31.4	9.9	29.2	126.3	779.9	VHT
VHD delay (hrs)	1.9	4.7	3.0	2.6	5.3	33.0	25.1	4.4	1.4	2.2	8.0	91.6	VHD
Space mean speed = VMTV / VHT (mph)	58.93	52.58	56.68	55.64	57.22	39.22	49.17	51.60	51.60	55.52	56.21	53.0	mph
Average density (vpmpl)	29.1	35.6	33.1	33.7	30.5	37.2	37.1	38.8	38.8	36.0	33.7	33.7	veh/mi/ln
Average density (pcpmpl)	29.8	36.5	33.9	34.5	31.3	38.1	38.1	39.7	39.7	36.9	34.5	34.6	pc/mi/ln

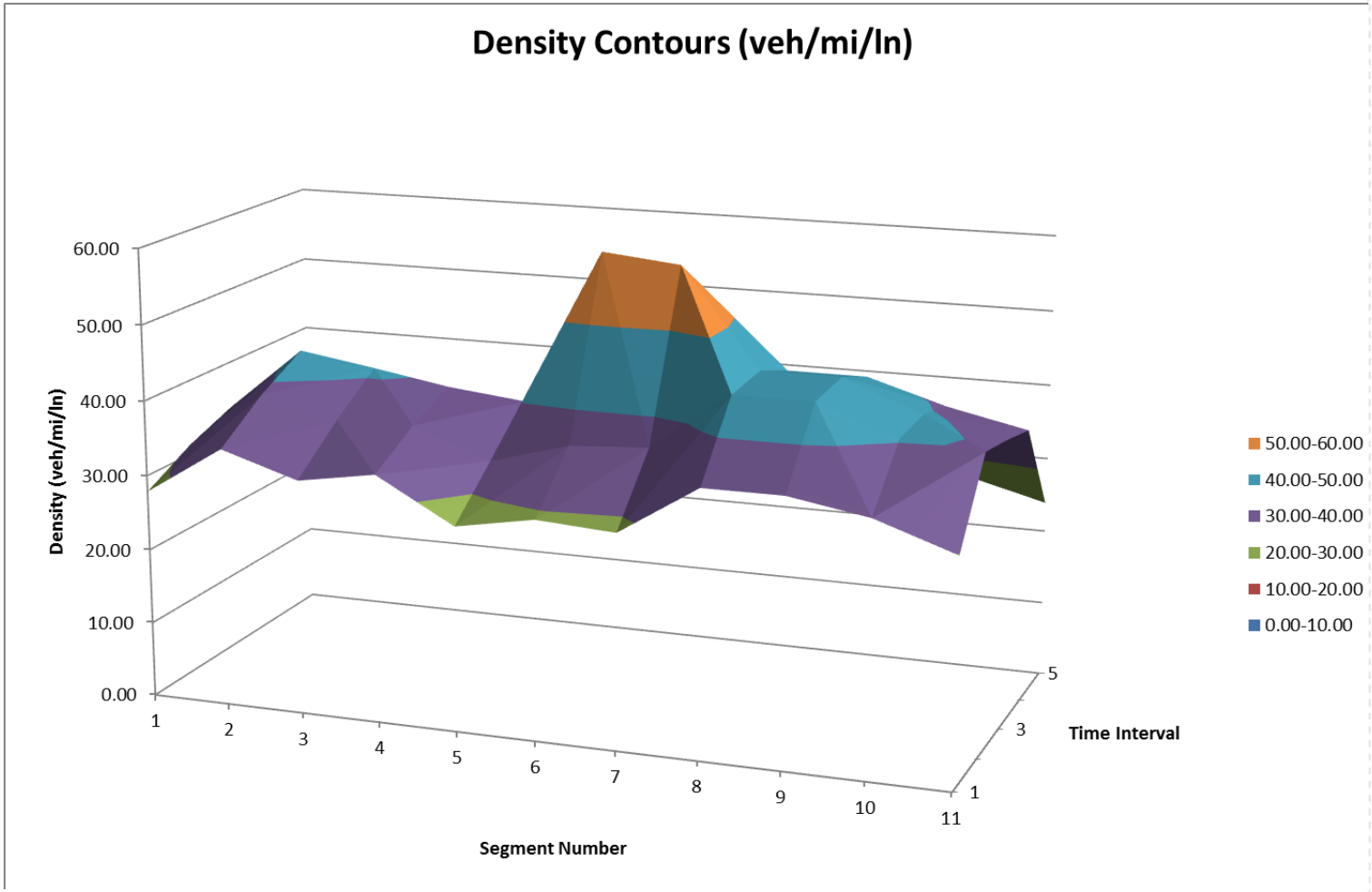
Traffic Considerations- Project



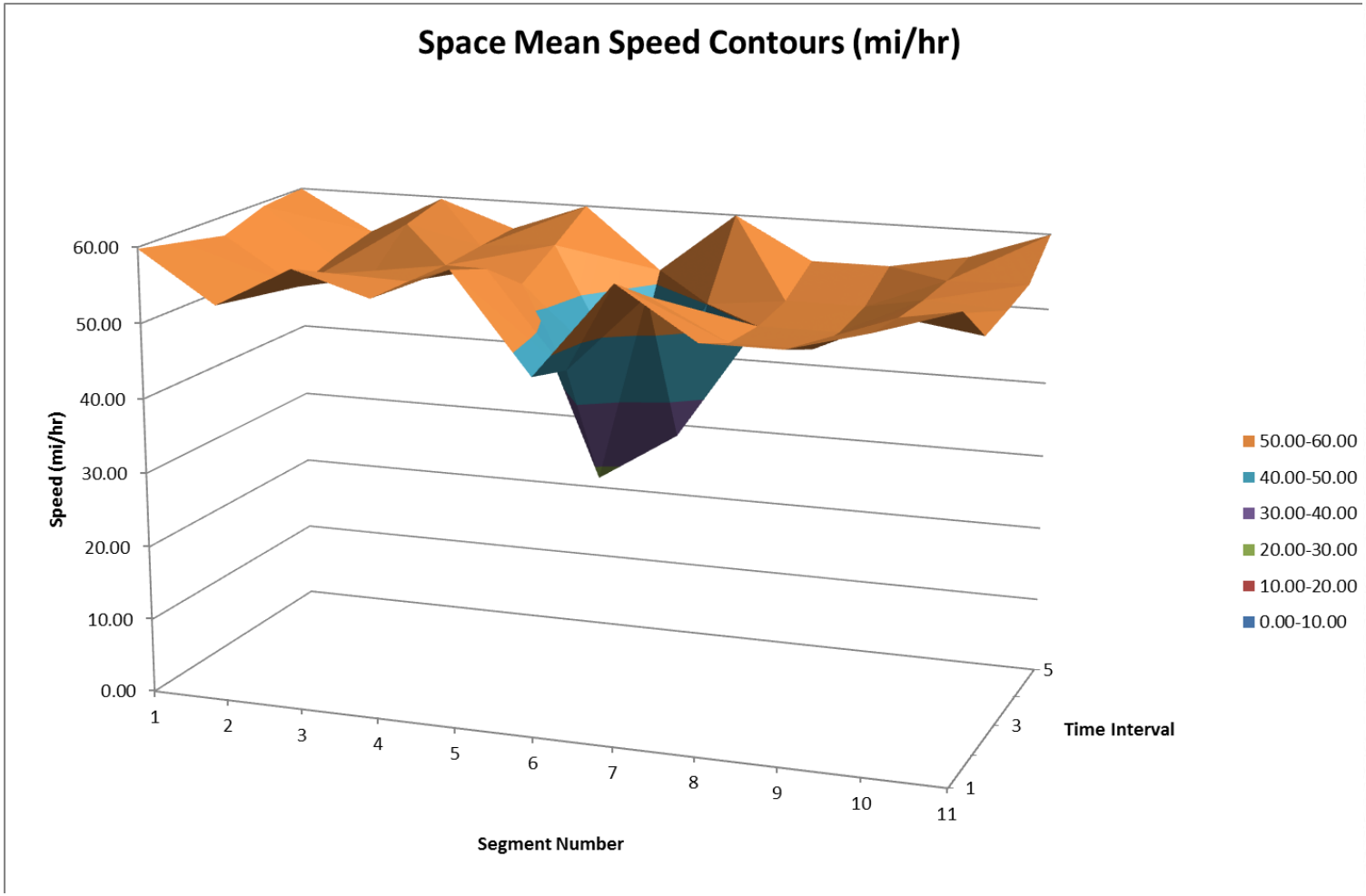
Traffic Considerations- Project



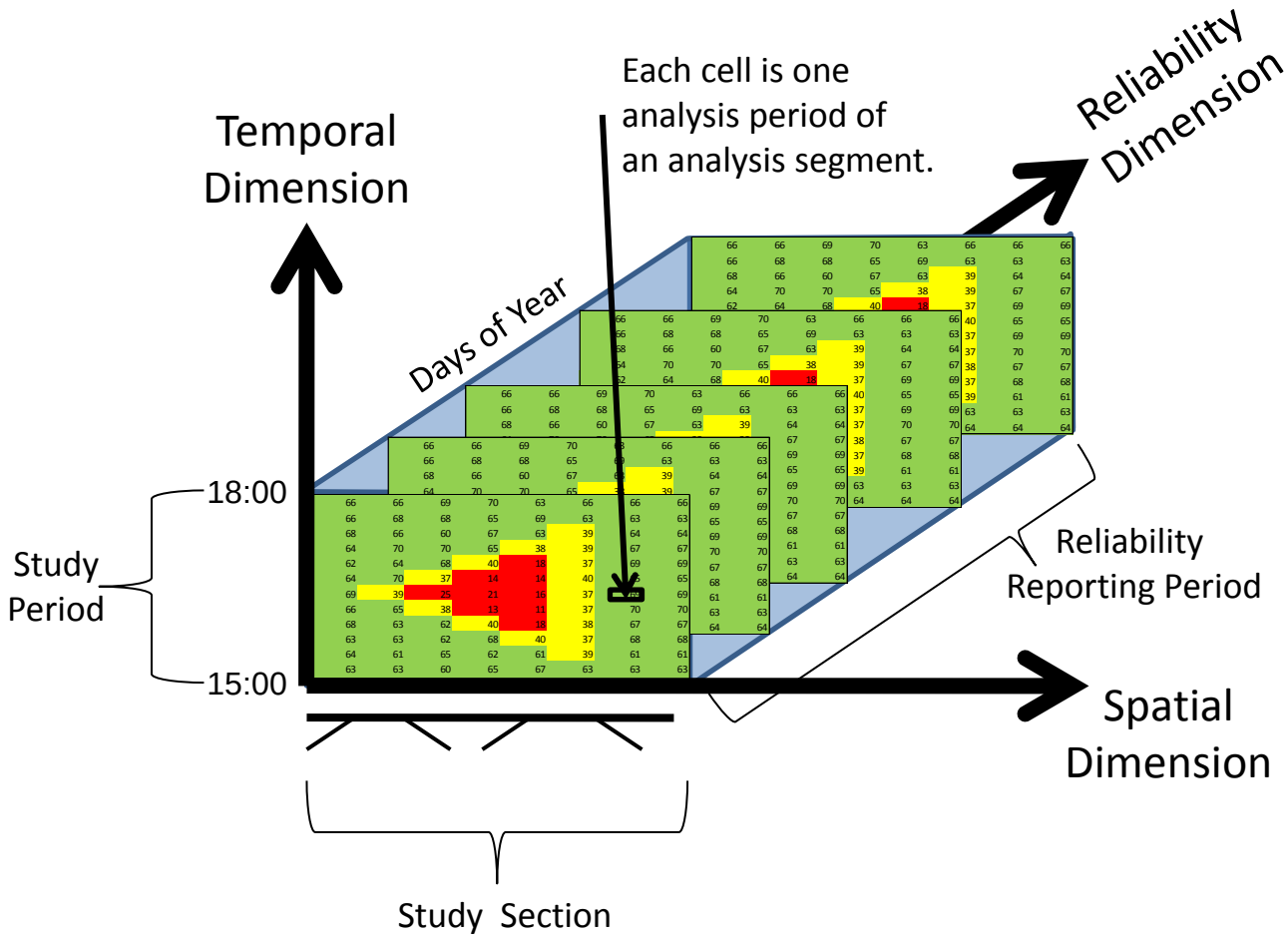
Traffic Considerations- Project



Traffic Considerations- Project



Traffic Considerations- Project



Traffic Considerations- Project

30 Scenarios

#	Demand	Weather	Incident	Work Zone	Probability
1	Low	Clear	No	None	14.25%
2	Low	Clear	No	Lng.Trm 1	1.02%
3	Low	Clear	PDO-1	None	1.14%
4	Low	Clear	PDO-1	Lng.Trm 1	0.08%
5	Low	Med.Rain	No	None	1.14%
6	Low	Med.Rain	No	Lng.Trm 1	0.08%
7	Low	Med.Rain	PDO-1	None	0.09%
8	Low	Med.Rain	PDO-1	Lng.Trm 1	0.01%
9	Low	Lt.Snow	No	None	0.86%
10	Low	Lt.Snow	No	Lng.Trm 1	0.06%
11	Med	Clear	PDO-1	None	3.99%
12	Med	Clear	PDO-1	Lng.Trm 1	0.29%
13	Med	Clear	No	None	49.89%
14	Med	Clear	No	Lng.Trm 1	3.56%
15	Med	Med.Rain	PDO-1	None	0.32%
16	Med	Med.Rain	PDO-1	Lng.Trm 1	0.02%
17	Med	Med.Rain	No	None	3.99%
18	Med	Med.Rain	No	Lng.Trm 1	0.29%
19	Med	Lt.Snow	PDO-1	None	0.24%
20	Med	Lt.Snow	PDO-1	Lng.Trm 1	0.02%
21	High	Clear	No	None	14.25%
22	High	Clear	No	Lng.Trm 1	1.02%
23	High	Clear	PDO-1	None	1.14%
24	High	Clear	PDO-1	Lng.Trm 1	0.08%
25	High	Med.Rain	No	None	1.14%
26	High	Med.Rain	No	Lng.Trm 1	0.08%
27	High	Med.Rain	PDO-1	None	0.09%
28	High	Med.Rain	PDO-1	Lng.Trm 1	0.01%
29	High	Lt.Snow	No	None	0.86%
30	High	Lt.Snow	PDO-1	Lng.Trm 1	0.00%
Average				Total	100.00%

Traffic Considerations- Project

Microsimulation Overview

- Model individual driver behavior
  - Consider driver characteristics
    - Desired speed, headway, lane, etc.
  - Consider vehicle characteristics
    - Vehicle type: car, truck, bicycle, etc.
    - Performance: acceleration, deceleration, etc.
- Model interactions of vehicles
  - With each other (e.g., car following)
  - With the roadway system (e.g., signals, ITS)

Traffic Considerations- Review

- Traffic has generally grown in recent years
  - However, not uniformly or absolutely
- Need Travel Demand Models for forecasts
  - Based on related factors (e.g., income)
  - Developed at regional scale
- Use traffic engineering principles to adapt for project-level analyses
- Variability at various scales
  - Temporally and spatially
- Use the right tool for the job- model, data

Traffic Considerations- References

Traffic Analysis Tools:
http://ops.fhwa.dot.gov/trafficanalysistools/
Interim Guidance-Travel & Land Use Forecasting in NEPA
http://environment.fhwa.dot.gov/projdev/travel_landUse.asp
Guide on Consistent Traffic Analysis:
www.fhwa.dot.gov/publications/research/operations/11064/index.cfm
Travel Trends:
www.fhwa.dot.gov/policyinformation/travel_monitoring/tvt.cfm
Traffic Flow Theory:
www.fhwa.dot.gov/publications/research/operations/tft/index.cfm
NCHRP Reports: (http://www.trb.org/Publications/Publications.aspx)
535-Predicting Air Quality Effects of Traffic-Flow Improvements
716-Travel Demand Forecasting: Parameters and Techniques
765-Analytical Travel Forecasting Approaches for Project-Level Planning and Design
Travel Model Improvement Project:
http://www.fhwa.dot.gov/planning/tmip/
Highway Capacity Manual 2010: http://www.hcm2010.org/

Contact Information:

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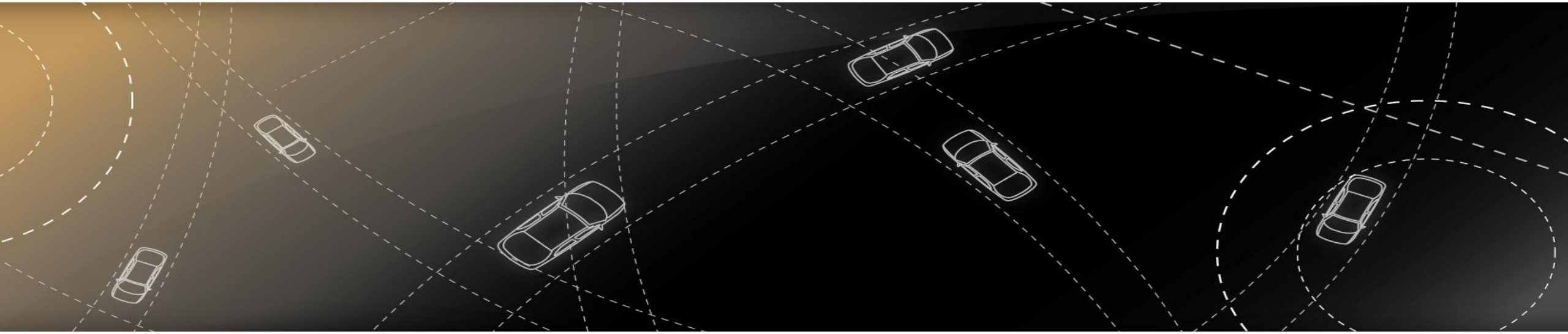
www.fhwa.dot.gov/resourcecenter



Models Used in Air Quality Analysis

Emission Factor Models

Madhusudhan Venugopal

Outline

- Background
- On-Road Emission Estimation Process
- Factors Influencing Emissions Rates
- EPA Approved On-Road Models
- Model Applications, Features, Working Process,
- Modeling Scales
- Input Data and Sources
- Model Output and User Options
- Emissions Modeling
- Resources

Background

Regional Emission Inventories

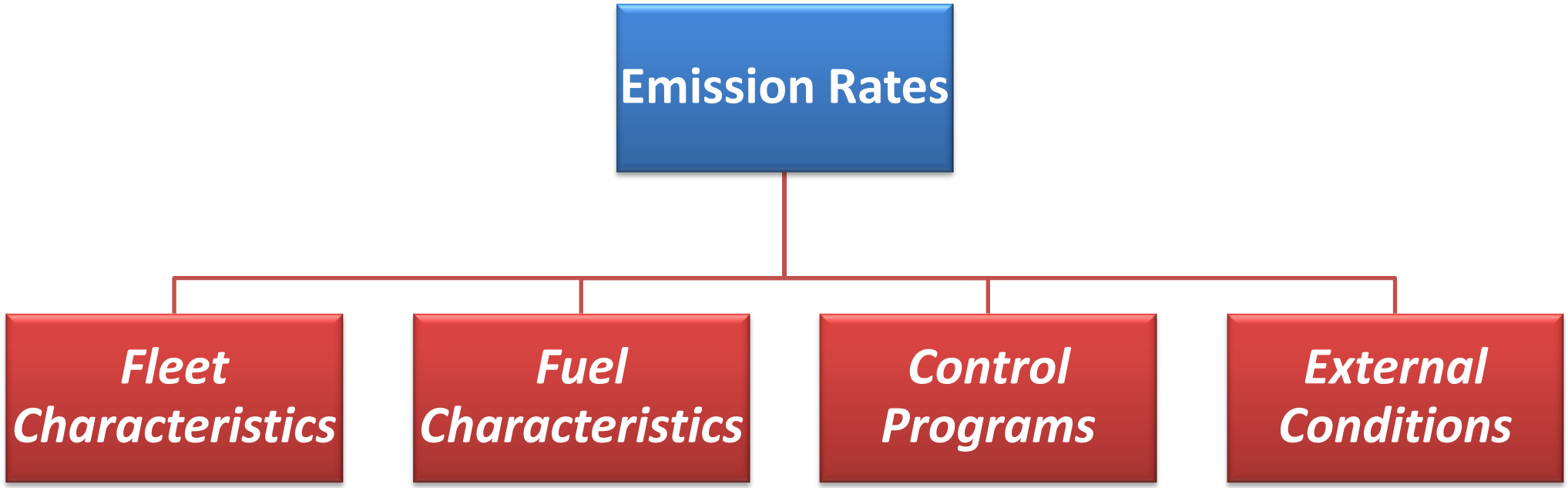
- On-road
- Point
- Area
- Non-Road
- Biogenic

Air Quality Planning

Attainment of Air Quality Standards

On-road Emission Estimation Process

Factors Influencing Emission Rates



EPA Approved On-Road Models

California

- *EMFAC2014, Effective December 14 2015*
- *Conformity Grace Period December 14, 2017*

Outside of California

- *MOVES2014/MOVES2014a, Effective October 7, 2014*
- *Conformity Grace Period October 7, 2016*

Model Application

State Implementation Plan (SIP)

- *Attainment Demonstration SIP*
- *Reasonable Further Progress SIP*

Regional Transportation Conformity

Project Level Analysis

- *Mobile Source Air Toxics*
- *CO & PM Hotspot*

Alternative Scenarios

- *Mobility Plan Analysis*
- *What-if Scenarios*

Trend Analysis

Emission Reduction Measure Analysis

- *Congestion Mitigation and Air Quality Reporting*
- *Project Selection (Cost-Effectiveness)*

Model Features

Structure

- *Graphical User Interface (GUI)*
- *Database*
  - *Default or User Supplied Data*

Scale

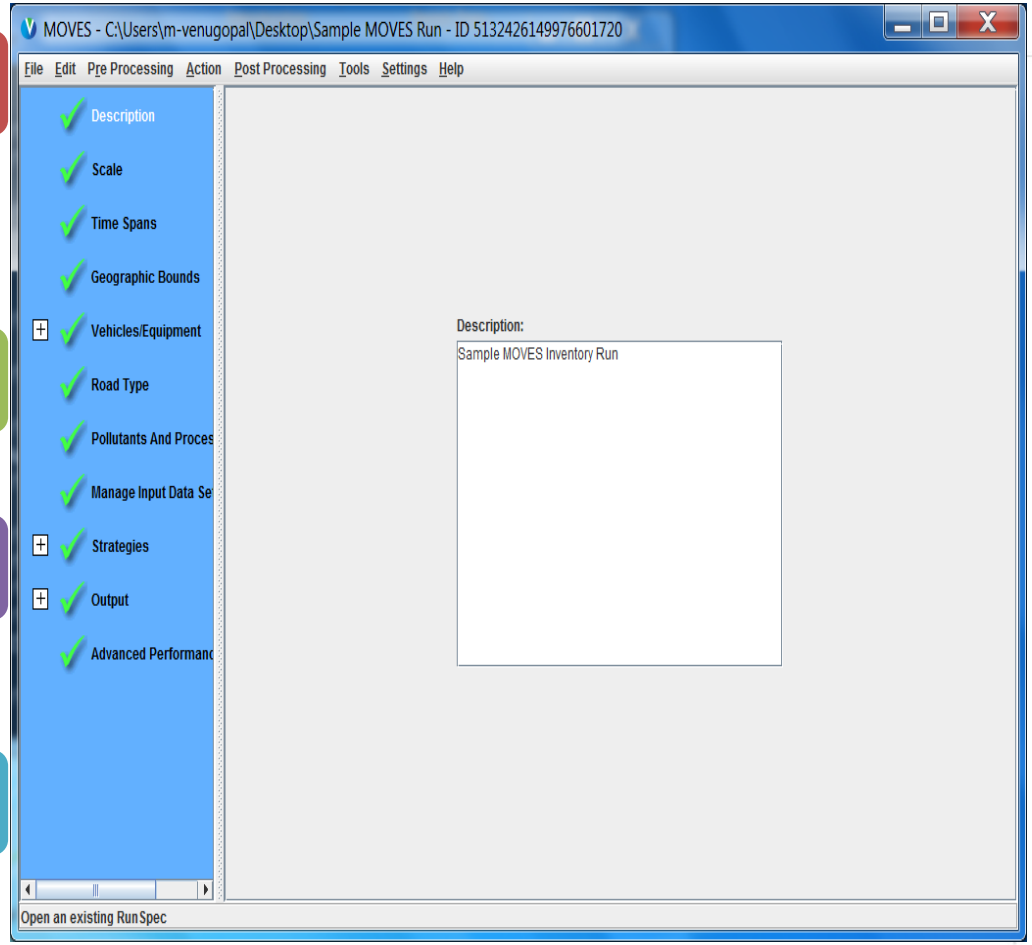
- *National, County, and Project*

Calculation Mode

- *Rate (mass/activity)*
- *Inventory (pounds, tons)*

Time Span

- *1990, 1999-2050*
- *Any or All Months of a Year*
- *Weekday and/or Weekend*
- *Any or All Hours of a Day*



Model Features Cont'd

Emission Processes

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

Pollutants

- *HC Species, CO, NOx, NH_3, SO_2, PM, CO_2, CH_4, N_2O, 50+ Toxics, Energy*

Fuels

- *Gasoline,CNG, Diesel, Ethanol (E-85), Electric*

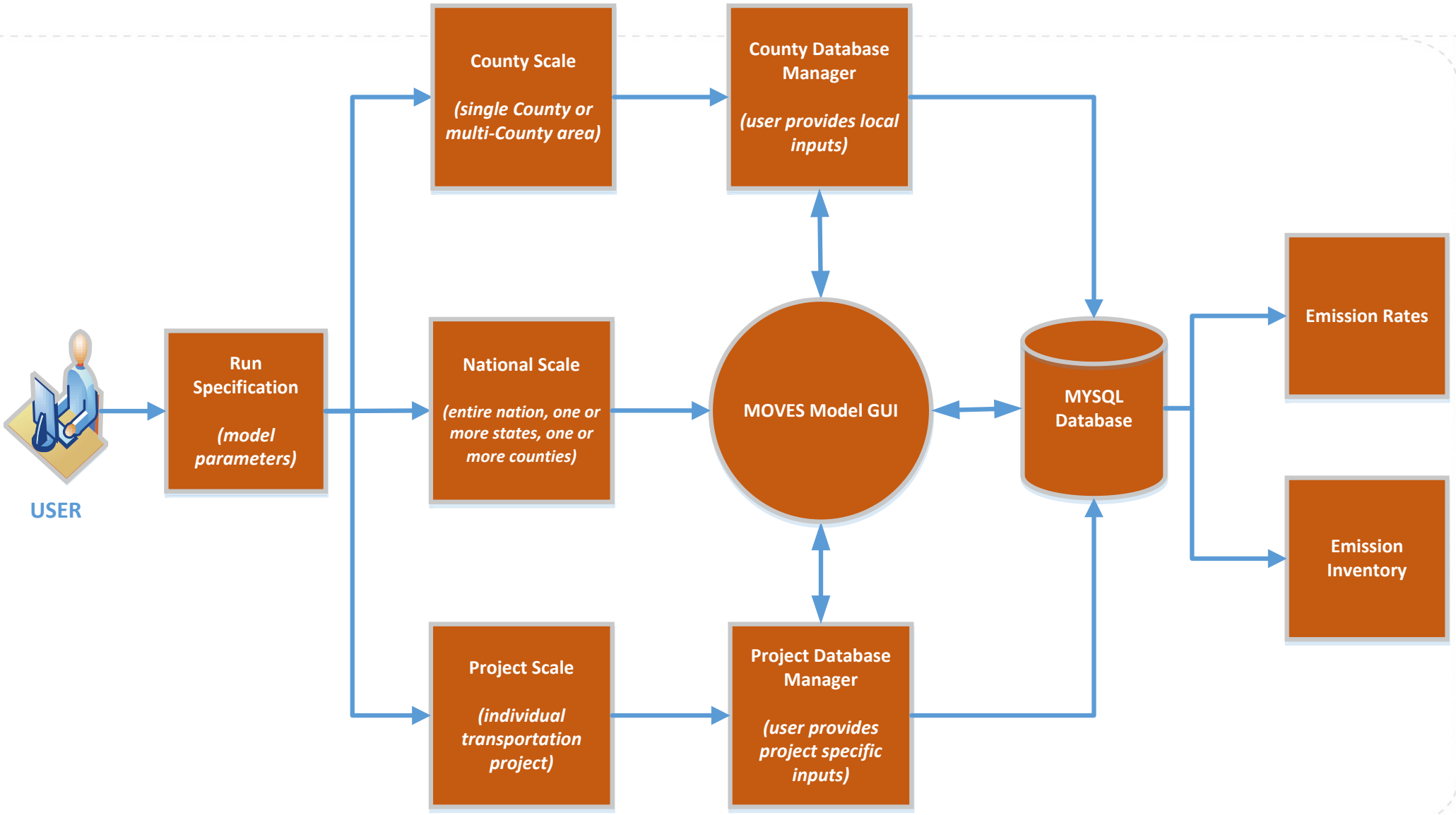
Vehicle Type

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

Roadway Type

- *On-network (Rural and Urban Restricted and Unrestricted Access)*
- *Off-network (Idling, starts, etc.)*

Model Working Process



Model Working Process Cont'd

Run Specification File (Runspec)

- Create Single Runspec and Modify Subsequent Ones
- Multiple Runspec Creator in MOVES model

County Data Manager and Project Data Manager

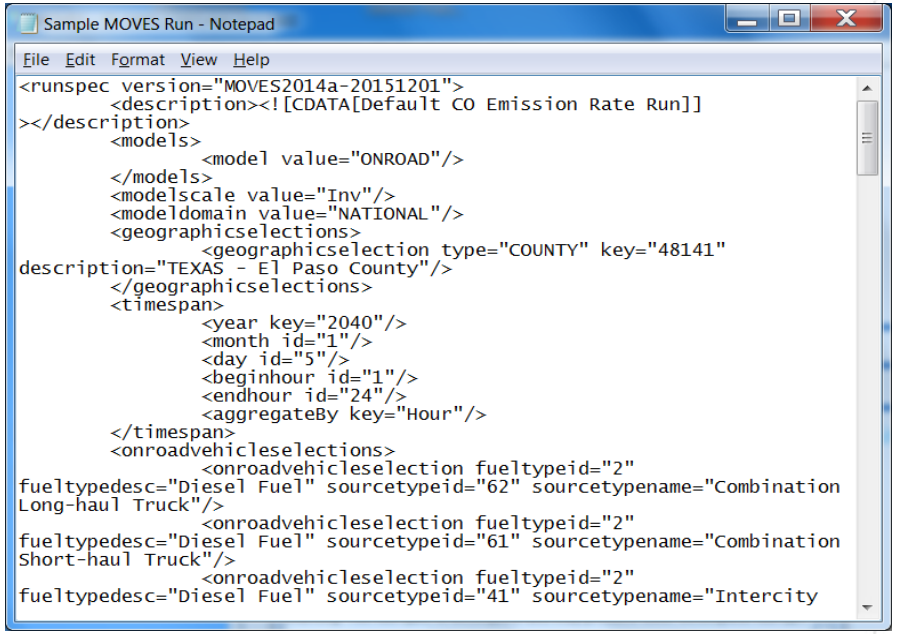
- Can Bypass Using MSQL Queries

Running Model

- Running Multiple Runspecs in One Instance
- Using Multiple Computers for Single Run
- Invoking Multiple Workers on Same Computer

Output

- Customize Output Using MSQL Queries
- Model Post Processing Tools



Modeling Scales

National

- *Uses Default Data*
- *Multiple States and Counties*
- *Both Rate and Inventory Calculations*
- *Not Recommended for Transportation Conformity and SIP*

County

- *User can Populate Local Data*
- *One County or Custom Domain*
- *Required for Transportation Conformity and SIP*
- *Both Rate and Inventory Calculations*

Project

- *Link level Modeling of Transportation Projects*
- *User can Populate Project Specific Data*
- *Required for Quantitative Hot-Spot Analysis*
- *Both Rate and Inventory Calculations*

Input Data & Sources

Not Necessary to Reinvent the Wheel

- Consult with Interagency Consultation Group
- Focus on Inputs Having Highest Impact on Emissions

Resources

- *State Air Agency*
- *State Department of Transportation*
- *Metropolitan Planning Organizations*
- EPA, join-EPA-MOBILENEWS@lists.epa.gov for model updates and send questions to MOBILE@epa.gov
- *Federal Highway Resource center, https://www.fhwa.dot.gov/resourcecenter/teams/airquality/index.cfm*

Input Data & Sources for County Scale

Data Type	MOVES Inputs	Rate Mode	Inventory Mode	Sources
Speed Distribution	Avgspeeddistribution	Default/Local	Local	Travel Demand Model
Fuel	fuelformulation, fuelsupply, fuelusagefraction, AVFT	Local	Local	Regional and National Fuel Surveys, Registration Data, Other Proprietary Sources
Hoteling	Hotellingactivitydistribution Hotellinghours	Optional	Optional	Regional Studies and Other Proprietary Sources
Vehicle Type VMT	hpmsvtypeyear, hourvmtfraction, dayvmtfraction, Monthvmtfraction	Default/Local	Local	Travel Demand Model, HPMS, Traffic Recording Stations, State DOT's, MPO's
Road Type Distribution	roadtypedistribution	Default/Local	Local	Travel Demand Model, Traffic Recording Stations
IM Program	imcoverage	Local	Local	State Air Agencies
Starts	Starts, Startshourfraction Startshouradjust, Startsperday Startssourcetypefraction, Importstartsopmodedistribution	Optional	Optional	Regional Studies and Other Proprietary Sources
Ramp Fraction	Roadtype	Local	Local	Travel Demand Model, HPMS, Traffic Recording Stations
Age Distribution	sourcetypeagedistribution	Local	Local	Registration Data, Other Proprietary Sources
Source Type Population	sourcetypeyear	Default/Local	Local	Registration Data, Other Proprietary Sources
Meteorology Data	zonemonthhour	Local	Local	National or State or Local Weather Agencies
Retrofit Data	onroadretrofit	Optional	Optional	Region Specific Programs

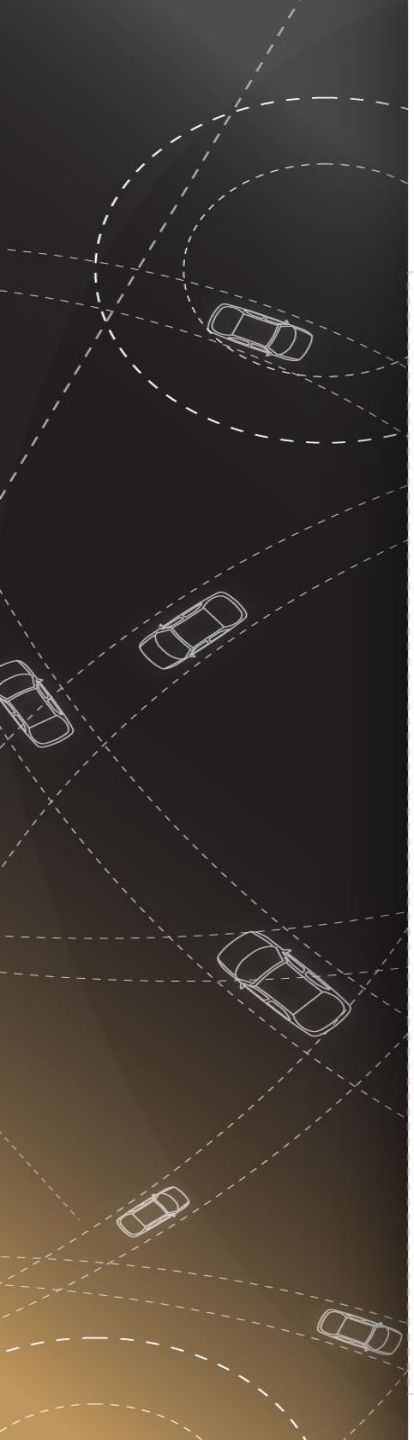
Input Data & Sources for Project Scale

Same as County Scale

- *Age Distribution, Meteorology Data, Fuel, Inspection/Maintenance, Hotelling, Retrofit Data*

Project Specific Data

- *Links, Off-Network, Link Source Types, Operating Mode Distribution, Link Drive Schedules*
- *Data Sources include Travel Models Output, Local Studies, Project Sponsors*



Model Output and User Options

User Options

- *Hour, Daily, Portion of the Week, Monthly, Annual*
- *Model year, Emission Process, Fuel, Road, and Source Use Types*
- *National, State, County, etc.*

Activity Output

- *Distance, Source Hours, Hoteling Hours, Population, Starts, etc.*

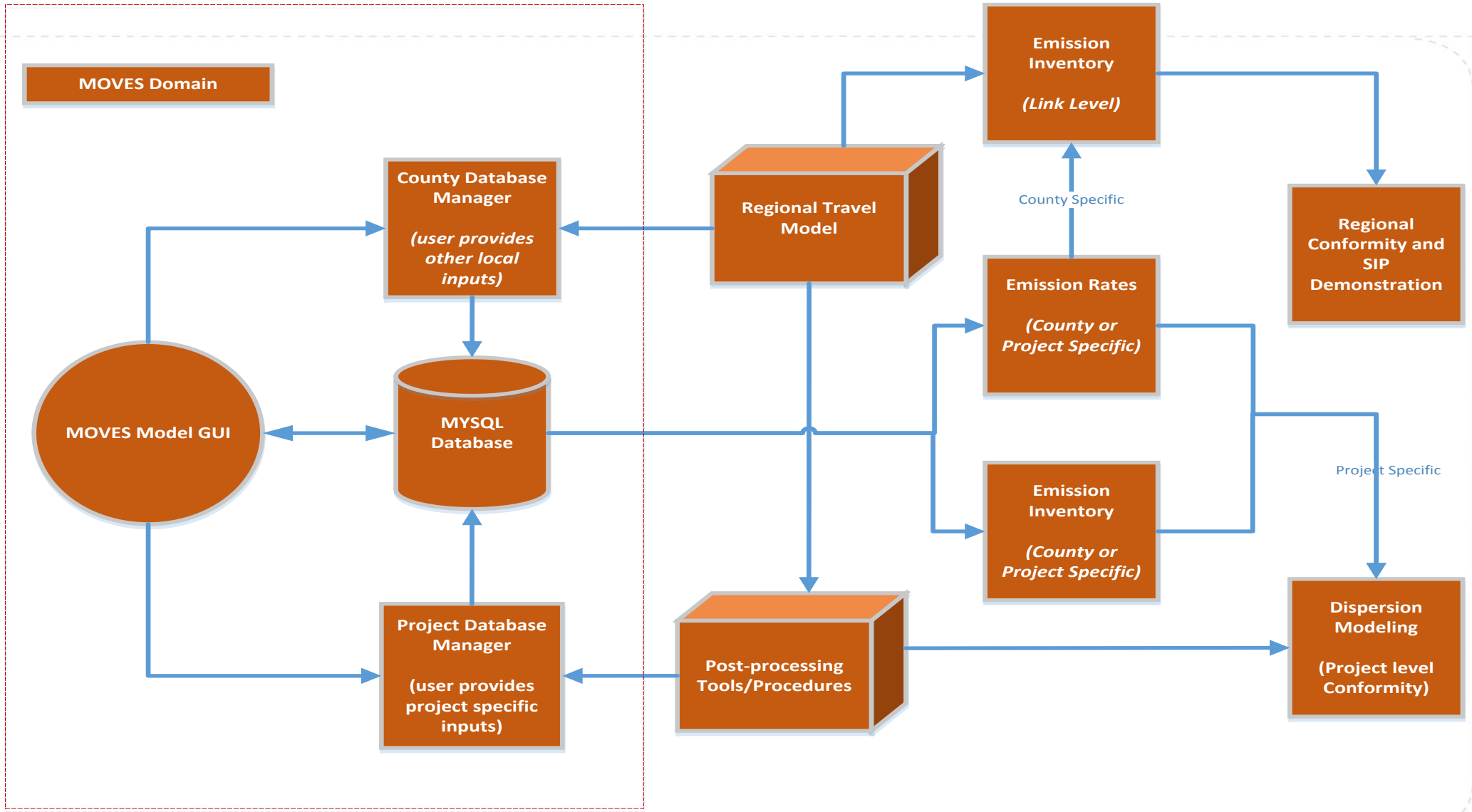
Rates Output

- *Rate per Distance*
- *Rate Per Profile*
- *Rate per Vehicle*
  - Rate Per Hour
  - Rate Per Start

Inventory Output

- *Emissions Quantity*

Emissions Modeling



Take Home Points

Data-Intensive

- *Most Critical Inputs*
- *Inventory Vs. Rate Mode Selection*
- *MYSQL Queries*
- *Changing Default Inputs Refer EPA Guidance*

Resource-Intensive

- *Runtime (Depends on Pollutant-Processes, Mode, Output Options, etc.)*
- *Inventory Vs. Rate Mode Selection*
- *Fast Computer & Large Hard-Drive Capacity*
- *Implement Errors Identification Procedures*

Refer EPA Guidance Documents and Training Modules

Resources

- EPA, MOVES2014 and MOVES2014a Technical Guidance
  https://www3.epa.gov/otaq/models/moves/index.htm

- FHWA, Air Quality Guidance
  - https://www.fhwa.dot.gov/environment/air_quality/conformity/methodologies/moves.cfm

- ARB, EMFAC
  - https://www.arb.ca.gov/msei/categories.htm

Contact

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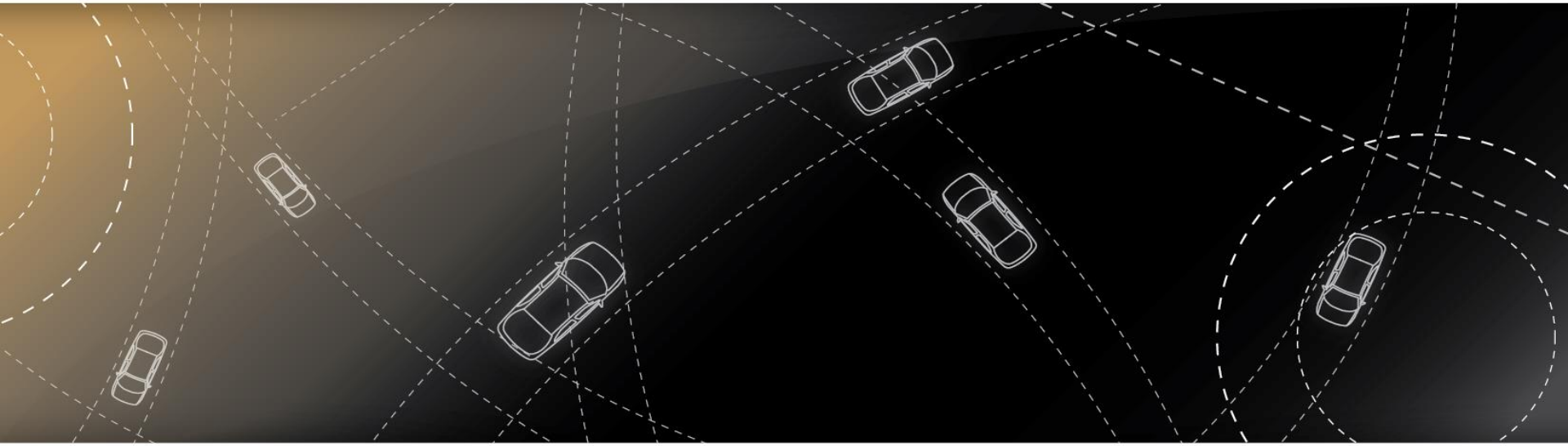
http://tti.tamu.edu/group/airquality/



Models Used in Air Quality Analysis

Highway Air Dispersion Models

Michael Claggett

Highway Air Dispersion Models

- Review
  - Spatial Regimes
  - Air Quality Model Features
  - Support Center for Air Quality Models
- Plume Dispersion from Highways
- The Gaussian Plume Equation
- Plume Dispersion Patterns
- Summary of Input Data Requirements
- Link / Receptor Configurations

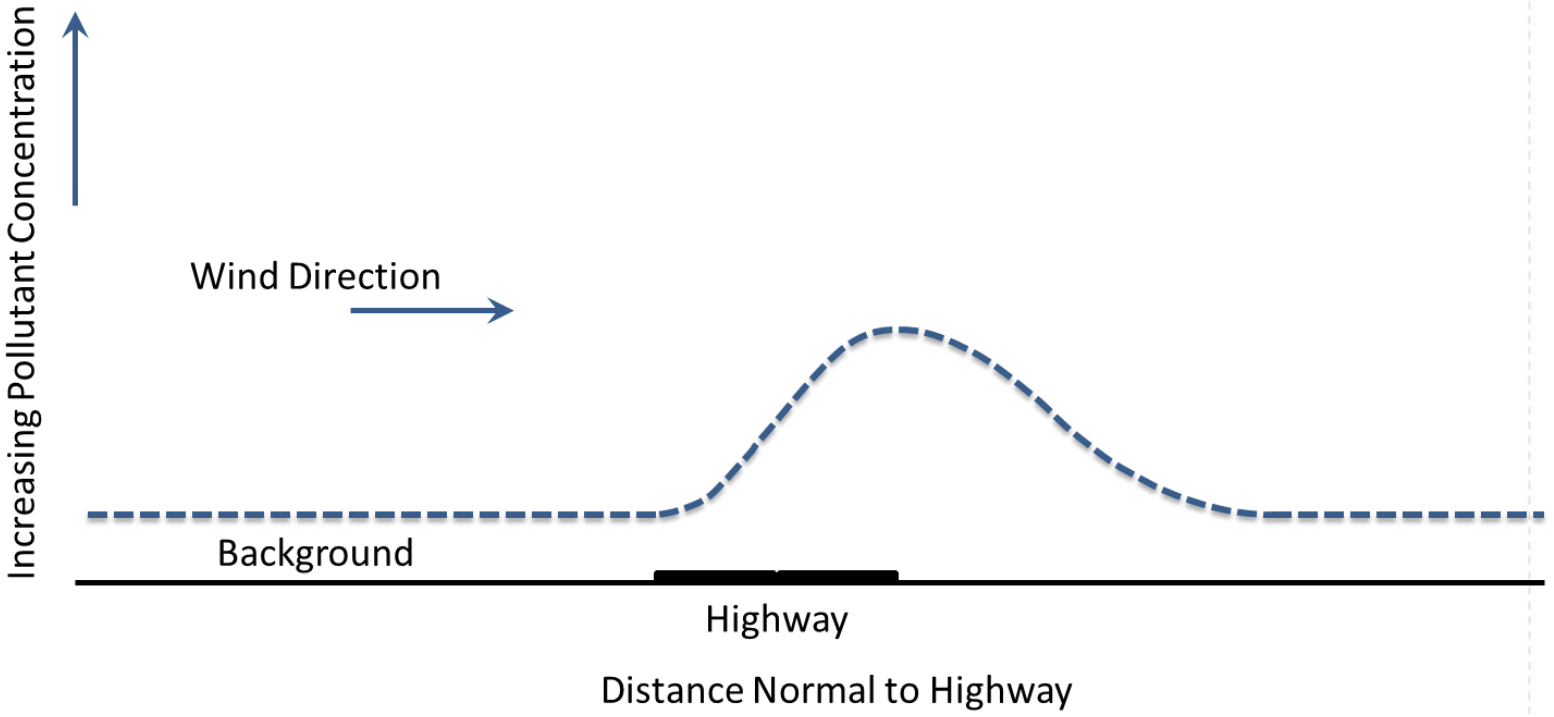
Highway Air Dispersion Models

- Characterizing Atmospheric Stability
- Highway Air Dispersion Model Results
- Analysis Tools
  - Graphical User Interfaces
  - Streamlining the Process / Templates
  - Receptor / Volume Source Spacing Tool
- Dispersion Model Comparison Studies
- EPA's Proposed Replacement of CALINE3 with AERMOD

Spatial Regimes

- Project scale / microscale:
  - Concentrations > ± 20% for distances ≤ 100 m
- Urban scale / mesoscale:
  - Concentrations < ± 20% for distances between 100 m and 10,000 m
- Regional scale / macroscale:
  - Concentrations < ± 20% for distances > 10,000 m

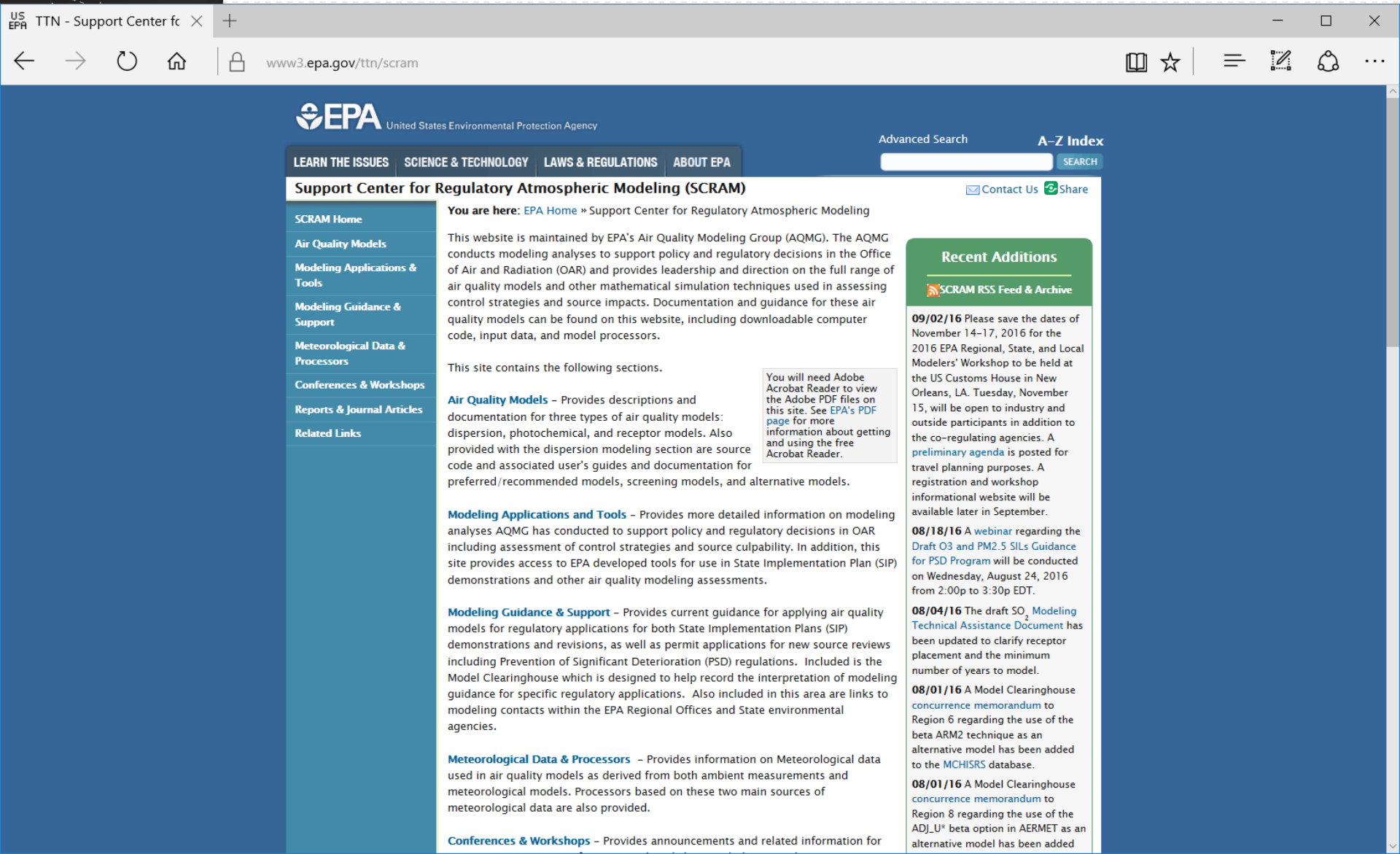
Project Scale



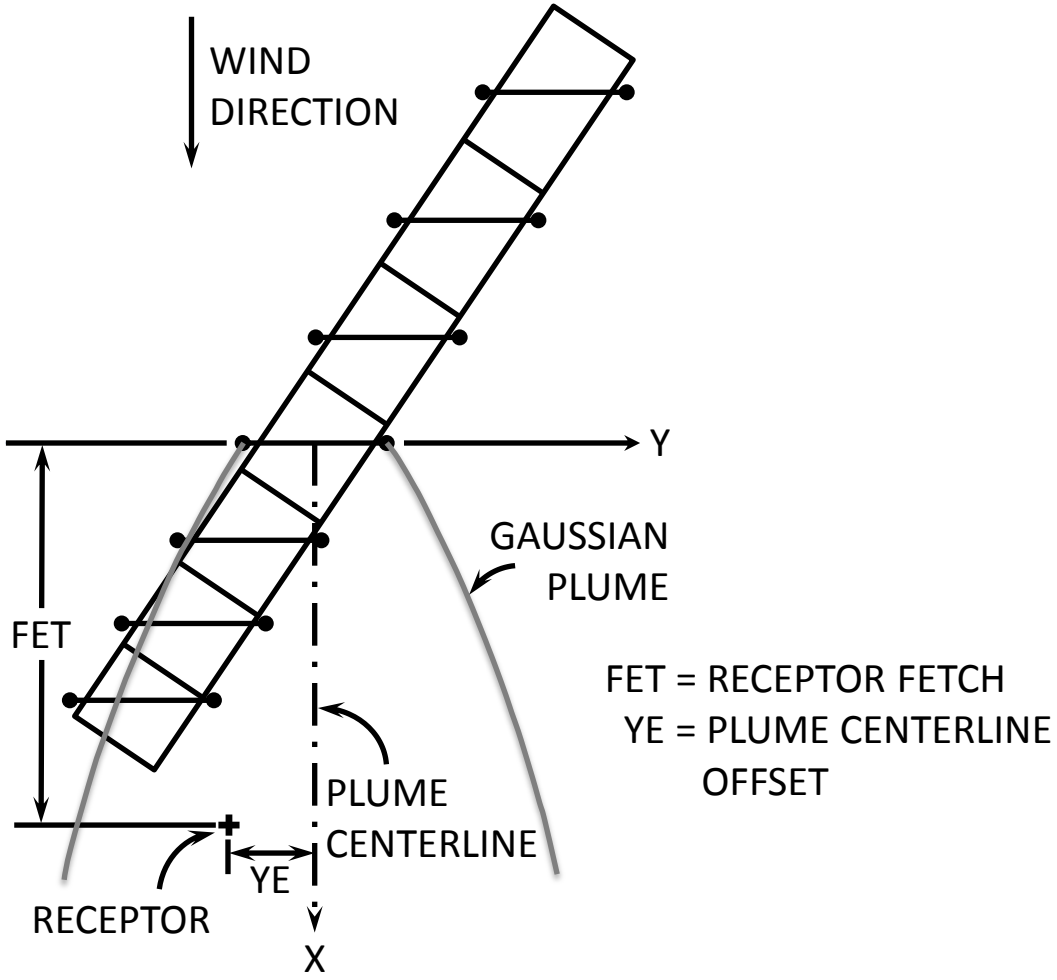
Highway Air Dispersion Model Features

Feature	*Atmospheric Scale*				
	Project Scale				
	CALINE3	CAL3QHC	CAL3QHCR	AERMOD	R-LINE
Exposure Scale					
Acute	●	●	●	●	●
Chronic			●	●	●
Source Characterization					
Free-flow Highways	●	●	●	●	Not recommended for regulatory applications
Signalized Intersections		●	●		
Transportation Terminals				●	
Urban Areas					
Pollutant Applicability					
Inert Pollutants	●	●	●	●	●
Reactive Pollutants				NO_2	
Mathematical Class					
Dispersion / Gaussian	●	●	●	●	●
Photochemical / Numerical					
Receptor					
Statistical, Empirical, Physical					
Level of Sophistication					
Screening					
Refined	●	●	●	●	●

www3.epa.gov/ttn/scram

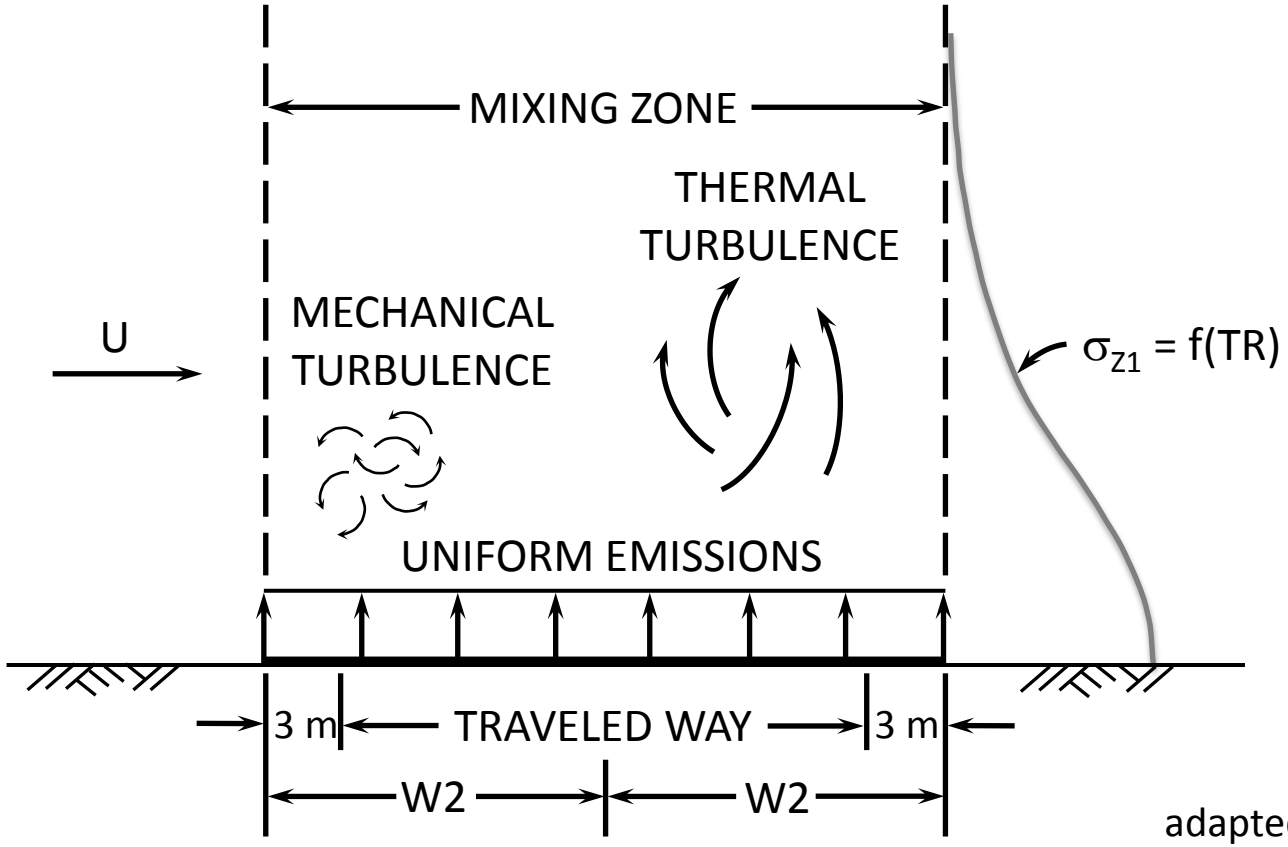


Plume Dispersion from Highways – CAL3 Series



adapted from Benson, 1979

Uniform Mixing Zone (CAL3 Series)



adapted from Benson, 1979

σ_{Z1} = INITIAL VERTICAL DISPERSION PARAMETER
TR = MIXING ZONE RESIDENCE TIME

The Gaussian Plume Equation

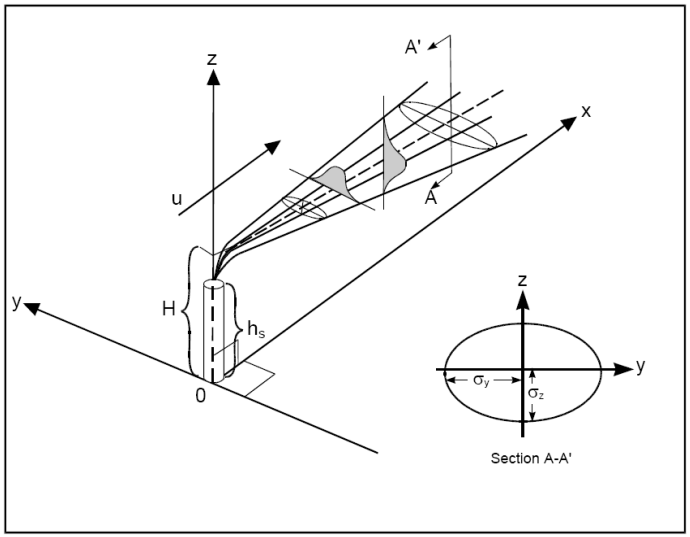
$$g/m^3 \Delta \frac{g/s}{m/s \times m^2}$$

$$\chi^* = \frac{Q}{u \times \pi \sigma_y \sigma_z}$$

where

σ_y is the plume horizontal dispersion coefficient (m)

σ_z is the plume vertical dispersion coefficient (m)



*χ is the ground-level concentration on plume centerline due to a ground-level source, typical of a highway

The Gaussian Plume Equation

$$\chi = \frac{Q}{2\pi\, u\, \sigma_y\, \sigma_z} \exp\left[-\frac{1}{2}\left(\frac{y}{\sigma_y}\right)^2\right] \times$$

Dilution Term

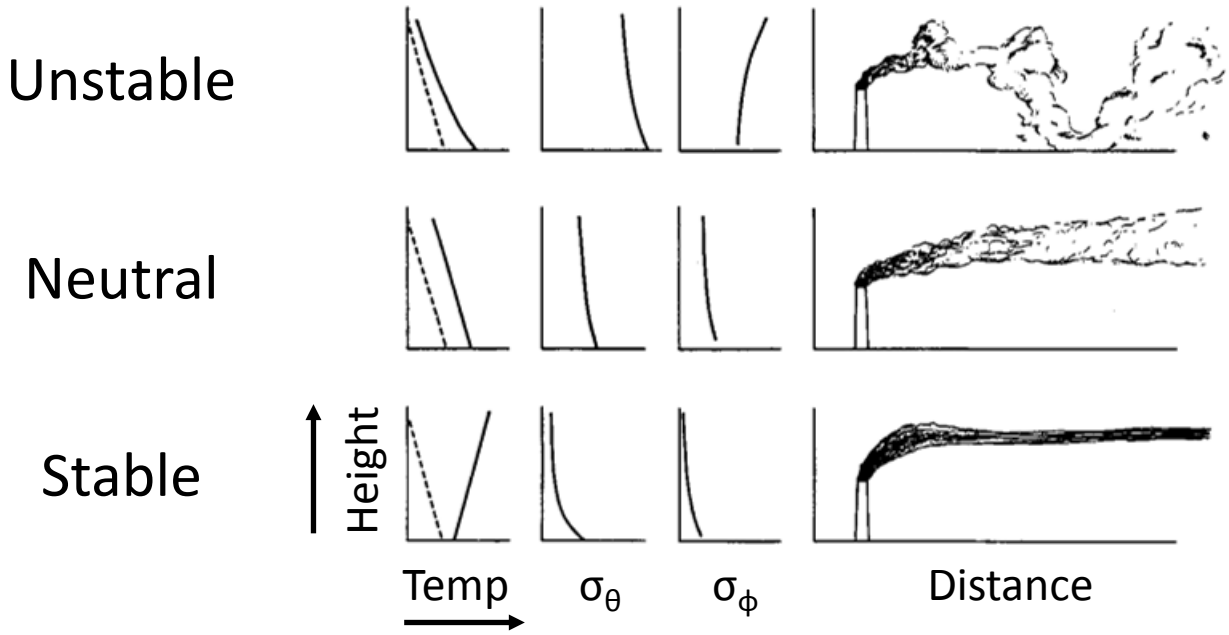
Crosswind Term

$$\left\{\exp\left[-\frac{1}{2}\left(\frac{z-H}{\sigma_z}\right)^2\right] + \exp\left[-\frac{1}{2}\left(\frac{z+H}{\sigma_z}\right)^2\right]\right\}$$

Vertical Term

Reflection Term

Plume Dispersion Patterns



adapted from Slade, 1968

Summary of Input Data Requirements

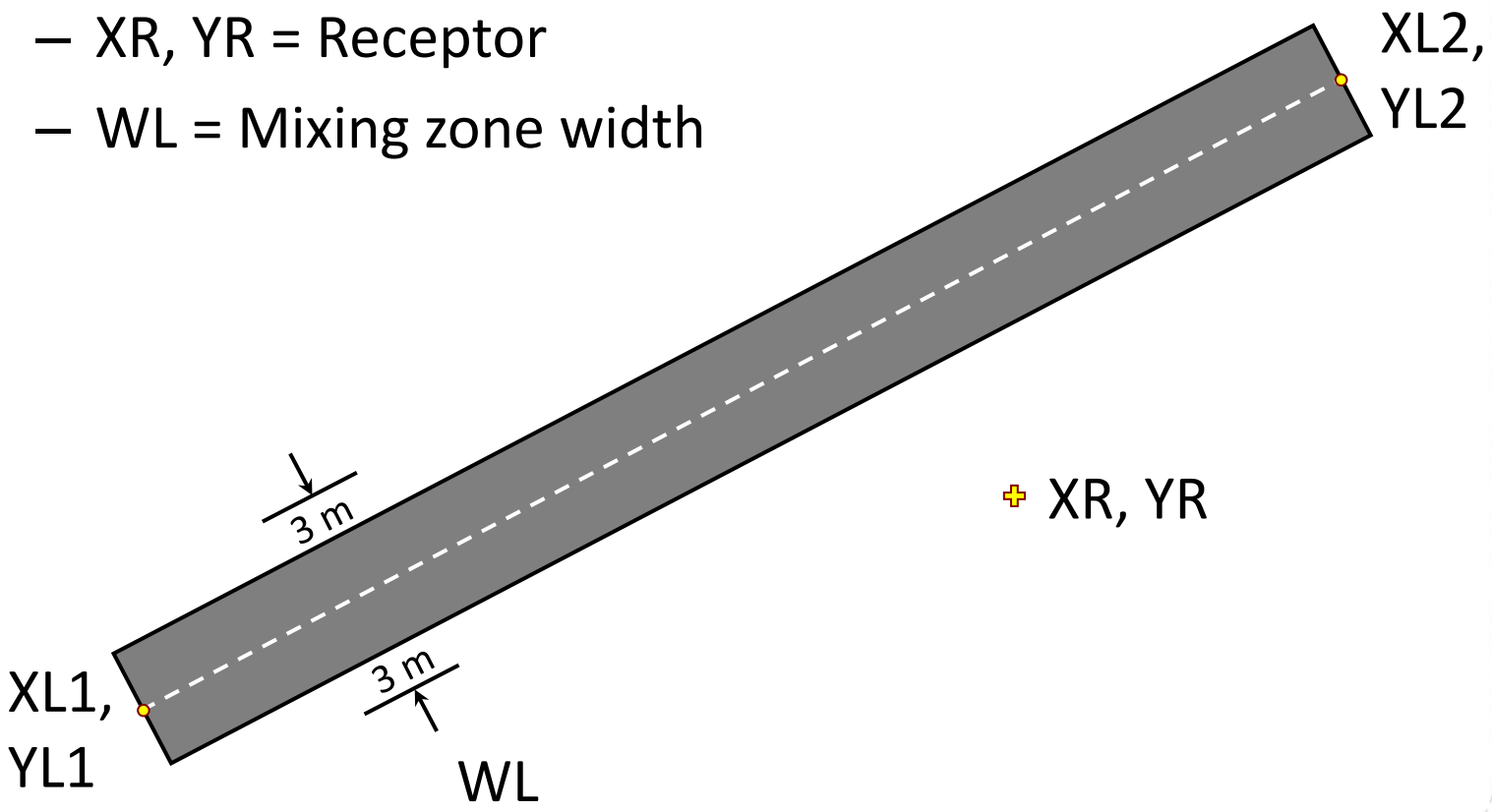
- Program Controls
  - Run options
  - Output options
- Receptor Locations
  - X and Y location coordinates
  - Height of the breathing zone
- Highway Configurations
  - Source location coordinates
  - Source height
  - Source width

Summary of Input Data Requirements

- Vehicle Emissions
  - Traffic volume
  - Emission factor or rate
- Meteorology
  - Wind speed
  - Wind direction
  - Atmospheric stability measure
  - Mixing height

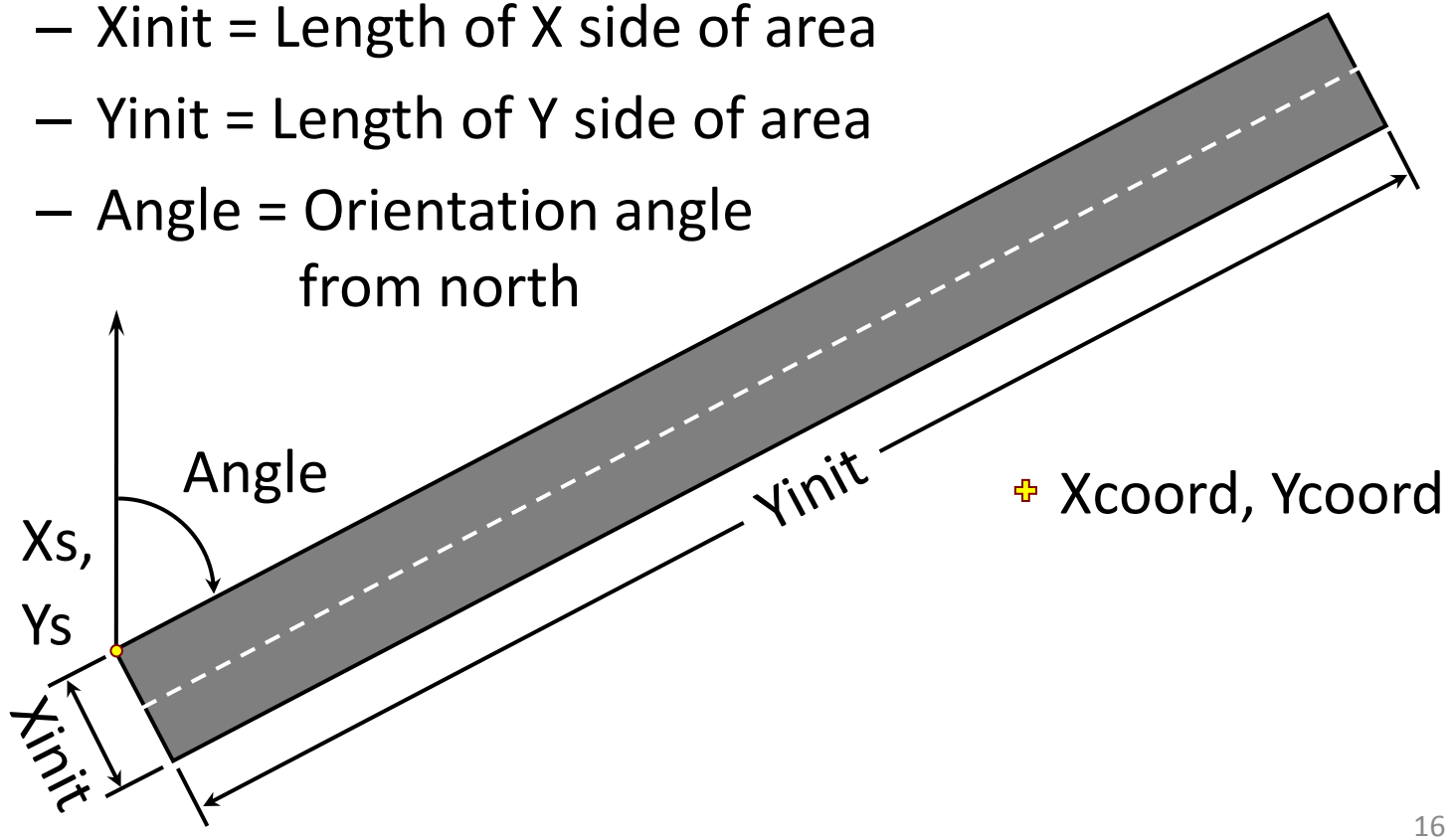
Link / Receptor Configuration – CAL3 Series

- XL1, YL1 = Link centerline start
- XL2, YL2 = Link centerline end
- XR, YR = Receptor
- WL = Mixing zone width



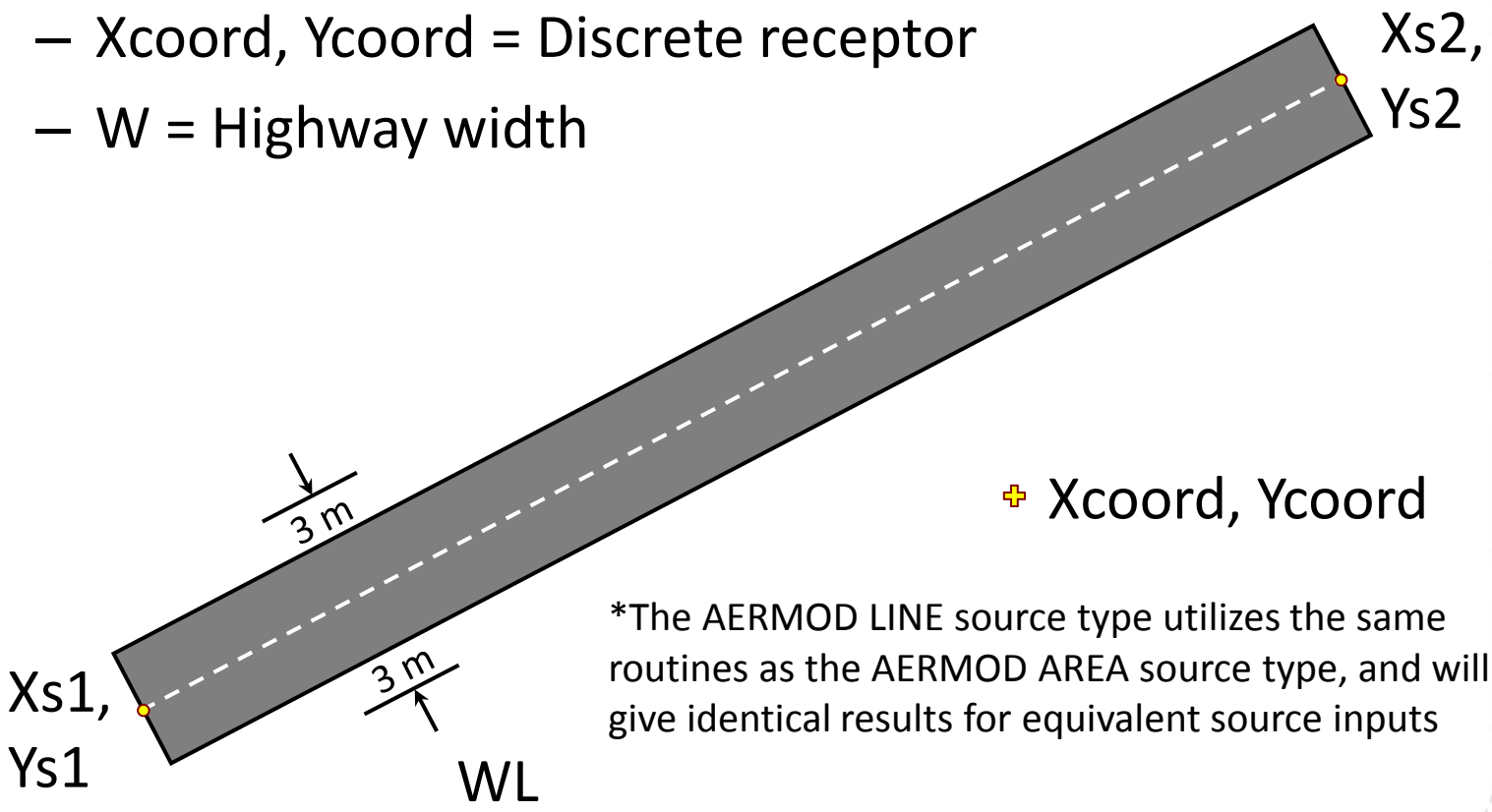
Link / Receptor Configuration – AERMOD Area

- Xs, Ys = Area source vertex
- Xcoord, Ycoord = Discrete receptor
- Xinit = Length of X side of area
- Yinit = Length of Y side of area
- Angle = Orientation angle from north



Link / Receptor Configuration – AERMOD Line*

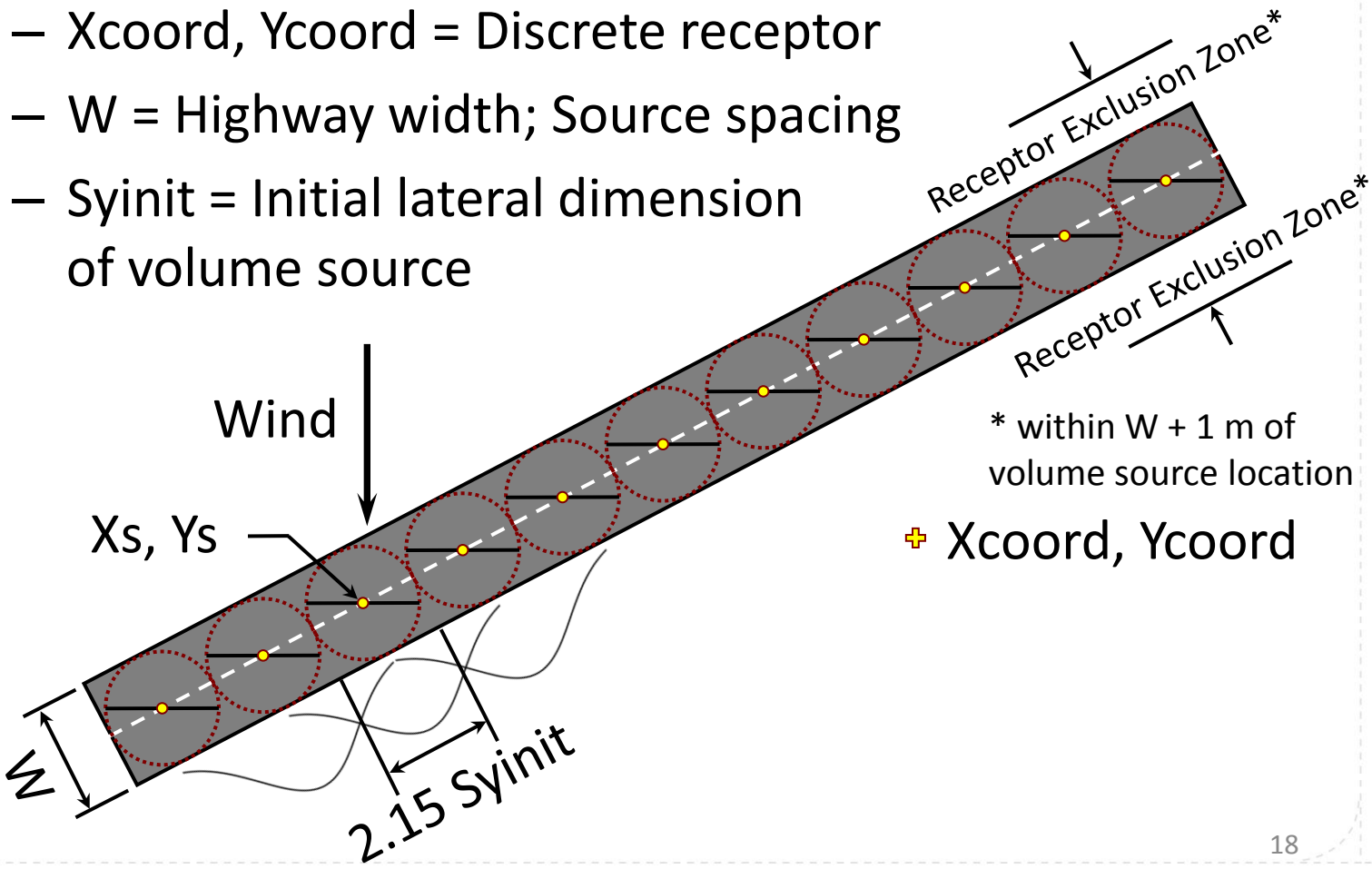
- Xs1, Ys1 = Line midpoint start
- XL2, YL2 = Line midpoint end
- Xcoord, Ycoord = Discrete receptor
- W = Highway width



*The AERMOD LINE source type utilizes the same routines as the AERMOD AREA source type, and will give identical results for equivalent source inputs

Link / Receptor Configuration – AERMOD Volume

- Xs, Ys = Volume source center
- Xcoord, Ycoord = Discrete receptor
- W = Highway width; Source spacing
- Syinit = Initial lateral dimension of volume source



Characterizing Atmospheric Stability – Pasquill's Categories

Surface Wind Speed (m/s)	Daytime Insolation			Nighttime Conditions	
	Strong	Moderate	Slight	≥ 4/8 Clouds	≤ 3/8 Clouds
< 2	A	A-B	B		
2	A-B	B	C	E	F
4	B	B-C	C	D	E
6	C	C-D	D	D	D
> 6	C	D	D	D	D

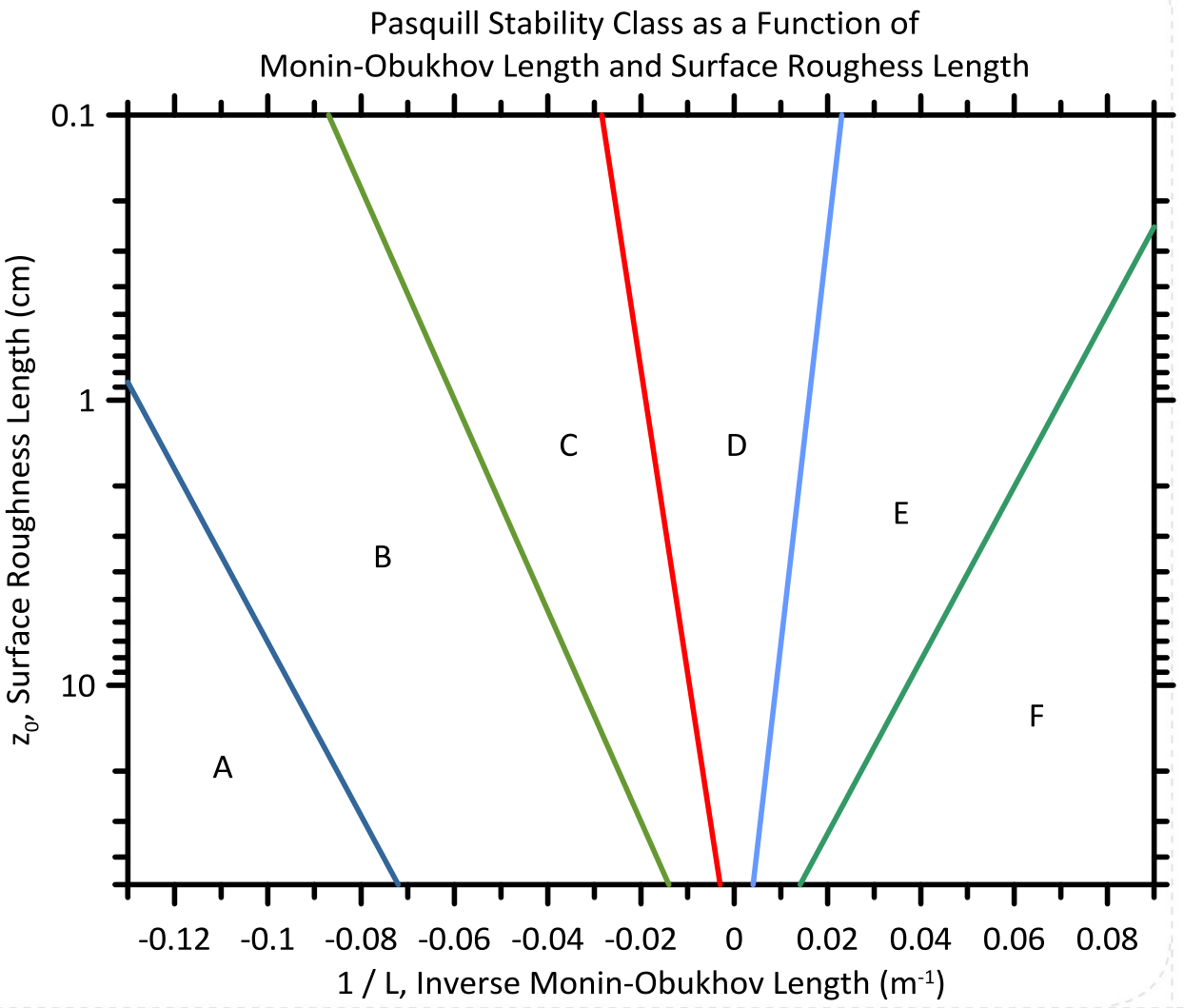
A: Extremely unstable
B: Moderately unstable
C: Slightly unstable
D: Neutral
E: Slightly stable
F: Moderately stable

adapted from Slade, 1968

Characterizing Atmospheric Stability – Obukhov Length

$z_0 \geq 50$ cm	
Stability Class	**L (m)**
A	-6.9
B	-42.6
C	-200.5
D	-8888
E	159.3
F	35.4

Based on Golder (1972) as employed in EPA's AERMOD model

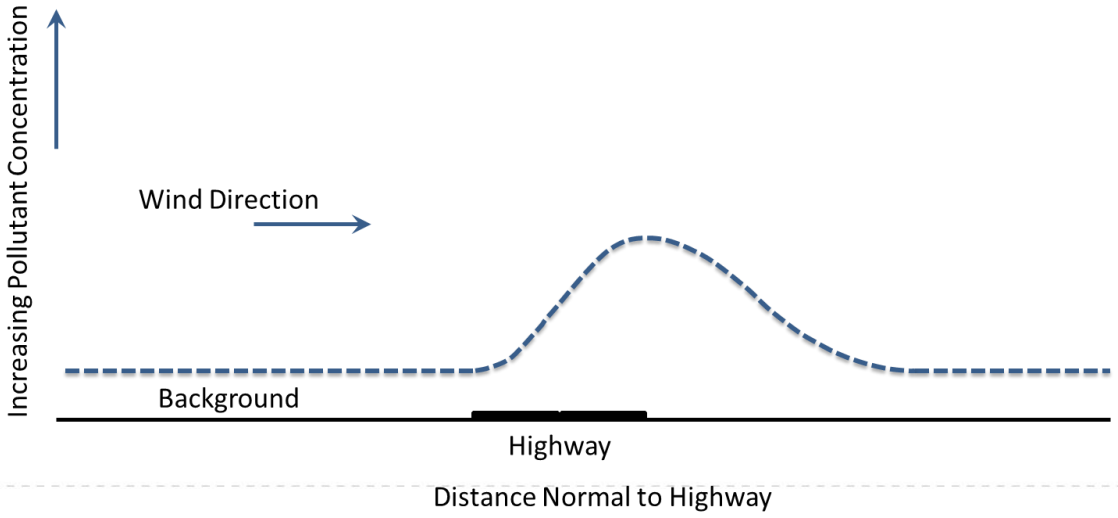


Meteorology Inputs

- Screening Meteorology
  - AERMOD – MAKEMET
  - CALINE3 / CAL3QHC – specified in EPA Guidance
- Refined Meteorology
  - AERMOD – AERMET
  - CAL3QHCR – MPRM

Air Quality Model Results

- Project scale
  - Ambient Concentration =
    - Background +
    - Highway Contribution +
    - Other Nearby Sources Not Reflected in Background



Highway Air Dispersion Model Results

- Compute design values
  - Ambient concentration statistic appropriate for comparison to a National Ambient Air Quality Standard (NAAQS)

    Design Value ≤ NAAQS ?

- NAAQS
  - CO
    - 9 ppm – 8-hours not to be exceeded more than once per year
    - 35 ppm – 1-hour not to be exceeded more than once per year

Highway Air Dispersion Model Results

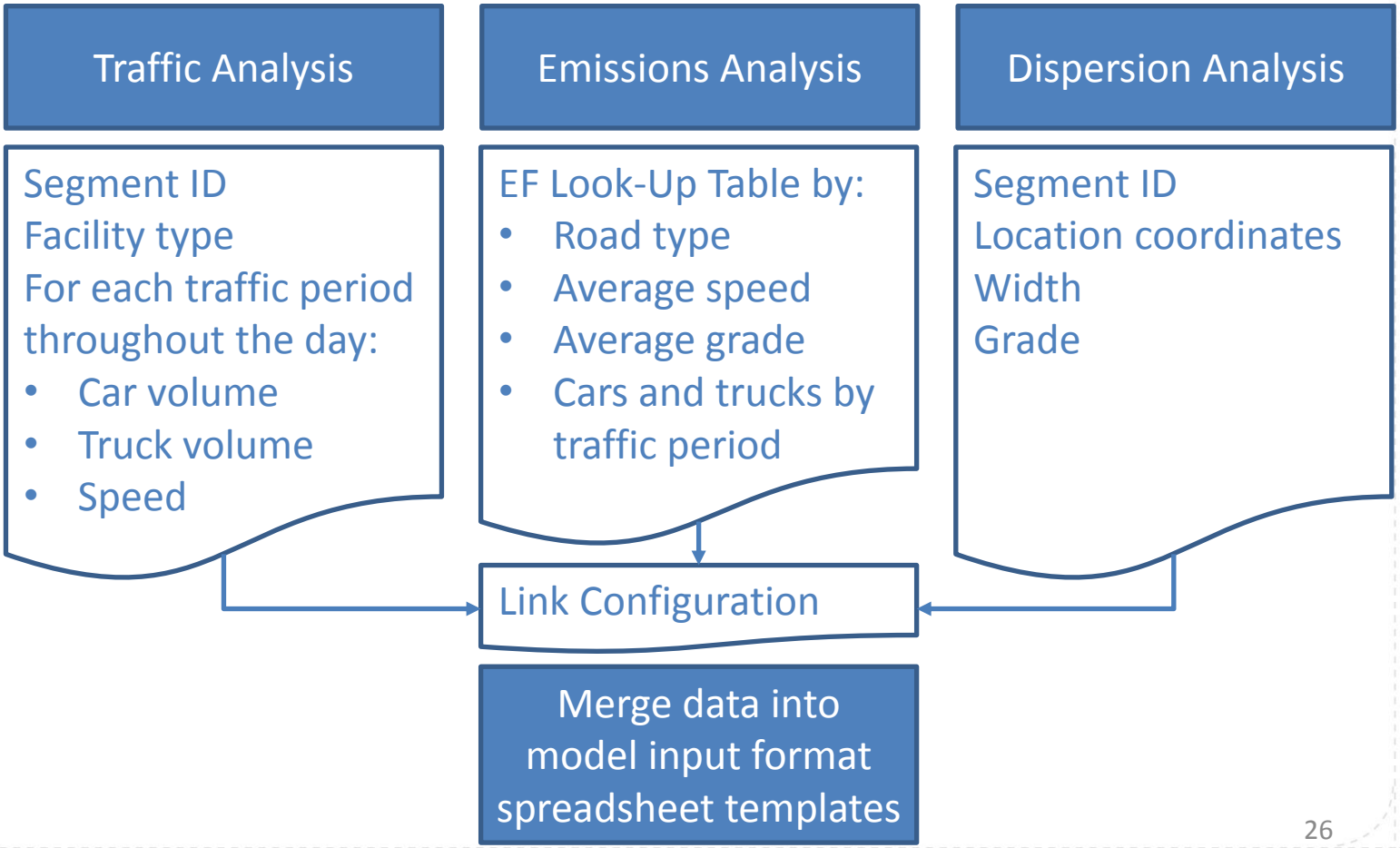
- NAAQS
  - PM2.5
    - 12.0 µg/m^3 (2012) – annual mean, averaged over 3 years
    - 35 µg/m^3 (2012) – 24-hours 98th percentile, averaged over 3 years
  - PM10
    - 150 µg/m^3 – 24-hours not to be exceeded more than once per year on average over 3 years

Analysis Tools

- Graphical User Interfaces
  - NCHRP 25-48 TRAQS (under development)
  - Commercial software available from a number of vendors
  - FHWA's CAL3i

Analysis Tools

- Streamlining the Process



Analysis Tools

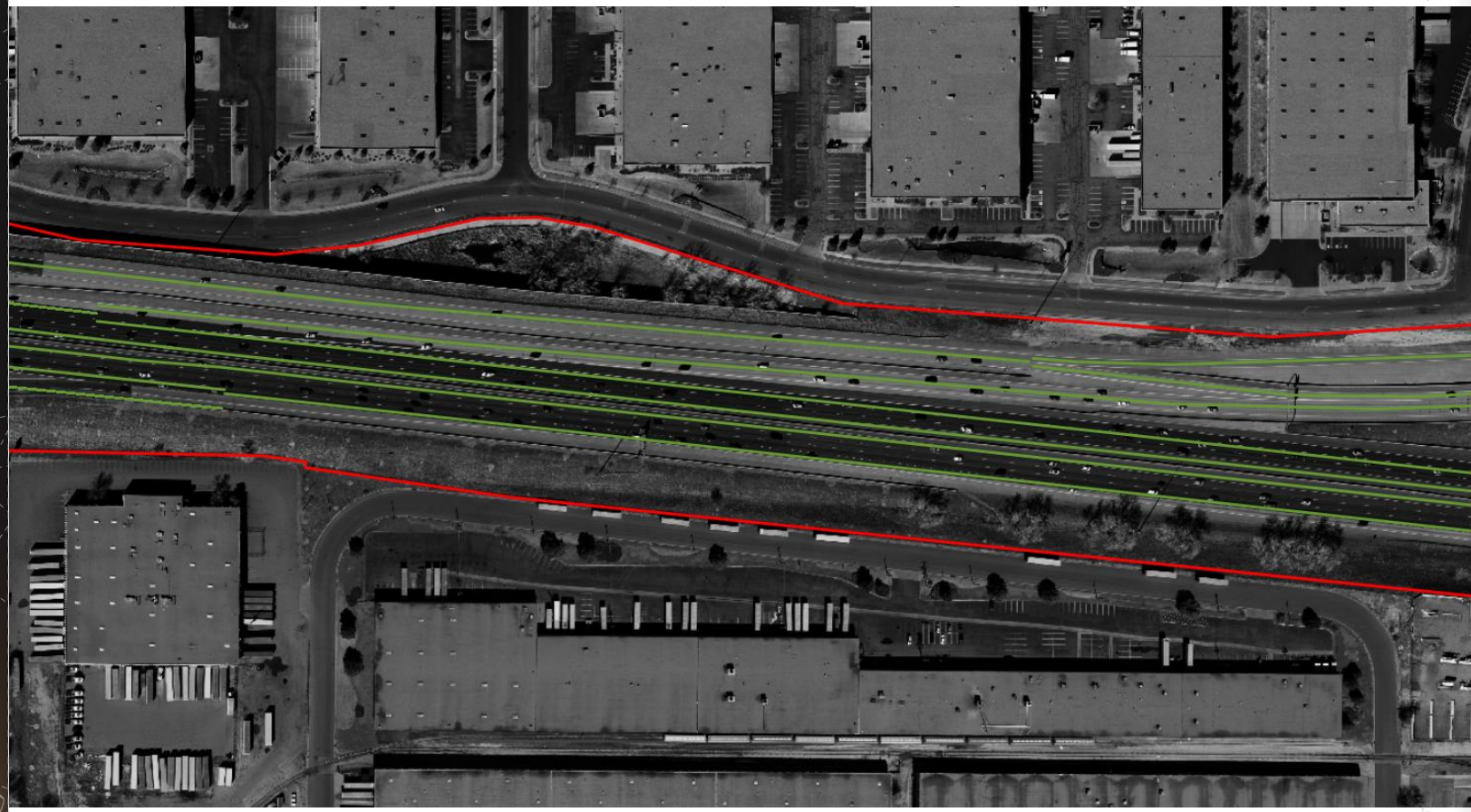
- Spreadsheet Templates

CO STARTING							
TITLEONE	2015 EMFAC2011 PM2.5 Example Arterial						
TITLETWO	2008-2012 Meteorology						
MODELOPT	FLAT CONC						
AVERTIME	24 ANNUAL						
URBANOPT	2000000						
POLLUTID	PM2.5						
FLAGPOLE	1.5						
RUNORNOT	RUN						
ERRORFIL	ERRORS.OUT						
CO FINISHED							
SO STARTING							
**				Xs1	Ys1	Xs2	Ys2
**	Scrid		Srctyp	(m)	(m)	(m)	(m)
**	-----		------	----------	----------	----------	----------
LOCATION		001	LINE	1899154.559	709066.640	1899156.326	709181
LOCATION		062	LINE	1901374.918	709459.414	1901573.182	709456
** Line Source			Lnemis	Relhgt	Width	Szinit	
** Parameters:			(g/s-m2)	(m)	(m)	(m)	
**	-----		--------	------	-----	------	
SRCPARAM		001	1.0	1.3	7.315	1.2	
SRCPARAM		062	1.0	1.3	7.315	1.2	
** Variable			Qflag	ON	AM1	AM2	ON
** Emission Rates:			------	----------	----------	----------	----------
EMISFACT		001	HROFDY	7*2.8228968E-07	6.0721223E-07	5.6048163E-07	2*2.8228968E
EMISFACT		062	HROFDY	7*5.1687225E-07	1.0886432E-06	1.0034244E-06	2*5.1687225E
URBANSRC	ALL						
SRCGROUP	ALL						
SO FINISHED							

RE STARTING			
**			
**	Receptor Array		
**			
**		Xcoord	Ycoord
**		(m)	(m)
**		----------	----------
DISCCART		1899132.486	709502.677
DISCCART		1900976.584	709237.315
RE FINISHED			
ME STARTING			
SURFFILE	23155_2008-2012.sfc		
PROFFILE	23155_2008-2012.pfl		
SURFDATA	23155 2008		
UAIRDATA	23230 2008		
PROFBASE	0.0		
ME FINISHED			
OU STARTING			
RECTABLE	24 1ST		
MAXTABLE	24 50		
POSTFILE	24 ALL PLOT 2015_EMFAC_PM		
POSTFILE	ANNUAL ALL PLOT 2015_EMFA		
OU FINISHED			

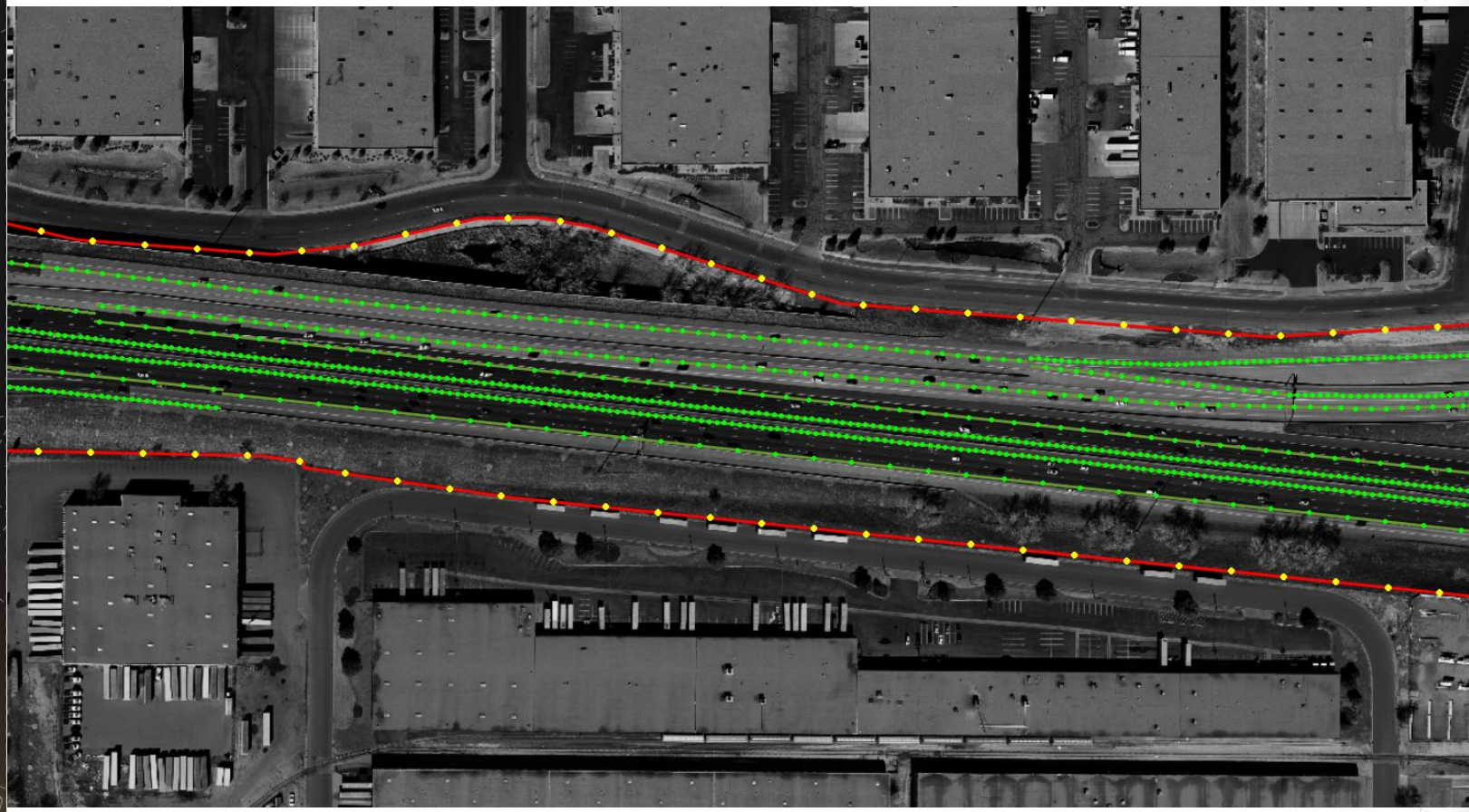
Analysis Tools

- Receptor / Volume Source Spacing



Analysis Tools

- Receptor / Volume Source Spacing



Dispersion Model Comparison Studies

- AERMOD Area versus CAL3QHCR
  - Lin and Vallamsundar (IL DOT study) observed 2.1 times higher predictions of annual average concentrations of $PM_{2.5}$
- AERMOD Volume versus AERMOD Area
  - Schewe reported 1.8 to 3.8 times higher concentration predictions

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Highway Air Dispersion Model Comparison Studies

- AERMOD Area versus AERMOD Volume
  - Pasch, et al. (Caltrans study) found that for a hypothetical 1.1 mile freeway widening project
    - AERMOD produced 2.6 times higher concentrations for area sources versus a few (i.e., 22) large volume sources; whereas,
    - the concentration difference was only 10% higher for area sources versus many (i.e., 968) small volume sources

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EPA's Proposed Replacement of CALINE3 with AERMOD

- Technical Support Document (TSD) for Replacement of CALINE3 with AERMOD
  - Comparison of CALINE3 and AERMOD
  - Scientific merit of each dispersion model
  - Existing model evaluations
  - Additional testing by EPA

    http://www.regulations.gov/#!docketBrowser;rpp=25;po=0;dct=SR%252BO;D=EPA-HQ-OAR-2015-0310

EPA's Proposed Replacement of CALINE3 with AERMOD

- EPA 11th Modeling Conference
  - Presentation by Chris Owen

    https://remote.dot.gov/ttn/scram/11thmodconf/presentations/,DanaInfo=www.epa.gov+1-8_CAL3_11th_MC.pdf
  - Recommendations for CO screening
    - AERSCREEN (single source) and AERMOD (multiple sources) in conjunction with MAKEMET to generate screening meteorological data based on worst case inputs

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