



Air Quality Analysis Methodologies for Transportation Control Measures

Raleigh, NC
March 25, 2009

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2. Variables to Consider

MOBILE6 Vehicle Classifications

<i>Number</i>	<i>Abbreviation</i>	<i>Description</i>
1	LDGV	Light-Duty Gasoline Vehicles (Passenger Cars)
2	LDGT1	Light-Duty Gasoline Trucks 1 (0-6,000 lbs. GVWR, 0-3,750 lbs. LVW)
3	LDGT2	Light-Duty Gasoline Trucks 2 (0-6,000 lbs. GVWR, 3,751-5,750 lbs. LVW)
4	LDGT3	Light-Duty Gasoline Trucks 3 (6,001-8,500 lbs. GVWR, 0-5,750 lbs. ALVW)
5	LDGT4	Light-Duty Gasoline Trucks 4 (6,001-8,500 lbs. GVWR, 5,751 lbs. and greater ALVW)
6	HDGV2b	Class 2b Heavy-Duty Gasoline Vehicles (8,501-10,000 lbs. GVWR)
7	HDGV3	Class 3 Heavy-Duty Gasoline Vehicles (10,001-14,000 lbs. GVWR)
8	HDGV4	Class 4 Heavy-Duty Gasoline Vehicles (14,001-16,000 lbs. GVWR)
9	HDGV5	Class 5 Heavy-Duty Gasoline Vehicles (16,001-19,500 lbs. GVWR)
10	HDGV6	Class 6 Heavy-Duty Gasoline Vehicles (19,501-26,000 lbs. GVWR)
11	HDGV7	Class 7 Heavy-Duty Gasoline Vehicles (26,001-33,000 lbs. GVWR)
12	HDGV8a	Class 8a Heavy-Duty Gasoline Vehicles (33,001-60,000 lbs. GVWR)
13	HDGV8b	Class 8b Heavy-Duty Gasoline Vehicles (>60,000 lbs. GVWR)
14	LDDV	Light-Duty Diesel Vehicles (Passenger Cars)
15	LDDT12	Light-Duty Diesel Trucks 1 and 2 (0-6,000 lbs. GVWR)
16	HDDV2b	Class 2b Heavy-Duty Diesel Vehicles (8,501-10,000 lbs. GVWR)
17	HDDV3	Class 3 Heavy-Duty Diesel Vehicles (10,001-14,000 lbs. GVWR)
18	HDDV4	Class 4 Heavy-Duty Diesel Vehicles (14,001-16,000 lbs. GVWR)
19	HDDV5	Class 5 Heavy-Duty Diesel Vehicles (16,001-19,500 lbs. GVWR)
20	HDDV6	Class 6 Heavy-Duty Diesel Vehicles (19,501-26,000 lbs. GVWR)
21	HDDV7	Class 7 Heavy-Duty Diesel Vehicles (26,001-33,000 lbs. GVWR)
22	HDDV8a	Class 8a Heavy-Duty Diesel Vehicles (33,001-60,000 lbs. GVWR)
23	HDDV8b	Class 8b Heavy-Duty Diesel Vehicles (>60,000 lbs. GVWR)
24	MC	Motorcycles (Gasoline)
25	HDGB	Gasoline Buses (School, Transit and Urban)
26	HDDBT	Diesel Transit and Urban Buses
27	HDDBS	Diesel School Buses
28	LDDT34	Light-Duty Diesel Trucks 3 and 4 (6,001-8,500 lbs. GVWR)



11. COMMUTER Model

Software and Documentations

COMMUTER Model v2.0 User Manual

EPA420-B-05-017

October 2005

Procedures Manual for the COMMUTER Model v2.0

EPA420-B-05-018

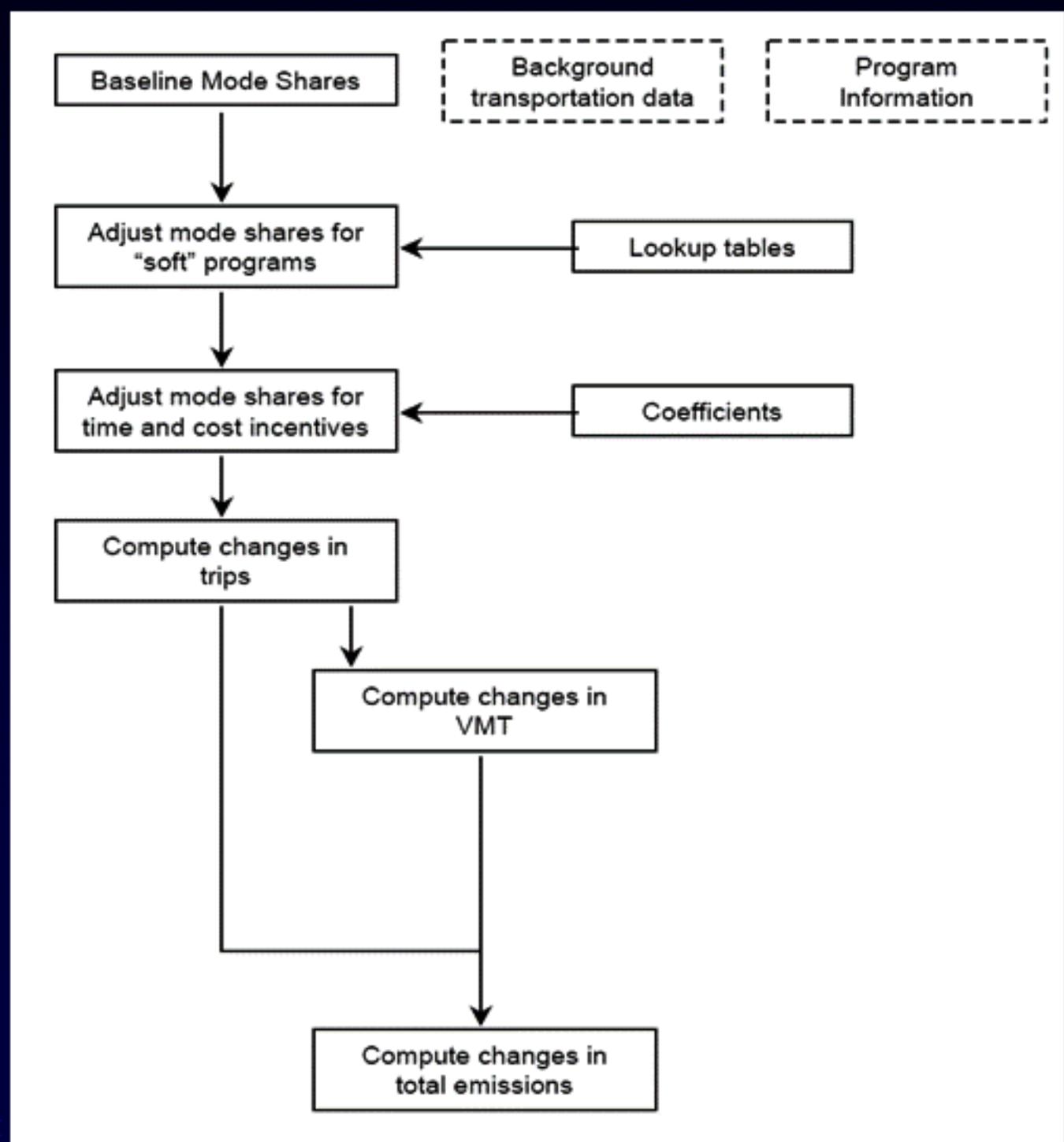
October 2005

**[http://www.epa.gov/otaq/stateresources/policy/pag_tr
ansp.htm#cp](http://www.epa.gov/otaq/stateresources/policy/pag_tr
ansp.htm#cp)**



11. COMMUTER Model

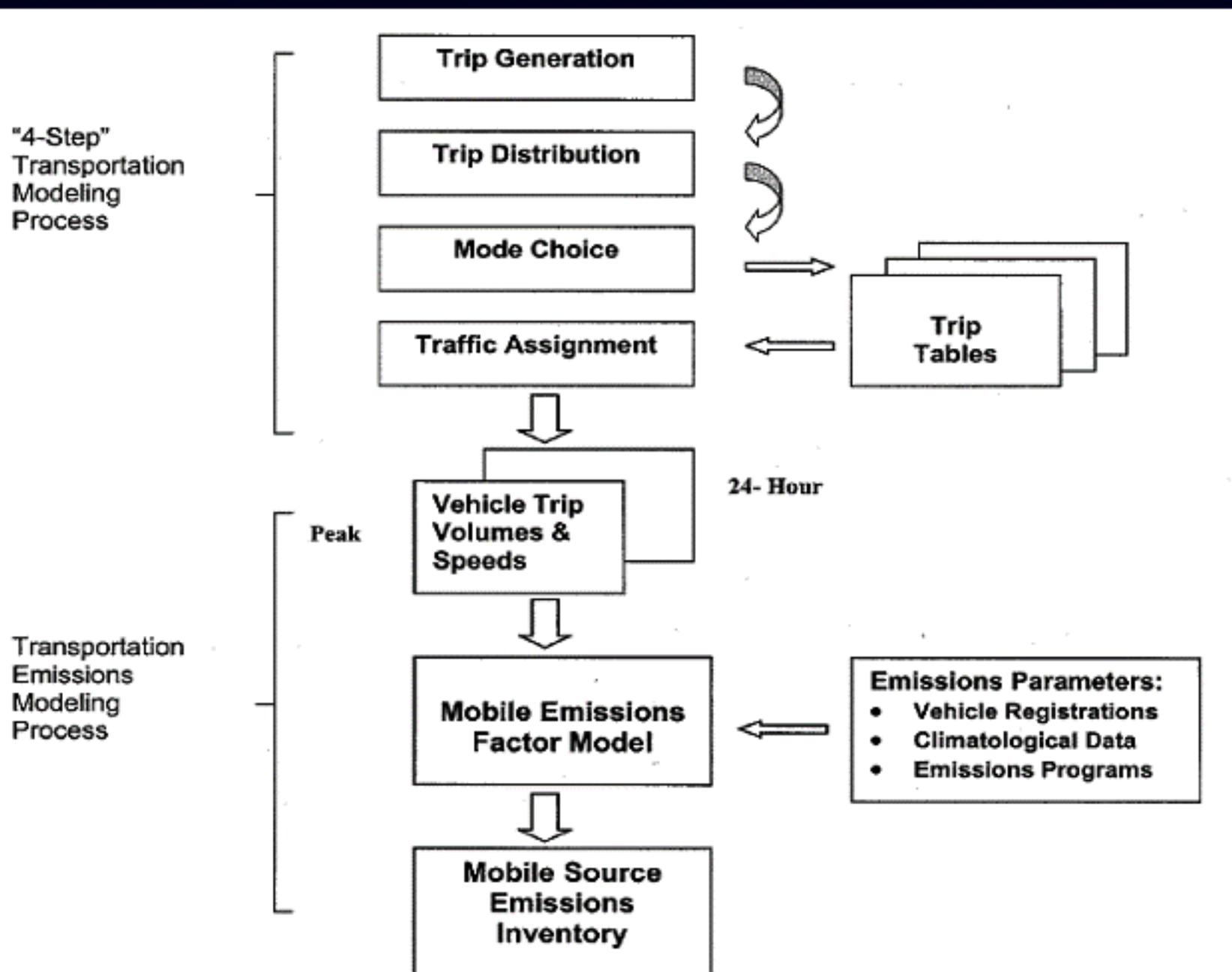
Model Overview





11. COMMUTER Model

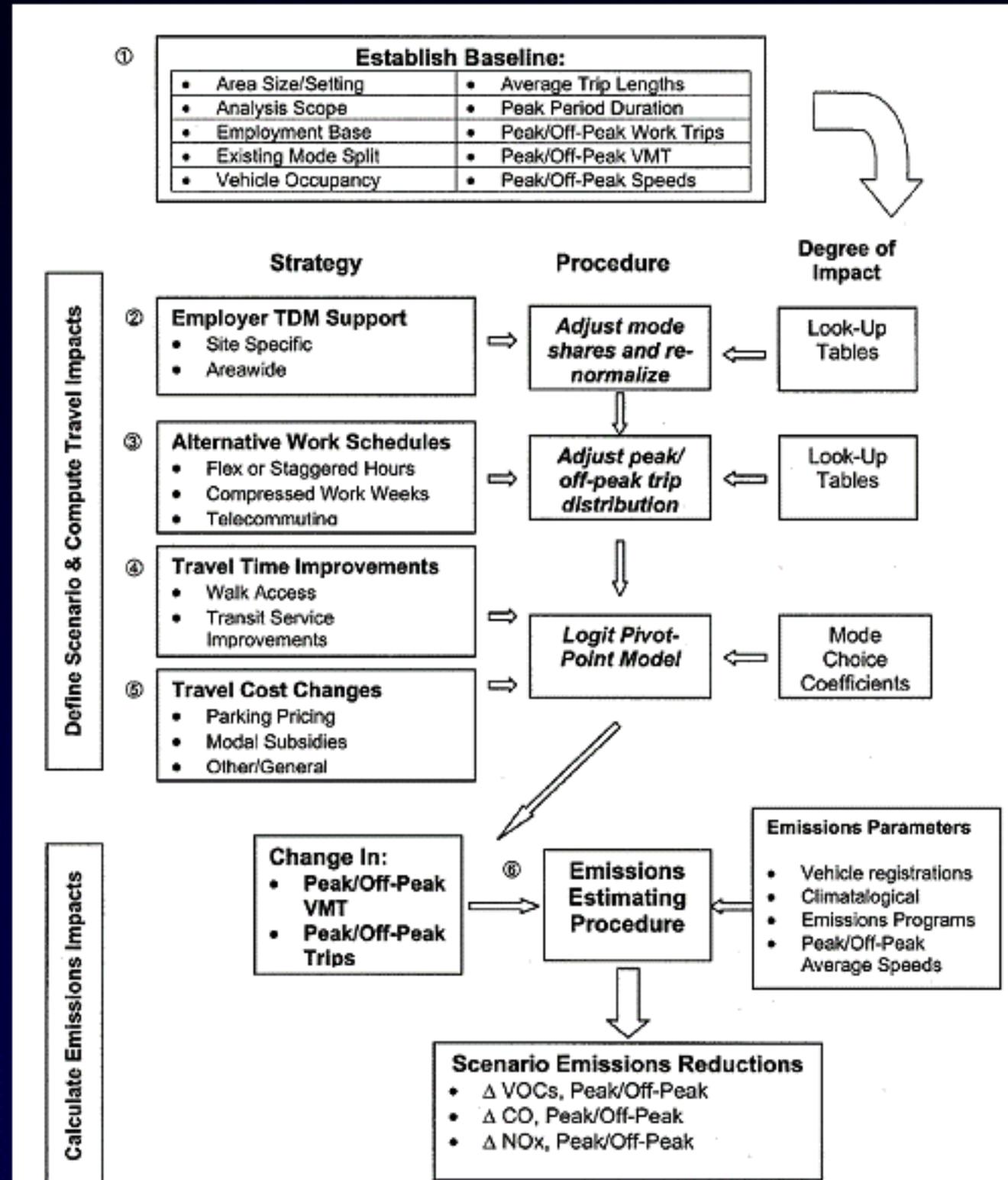
Traditional Mobile Source Emissions Analysis Process





11. COMMUTER Model

COMMUTER Model Approach





11. COMMUTER Model

FHWA COMMUTER Model Workshop Agenda

Day 1 Morning Session

Introduction

Analysis Procedure

Background Information

Estimating Travel Impacts of Employer Support Programs

Day 1 Afternoon Session

Estimating Travel Impacts of Alternative Travel
Time and Cost Changes

Converting Travel Impacts to Emission Reductions

Day 2: COMMUTER Hands-On Class Exercise

Software Installation/Running

Input Screens

Examples

Importing MOBILE Emission Factors into the COMMUTER Model



2. Variables to Consider



Vehicle Classes (Mix)

Vehicle Ages

Speed

Facilities (H-way, Arterial, Local, & H-Ramp)

Hour (peak/off-peak)



2. Variables to Consider

Vehicle (Engine) Starts

Vehicle Types Affected

Number of Engine Starts

Hot/Cold Starts (MOBILE1-5)

Soak Distribution (MOBILE6.2)

Starts per Day



2. Variables to Consider

Vehicle Idling

Vehicle Classes Affected

Vehicle Delay

Time of Day



2. Variables to Consider

Vehicle Classes Affected by Engine Starts

ID	Label	Description
1	LDGV	Light-Duty Gasoline Vehicles (Passenger Cars)
2	LDGT1	Light-Duty Gasoline Trucks 1 (0-6,000 lbs. GVWR, 0-3750 lbs. LVW)
3	LDGT2	Light-Duty Gasoline Trucks 2 (0-6,000 lbs. GVWR, 3751-5750 lbs. LVW)
4	LDGT3	Light-Duty Gasoline Trucks 3 (6,001-8,500 lbs. GVWR, 0-5750 lbs. ALVW)
5	LDGT4	Light-Duty Gasoline Trucks 4 (6,001-8,500 lbs. GVWR, 5751 lbs. and greater ALVW)
6	HDGV2B	Class 2b Heavy-Duty Gasoline Vehicles (8501-10,000 lbs. GVWR)
7	HDGV3	Class 3 Heavy-Duty Gasoline Vehicles (10,001-14,000 lbs. GVWR)
8	HDGV4	Class 4 Heavy-Duty Gasoline Vehicles (14,001-16,000 lbs. GVWR)
9	HDGV5	Class 5 Heavy-Duty Gasoline Vehicles (16,001-19,500 lbs. GVWR)
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24	MC	Motorcycles (Gasoline)
25	HDGB	Gasoline Buses (School, Transit and Urban)
28	LDDT34	Light-Duty Diesel Trucks 3 and 4 (6,001-8,500 lbs. GVWR)



2. Variables to Consider

Starts per Day
(MOBILE6.2 Default Values)

Vehicle Type	Weekday	Weekend
Light Duty Car	7.28	5.41
Light Duty Truck	8.06	5.68
Motorcycle	1.35	
Heavy Duty Gas Vehicle & Bus	6.88	
Heavy Duty Diesel Vehicle & Bus	6.65	



2. Variables to Consider

Starts by Hour
(MOBILE6.2 Default Values)

M O B I L E 6 H o u r l y I n d e x	W e e k d a y	W e e k e n d
1	2.04	0.91
2	5.54	1.93
3	6.02	3.10
4	4.73	6.45
5	5.16	6.91
6	6.72	7.97
7	8.07	10.16
8	7.30	7.26
9	8.04	8.89
10	8.98	7.36
11	8.41	8.02
12	7.73	7.11
13	6.02	6.15
14-24	15.24	17.78



2. Variables to Consider

Control Measures

Fuel Related Programs

RVP

Oxygenated Fuel

RFG

Sulfur Level

Vehicle Related Programs

I/M, Anti-Tampering, State II Refueling

Vehicle Classes Affected

Impacts on % of VMT



2. Variables to Consider

MOBILE6.2 Input Considerations

National Defaults vs. Local Input Data

Vehicles Characteristics

Fuel Characteristics

Vehicle Operational Characteristics

Environmental Factors

Vehicle Control Strategies

Matching Local Input Data from Vehicle Activities (before & after)

VMT

Idling

Starts

Control Measures



3. Available Methodologies

FHWA Methods Compilation References/Sources

Methods and Models - Transportation Control Measures - Environment - FHWA - Microsoft Internet Explorer

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Address <http://www.fhwa.dot.gov/environment/tcm/tcm3.htm>

U.S. Department of Transportation
Federal Highway Administration

FHWA Home | Feedback

Environment

TCM Methods and Models

This page links you to documents that are useful for understanding the various methodologies and models in use throughout the country. These documents will help you determine the emission reduction and cost benefits of certain TCMs and TCM type activities.

Related Information

- Public Agency Guidance on Employer-Based TDM Programs and Employer Technical Memorandum on Characteristics of Effective TDM Programs and Employer Technical Memorandum: Characteristics of Effective TDM Programs**
Abstract: *Public Agency Guidance on Employer-Based TDM Programs and Employer Technical Memorandum on Characteristics of Effective TDM Programs* (TRB's Transit Cooperative Research Program (TCRP) Web Document 22) was created for the Federal Transit Administration in an effort to assist public agencies in developing more cost effective transportation demand management (TDM) programs. This document is and its companion piece for *Cost-Effectiveness of Transportation Demand Strategies* (TRB's TCRP Project B-4), *Employer Technical Memorandum: Characteristics of Effective TDM Programs*, are available in PDF at www4.nationalacademies.org/trb/crp.nsf/All+Projects/TCRP+B-04.
- A Sampling of Emissions Analysis Techniques for Transportation Control Measures** FHWA, November, 2000. Publication: FHWA-EP-01-01. (Also in PDF - 2.9 MB)
Abstract: This report describes modeling tools and other methods that can be used to assess the emissions benefits of transportation control measures and other projects in applying for CMAQ funds. The report is primarily intended for state or local air quality/transportation program analysts, but also others interested in estimating the emissions benefits of CMAQ projects.
- Off-Model Air Quality Analysis: A Compendium of Practice** (PDF - 65 KB) Andrew Edwards, FHWA Southern Resource Center, August 1999.
Abstract: This compendium offers a look into several methodologies, utilized in the FHWA's Southern Resource Center geographic area, that provide for the evaluation of possible emission reductions. These methodologies are not all encompassing but should offer insight into off-model practice.
- Commuter Connections Transportation Demand Management Evaluation: TCMs Evaluation Framework** WashCOG No. 98614. March 1998
Abstract: This report presents results of an analysis of commuter transportation assistance services offered by the Commuter Connections Program of the Metropolitan Washington Council of Governments (COG) to commuters and employers in the Washington, DC region between July 1 and September 30, 1997. This report estimates transportation and air quality impacts, cost effectiveness of Commuter Connections' services and one transportation emission reduction measure (TERM), implemented by Commuter Connections: Guaranteed Ride Home.

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<http://www.fhwa.dot.gov/environment/tcm/tcm3.htm>



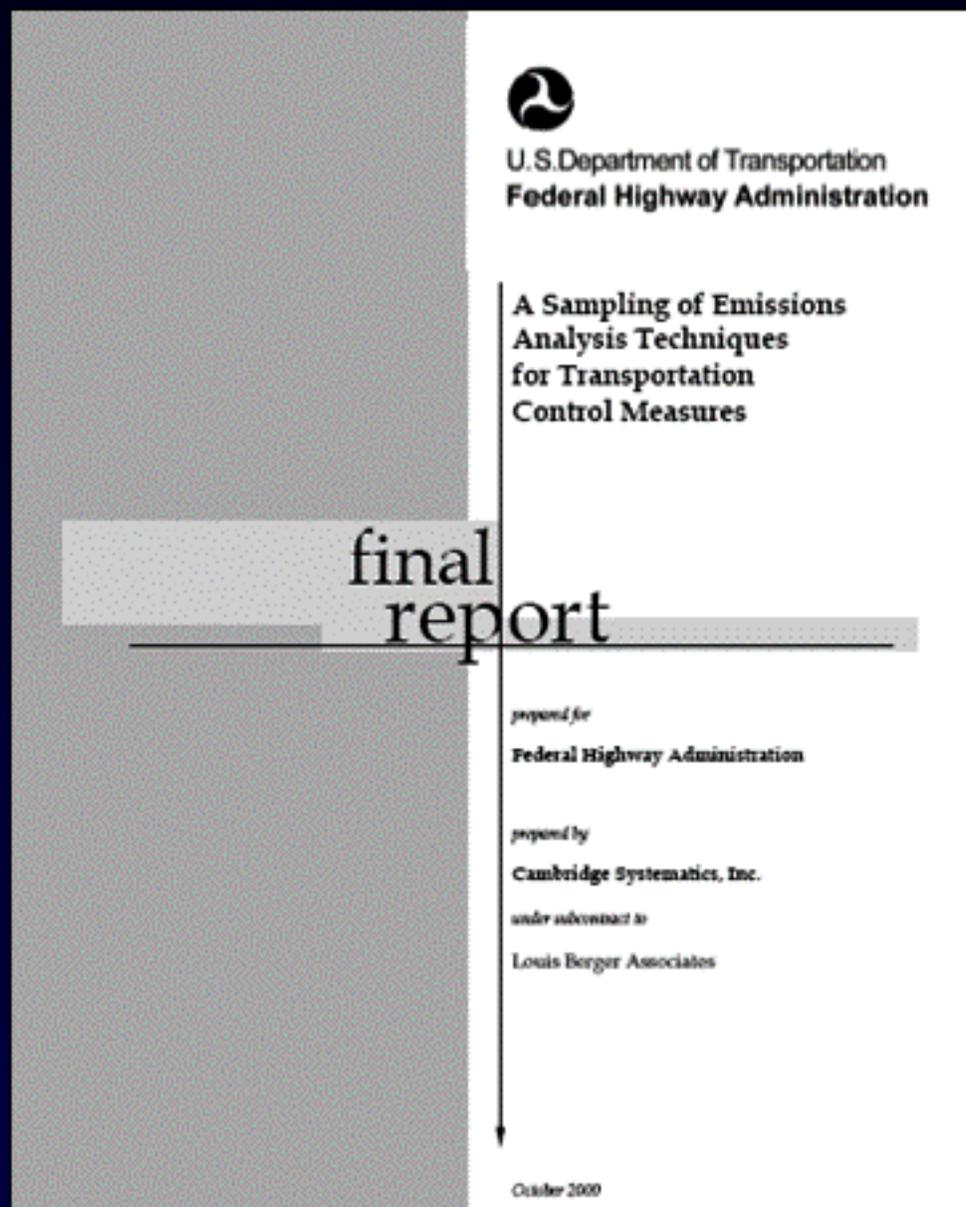
Contents

1. Emissions Analysis
2. Variables to Consider
3. Available Technologies
4. Ride Sharing Programs
5. Bike/Pedestrian Projects
6. Traffic Flow Improvement Projects
7. Transit Projects
8. Demand Management Measures
9. I/M and Other Control Measures
10. Cost Benefit Analysis
11. COMMUTER Model



3. Available Methodologies

FHWA Methods Compilation References/Sources/2000 Booklet

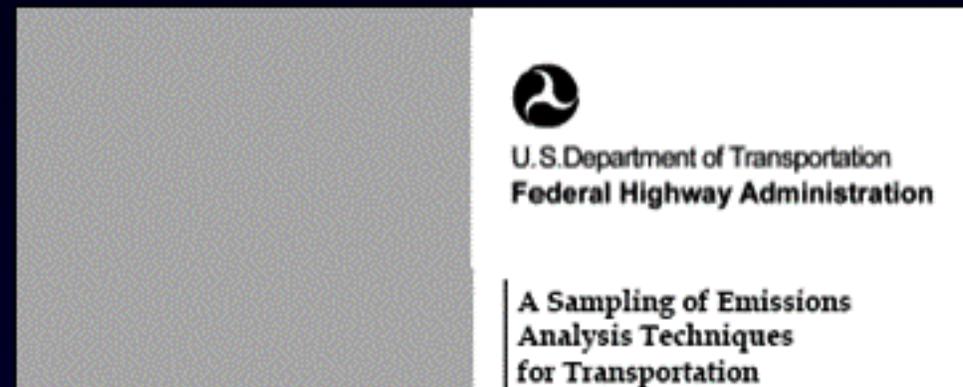


<http://www.fhwa.dot.gov/environment/cmaqat/cmaqat.pdf>

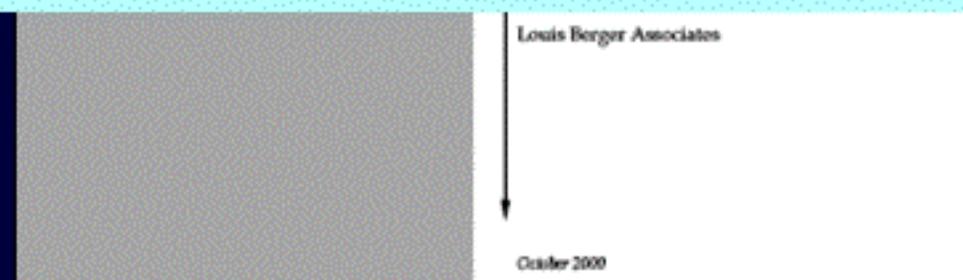


3. Available Methodologies

FHWA Methods Compilation References/Sources/2000 booklet



This report compared various commercial software packages for their applications in CMAQ air quality estimations.



<http://www.fhwa.dot.gov/environment/cmaqeat/cmaqeat.pdf>



3. Available Methodologies

Estimating Emission and Travel Activity Effects of TCMs

Final Report

**METHODOLOGIES FOR ESTIMATING
EMISSION AND TRAVEL ACTIVITY
EFFECTS OF TCMs**

July 1994

SYSAPP94-92/096

Prepared for

Ms. Valerie Broadwell
U.S. Environmental Protection Agency
Office of Air Quality Planning and Standards

and

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U.S. Environmental Protection Agency
Office of Mobile Sources

Prepared by

B. S. Austin
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L. L. Duvall



3. Available Methodologies

Estimating Emission and Travel Activity Effects of TCMs

The 1994 Methodologies covers the following activities:

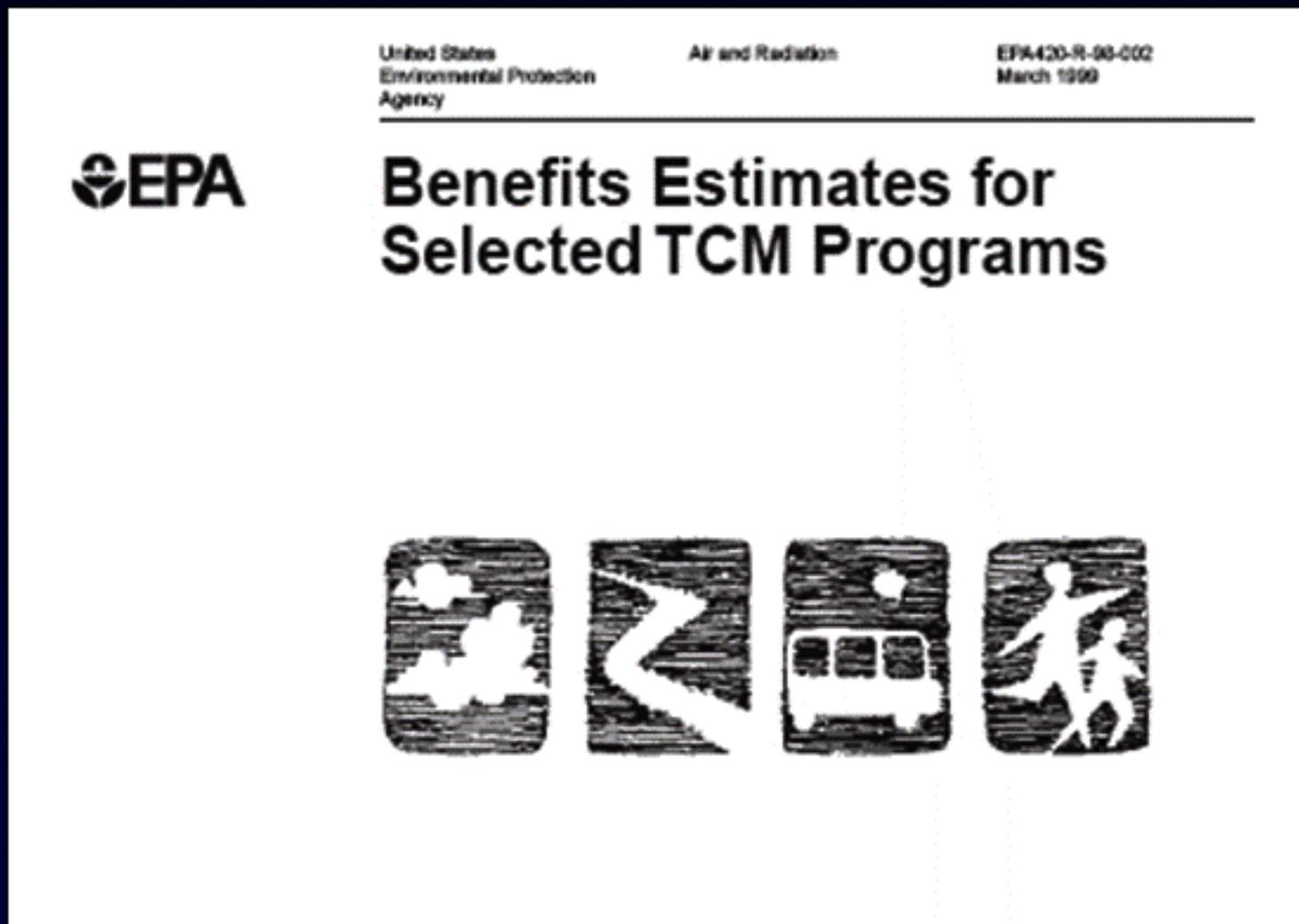
- 1) Telecommuting
- 2) Flextime
- 3) Compressed Work Weeks
- 4) Ridesharing
- 5) Parking Management
- 6) Methods for Decreasing Fares and Increased Fares



3. Available Methodologies



EPA's 1999 Sample TCMs Study





3. Available Methodologies

EPA's 1999 Sample TCMs Study

United States
Environmental Protection
Agency

Air and Radiation

EPA-420-R-98-002
March 1999



Benefits Estimates for Selected TCM Programs

This report documented the application of the 1994 methods in six real world projects.





3. Available Methodologies

Common Estimation Methodologies

- 1) Hand calculation (not a black box computer program)
- 2) Relatively straightforward. However, it can get complicated quickly
- 3) A lot of assumptions just like any other methods



Key Aspects To Remember When Evaluating CMAQ Projects

- 1) In order to use CMAQ project air quality benefits for conformity purposes, interagency coordination must be carried out to ensure your methods are acceptable by all parties.
- 2) Most of the CMAQ projects are relatively small. Regionally significant projects shall be modeled through the travel demand forecasting program.
- 3) Pay particular attention to significant transit projects. Often, transit and highway programs are carried out by different agencies.



4. Ride Sharing Programs

Major Types of Rideshare Projects and Programs

- 1) Park/Ride Lot
- 2) Carpooling/Vanpooling
- 3) Outreach and public education
- 4) Others



4. Ride Sharing Programs

Mass Transit Facility

Part 1: Daily VMT computation

- 1) Determine the # of parking spaces available: N
- 2) Collect other similar parking facility utilization rates in the city or municipality. The utilization rate can be more than 100% since each space can be utilized by several vehicles during a 24 hour time period: UR
- 3) Convert parking space # to passenger vehicle trips reduced: $VT = N \times UR \times 2$
- 4) Determine the route length of the mass transit served and daily service frequency: L and F (one-way)
- 5) Estimate the average passenger trip length departing the mass transit vehicle: PL
- 6) Daily passenger VMT reduced from passenger vehicle $PV_VMT = VT \times PL$
- 7) Daily mass transit VMT estimation: $MT_VMT = L \times F$



1. Emissions Analysis

Key Parameter Groups Affecting Emissions

- 1) Travel activities
- 2) Vehicle emission factors



4. Ride Sharing Programs

Mass Transit Facility

Part 2: Emission factor computation

- 1) Determine the type of the mass transit vehicles: Diesel, gas, or electrical)
- 2) Run MOBILE6.2 by using default data unless local data are known to obtain passenger vehicle emission factor (exclude HDGV and HDDV): PV_EF
- 3) If mass transit is electrical, assume MT_EF= 0 g/mi.
- 4) Use MOBILE6.2 and the EXPAND command to obtain the appropriate emission factor for transit vehicles by using MOBILE6.2: MT_EF



4. Ride Sharing Programs

Mass Transit Facility

Part 3: Net Daily Changes

Reduction from Passenger vehicles:

$$PV_VMT \times PV_EF$$

Increase due to the operation of mass transit:

$$MT_VMT \times MT_EF$$

$$\text{Net Effects} = (PV_VMT \times PV_EF) - (MT_VMT \times MT_EF)$$



4. Ride Sharing Programs



Part 1: Daily VMT computation

- 1) Determine the # of parking spaces available: N
- 2) Collect other similar parking facility utilization rates in the city or municipality on a daily basis : UR
- 3) Convert parking space # to total passenger vehicle trips: $VT = N \times UR \times 2$
- 4) Estimate average carpool vehicle trip length (one-way): L
- 5) Total VMT reduction: $VMT = VT \times L$



4. Ride Sharing Programs

Car Pooling Lot

Part 2: Daily Emission factor computation

Run *MOBILE6* by using default data unless local data are known to obtain passenger vehicle emission factor (exclude HDGV and HDDV): PV_EF



4. Ride Sharing Programs

Car Pooling Lot

Part 3: Net Daily Changes:

Reduction from passenger vehicles:

$$VMT \times PV_EF$$

$$\text{Net Effects} = VMT \times PV_EF$$



5. Bike/Pedestrian Projects

Bike Lane





5. Bike/Pedestrian Projects



Part 1: Daily VMT computation

During a typical day, assess the usage rate of the bike lane (average daily count: ADC). Past history is very important.

- 1) Assess auto occupancy rate: OR
- 2) Assess transit occupancy rate: TR
- 3) Average bike trip length (one-way): L
- 4) Attracted trips from auto and transit (AS vs. TS in %)
 - Daily auto person trips = $ADC \times AS$
 - Daily transit person trips = $ADC \times TS$
- 5) Total passenger vehicle VMT reduced:
- 6) $PV_VMT = ADC \times AS / OR \times L$
- 7) Total transit vehicle VMT reduced:
Reduced # of transit vehicle trips: $TV = ADC \times TS / TR$
Transit vehicle route length: TL
 $MT_VMT = TV \times TL$



5. Bike/Pedestrian Projects



Part 2: Daily vehicle emission factor computation

1. Determine the type of passenger vehicle emission factor
2. Determine the type of transit vehicles : diesel, gas, vs. electrical
3. Run MOBILE6.2 for passenger vehicles (exclude HDDGV & HDDV):
PV_EF
4. Run MOBILE6.2 for transit vehicles: MT_EF



5. Bike/Pedestrian Projects



Part 3: Daily Net Changes

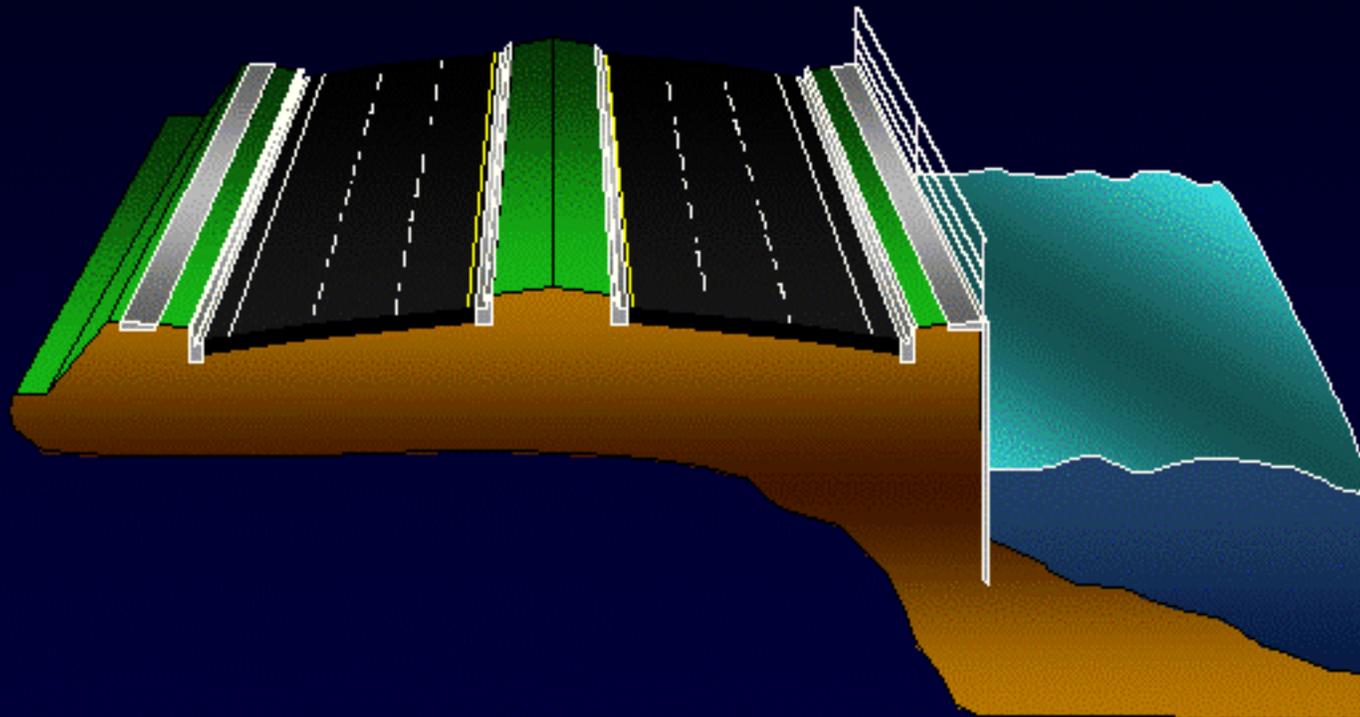
Reduction from passenger vehicles: $PV_VMT \times PV_EF$

Reduction from transit vehicles: $MT_VMT \times MT_EF$

Net Changes = $(PV_VMT \times PV_EF) + (MT_VMT \times MT_EF)$



5. Bike/Pedestrian Projects





1. Emissions Analysis

Key Parameters Affecting Travel Activities

- 1) Vehicle types (mode share)
 - Auto/Transit/Carpool/Vanpool/Bike/Walk
 - # of person trips
 - Occupancy rates
- 2) Trip length
 - Distance: VMT
 - Time: VHT
- 3) # of vehicle trips
 - # of engine starts
- 4) Time of Travel
 - Peak vs. Off-peak
- 5) Land Use
 - Travel Demand



5. Bike/Pedestrian Projects



Evaluation Method:

Methodology used for "Bike Lane" analysis can be used.



5. Bike/Pedestrian Projects

Bike Path/Trail





5. Bike/Pedestrian Projects

Bike Path/Trail



These projects must be able to document air quality benefits. Recreational usage only will not make them eligible for CMAQ Fund.





6. Traffic Flow Improvement Projects

Potential Project Types

- 1) Intersection signal: optimization, interconnection, and synchronization
- 2) Intersection layout: adding exclusive LT/RT lanes, roundabout in place of 4-way stops
- 3) Freeway on/off ramp length increase
- 4) Variable message signs/dynamic message signs
- 5) ITS operation: 511, 711 systems highway Rescue/Assistance/Service Patrol, Surveillance System/Devices, Incident Management Center
- 6) Adding lanes at "bottle neck" places
- 7) Access management: median opening/closure, accessing point changes
- 8) HOV



6. Traffic Flow Improvement Projects

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- 8) HOV



6. Traffic Flow Improvement Projects

Intersection Signal and Intersection Layout Projects

Part 1: Existing Condition (before) Assessment:

Use HCM (software is available) or any other appropriate industry standard intersection analysis tools such as NETSIM, SYNCHRO, TRANSYT-7F to assess intersection delay (average delay per vehicle = D_b).

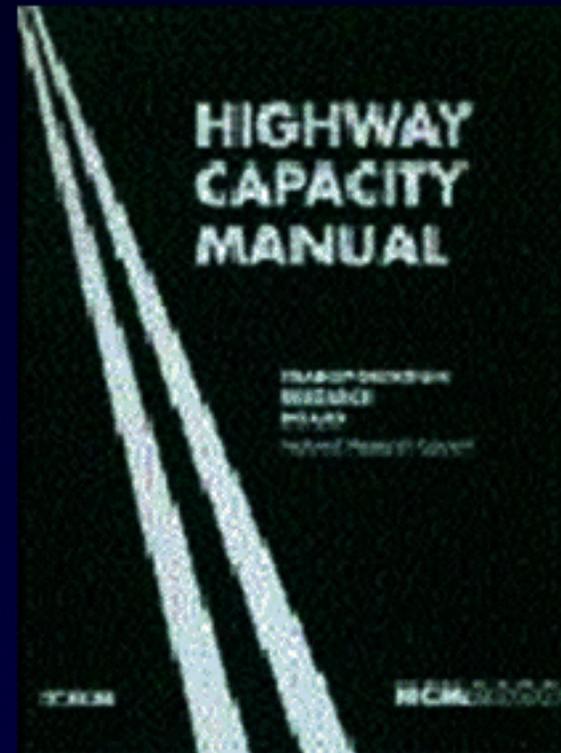
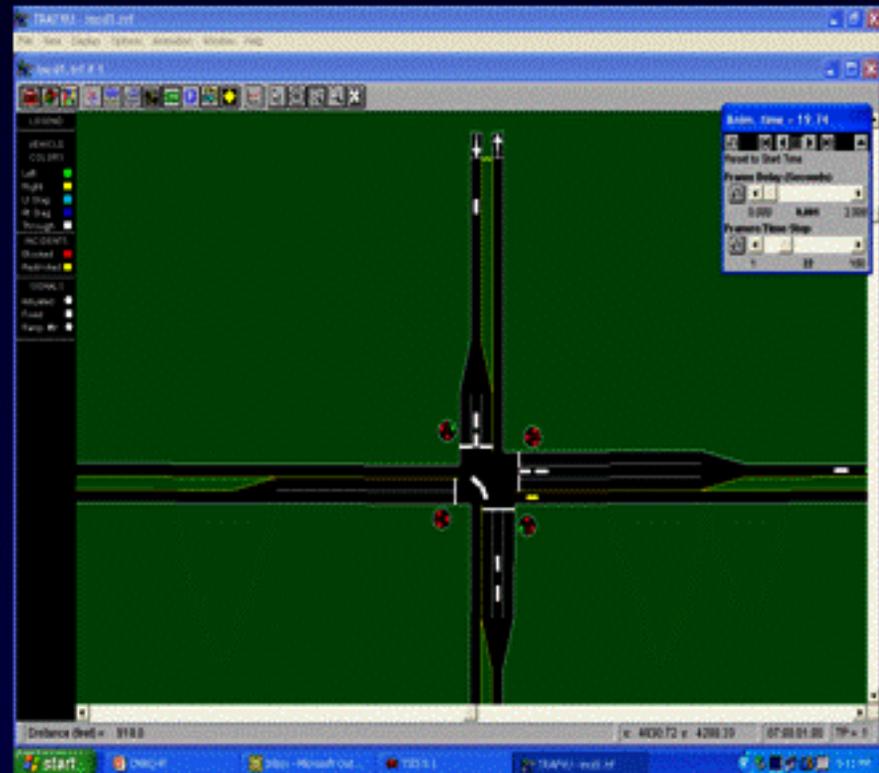
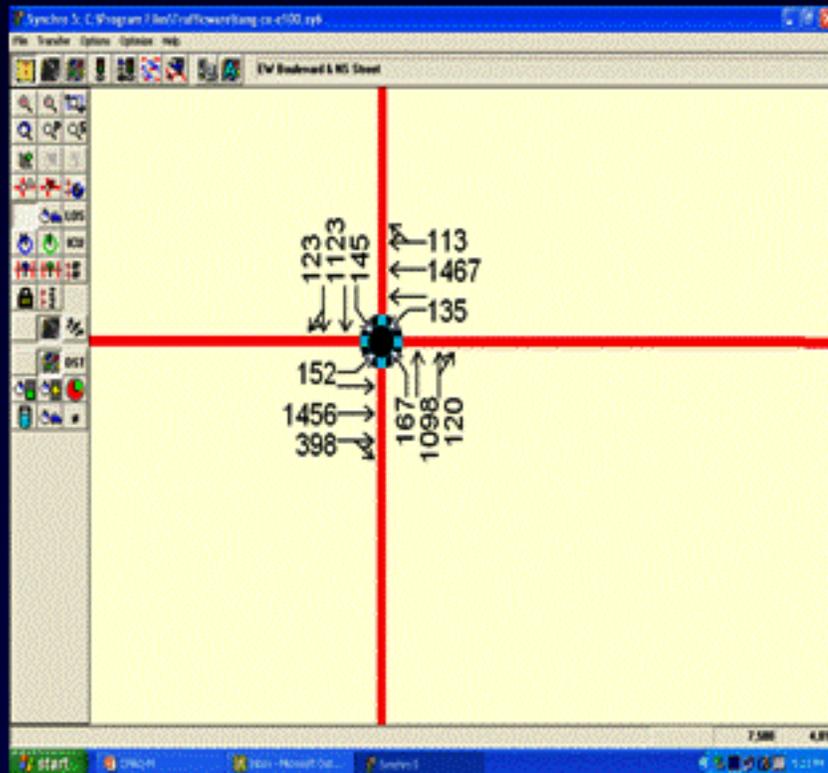
Compute intersection delay: $T D_b = D_b \times A A D T$

(AADT is the total AADT for all intersecting roadways)



6. Traffic Flow Improvement Projects

Intersection signal and Intersection Layout Projects





6. Traffic Flow Improvement Projects

Intersection signal and Intersection Layout Projects

Part 2: Proposed Condition (after) Assessment:

Use HCM or any other appropriate industry standard intersection analysis tools such as NETSIM, SYNCHRO, TRANSYT-7F to assess intersection delay (average delay per vehicle = D_a)

Compute total delay time: $T D_a = D_a \times AADT$



6. Traffic Flow Improvement Projects

Intersection signal and Intersection Layout Projects

Part 3: Evaluate the emission factor

Use the *AVERAGE SPEED* command: *ARTERIAL* command with 2.5 mph speed to estimate idling emission factor (*IDL_EF*).



6. Traffic Flow Improvement Projects

Intersection signal and Intersection Layout Projects

Part 4: Net Daily Changes:

$$\text{Net Effects} = (\text{TDb} - \text{TDa}) \times \text{IDL_EF}$$



1. Emissions Analysis

Key Parameters Affecting Vehicle Emission Rates

- 1) Vehicle Fleet Characteristics
 - Vehicle types (Auto vs. Transit etc.), Vehicle ages
- 2) Fuel Characteristics
 - Fuel programs, Fuel volatility, Chemical Composition
- 3) Vehicle Operating Characteristics
 - Hour of operation, Speed, Starts per VMT (trip length)
- 4) Vehicle Operating Environment
 - Calendar year, evaluation month, temperature, humidity
- 5) Emission Control Strategies
 - Anti-Tampering Program, I/M, OBD, Stage II Refueling



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

These types of programs are aimed to reduce the time required to reopen travel lanes and the number of lanes closed during an accident or incident (e.g., instead of close two lanes, now only one lane is closed.)

The key impact to air quality is due to speed changes associated with the closure and opening of travel lanes.



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

Capacity Available Under the Following Freeway Incident Conditions

# of lanes by direction	shoulder disablement	shoulder accident	one lane blocked	two lanes blocked	three lanes blocked
2	0.95	0.81	0.35	0	N/A
3	0.99	0.83	0.49	0.17	0
4	0.99	0.85	0.58	0.25	0.13
5	0.99	0.87	0.65	0.4	0.2
6	0.99	0.89	0.71	0.5	0.26
7	0.99	0.91	0.75	0.57	0.36
8	0.99	0.93	0.78	0.63	0.41

For limited access roadway (freeway) facilities, the maximum capacity is 2300 passenger vehicles per hour per lane.



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

For air quality benefit estimation, the congested speed (to compute emission factor) and congested roadway length caused by an incident (to compute VMT) are required.

For limited access roadway (freeway) facilities, the maximum capacity is 2300 passenger vehicles per hour per lane (Highway Capacity Manual, 2000)



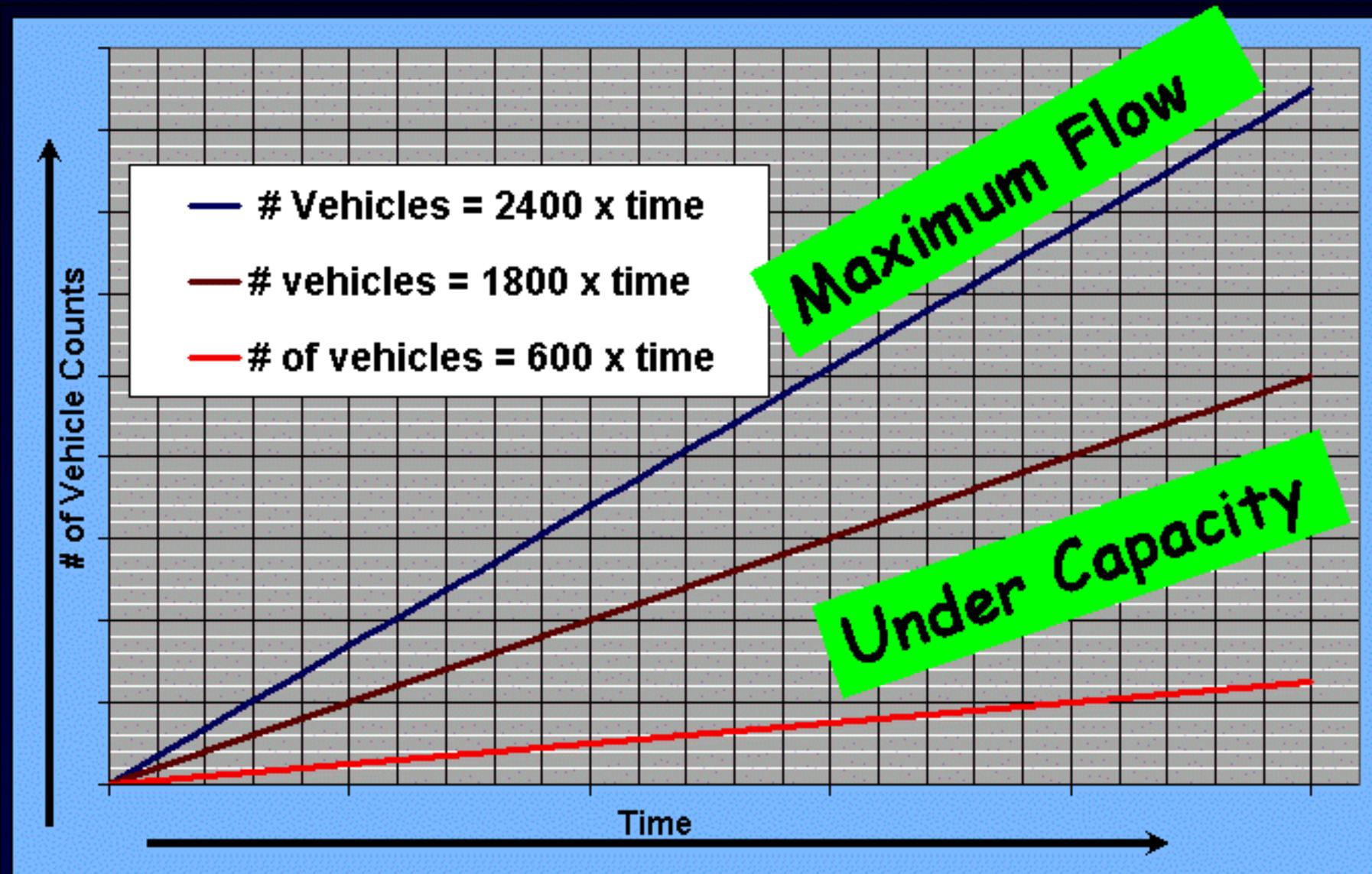
6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others



6. Traffic Flow Improvement Projects

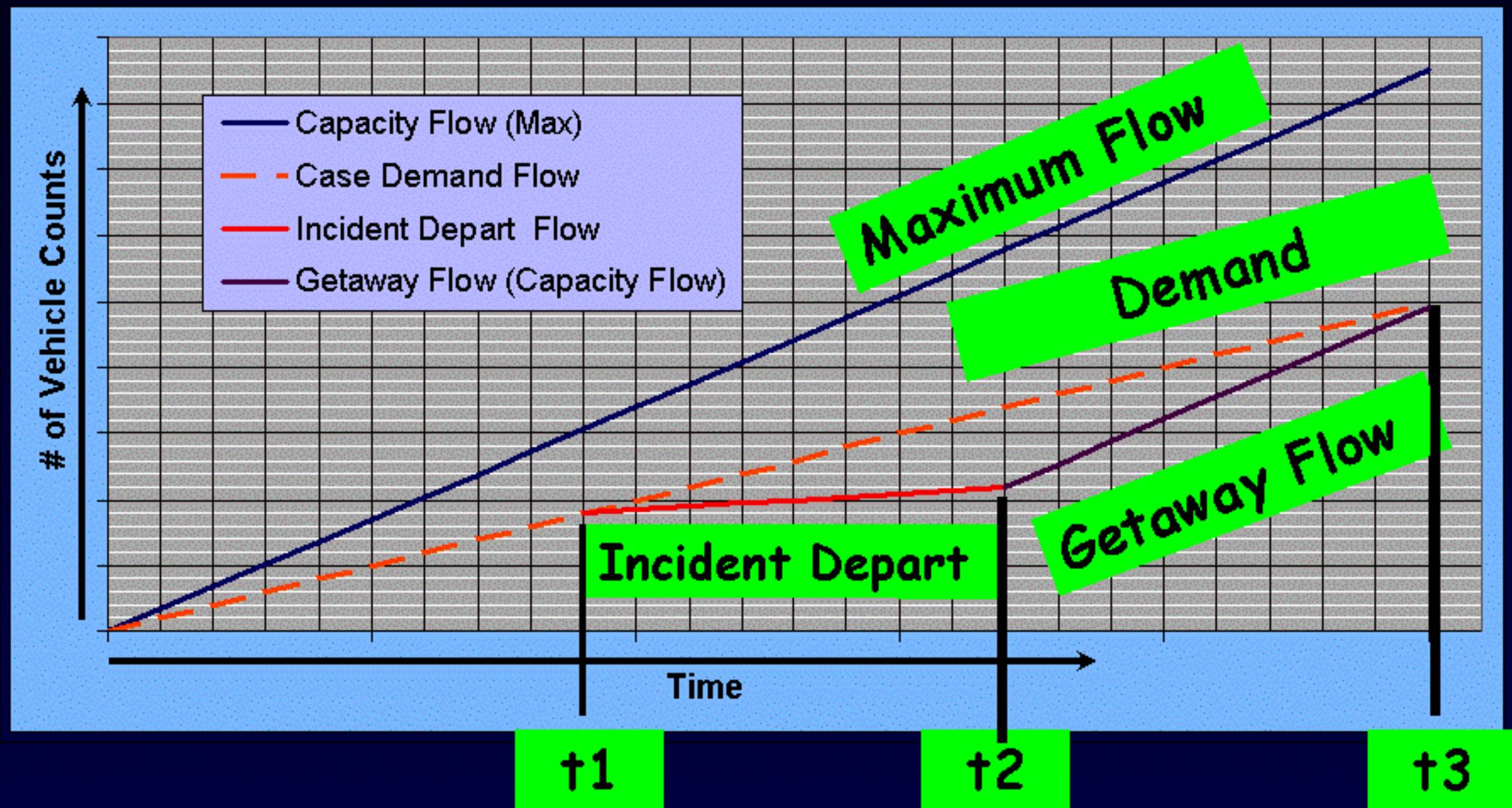
Freeway Service/Assistance Program, Incident Management Program and others





6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

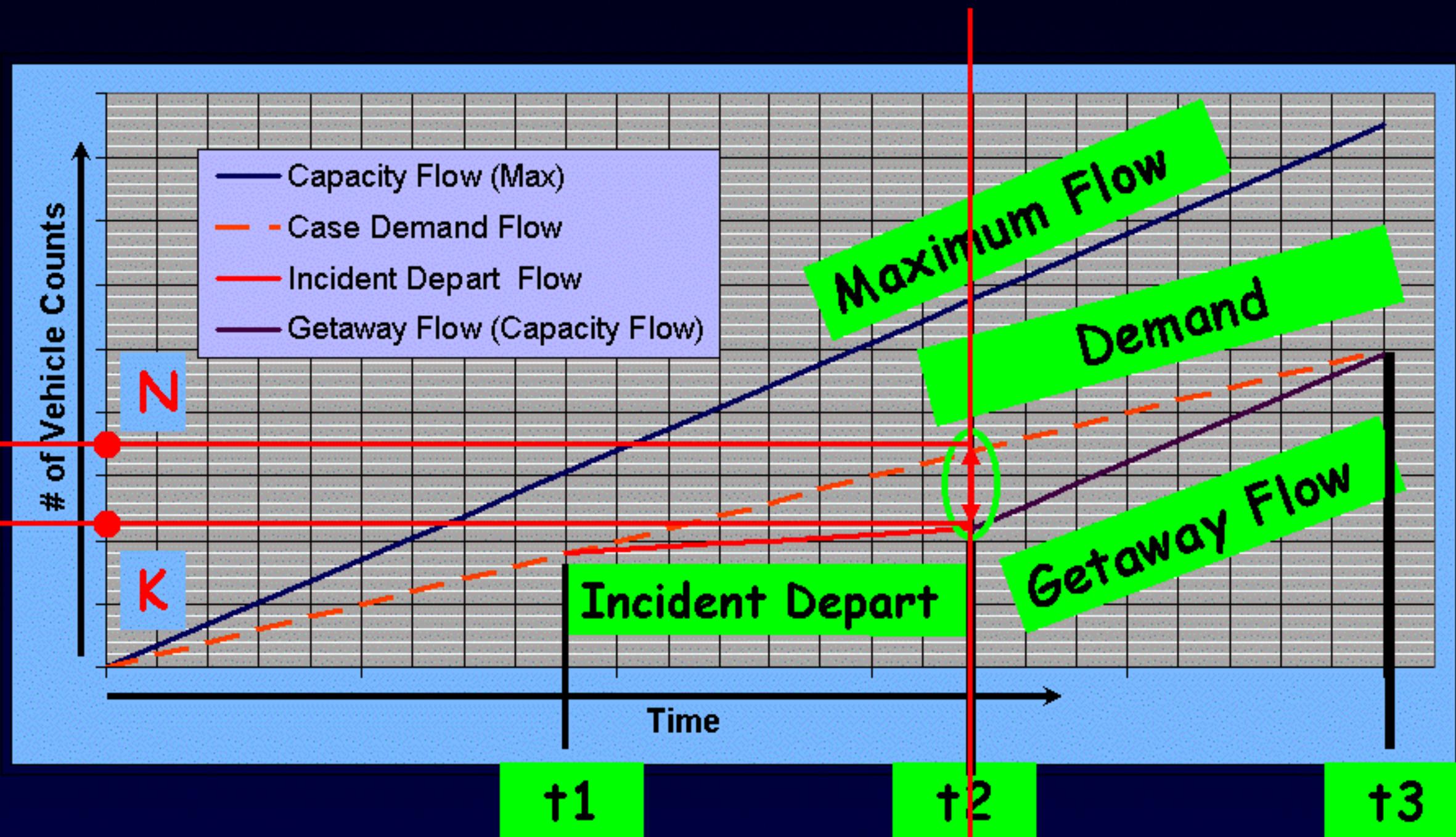


Based on theory outlined in the 5th Edition "Traffic Engineering Handbook", ITE



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

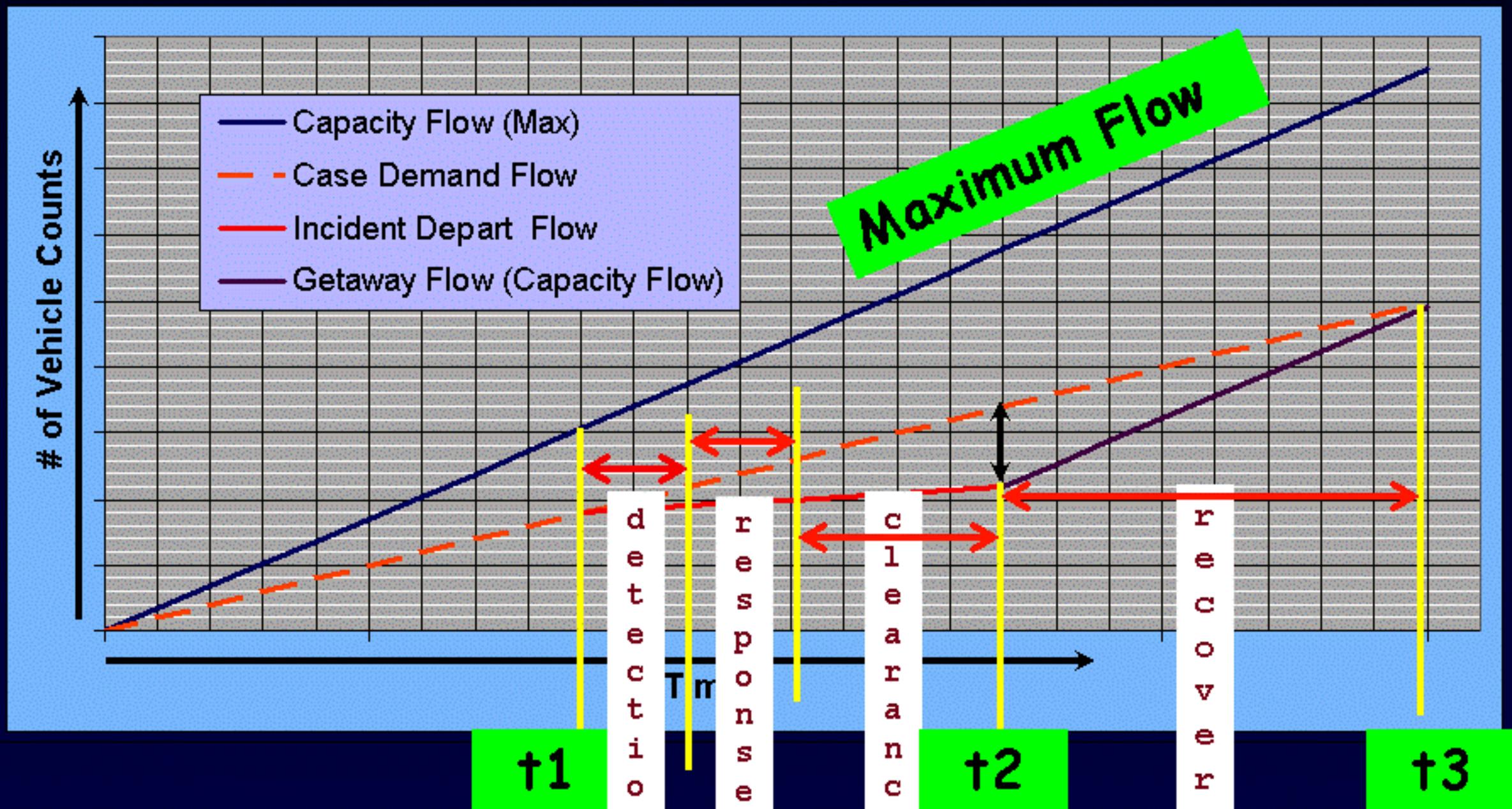


Based on theory outlined in the 5th Edition "Traffic Engineering Handbook", ITE



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others



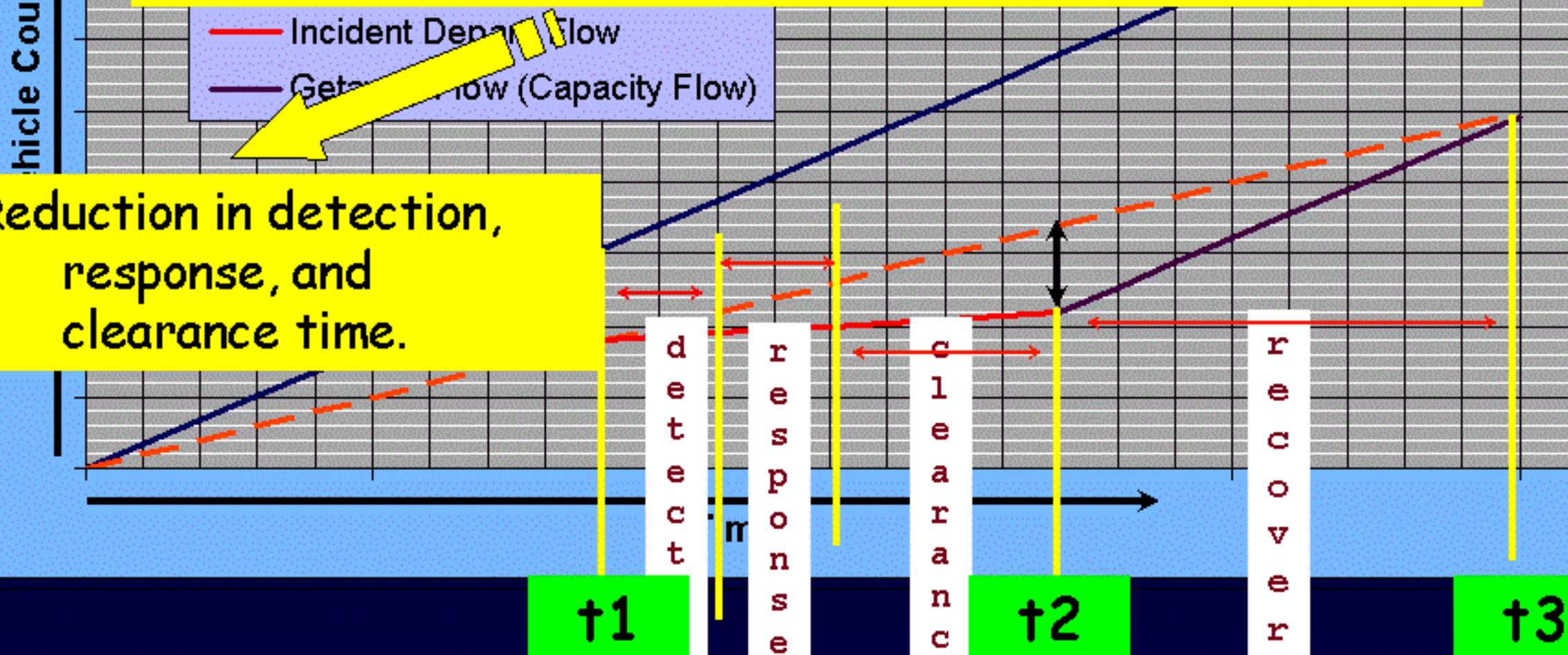
Based on the data outlined in the 5th Edition "Traffic Engineering Handbook", ITE



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

- 1) Incident Management, 2) Freeway Service & Assistances, 3) ITS/Camera/Traffic Control Center, 4) Agreement with Highway Patrol/Fire/Rescue



Based on theory outlined in the 5th Edition "Traffic Engineering Handbook", ITE



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

Step 1: Speed Computation:

- 1: Determine the demand flow (v)
- 2: Determine the free flow speed (s)
- 2: Determine the type of incident blockage and obtain the appropriate blockage factor.
- 3: Compute the incident condition capacity (c):
maximum capacity \times blockage factor
- 4: Use the BPR Formula to obtain speed (S):

$$S = \frac{s}{1 + 0.15(v/c)^4}$$



1. Emissions Analysis

The April 1999 FHWA CMAQ Program Guidance

Encourage States, MPOs, and transit agencies to develop their own air quality benefit estimation procedures

Recognize that a single nationwide method is not feasible (why?)

<http://www.fhwa.dot.gov/environment/cmaq99gm.htm>



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

Example : Speed Computation for A 3-lane Facility (each direction)

- 1: Determine the demand flow (v): 5460 vehicles/hour
- 2: Determine the free flow speed (s): 65mph (posted)
- 2: Determine type of incident blockage and obtain the appropriate blockage factor. One lane blocked, 0.49
- 3: Compute incident condition capacity (c): maximum capacity \times blockage factor = $2400 \times 3 \times 0.49 = 3529$
- 4: Use the BPR Formula :

$$S = \frac{65}{1 + 0.15(5460/3529)^4} = 35$$



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

Example: Speed Computation for A 3-lane Facility (each direction)

- 1: Determine the demand flow (v): 5460 vehicles/hour
- 2: Determine the free flow speed (s): 65mph (posted)
- 2: Determine type of incident blockage and obtain the appropriate blockage factor. Shoulder incident, 0.83
- 3: Compute incident condition capacity (c): maximum capacity \times blockage factor = $2400 \times 3 \times 0.83 = 5976$
- 4: Use the BPR Formula :

$$S = \frac{65}{1 + 0.15(5460/5976)^4} = 58$$



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

Step 2: Length of Congested Roadway Segment Computation

- 1: Determine the time (t) from incident occurred to incident cleared
- 2: Determine demand flow (v)
- 3: Determine incident condition capacity (BCC)
- 4: Determine total # of vehicles in the congested incident segment
 $(v - BCC) \times t$
- 5: headspace: 20'
- 6: Total length: $(DC - BCC) \times (t) \times 20 / \# \text{ lanes}$



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

Example: Length of Congested Roadway Segment Computation

- 1: Determine the time (t) from incident to incident cleared: 60 minutes
- 2: Determine demand flow (v): 5450 vehicles/hour
- 3: Determine blocked condition capacity (BCC):
one lane blockage BCC = 3528 vehicles/hour
- 4: Determine total # of vehicles in the congested incident segment
 $(v - BCC) \times t$
one lane blockage: $(5450 - 3528) \times 1 = 1922$ vehicles
- 5: Headspace: 20'
- 6: Total length: $1922 \times 20 / 3 = 12813$ feet = 2.4 miles
- 7: Total VMT = 2.4 miles \times 5450 vehicles = 13080 VMT



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

Step 3: Emission Benefits Computation

- 1: Run MOBILE6.2 by using the AVERAGE SPEED command to compute emission factors.
- 2: Compute total benefits by using $EF \times VMT$
- 3: Compare different scenario results:
 - a: shoulder incident instead of one lane blockages
 - b: one lane blockage vs. two lane blockage
 - c: 60 minutes incident time vs. 45 minutes time
 - d: others



6. Traffic Flow Improvement Projects

Freeway Service/Assistance Program, Incident Management Program and others

For a given program: the following factors must be assessed:

- 1: Accident/incident data
- 2: Existing average time between incident occurred and incident cleared
- 3: Under proposed condition, what is the proposed reduction time for item #2? (early detection, instant detection, et al)
- 4: Reduction of lane blockage types under proposed program. For example, instead of one lane block, it will be a shoulder incident; instead of a two lane blockage, it is a one lane blockage, et al.



6. Traffic Flow Improvement Projects

Increase Freeway on/off Ramp Length

These types of projects are aimed to smooth the flow at the freeway weaving area. By increase the smoothness of traffic operation (less high acceleration), emissions are going down.



6. Traffic Flow Improvement Projects

Increase Freeway on/off Ramp Length





6. Traffic Flow Improvement Projects

Access Management Projects

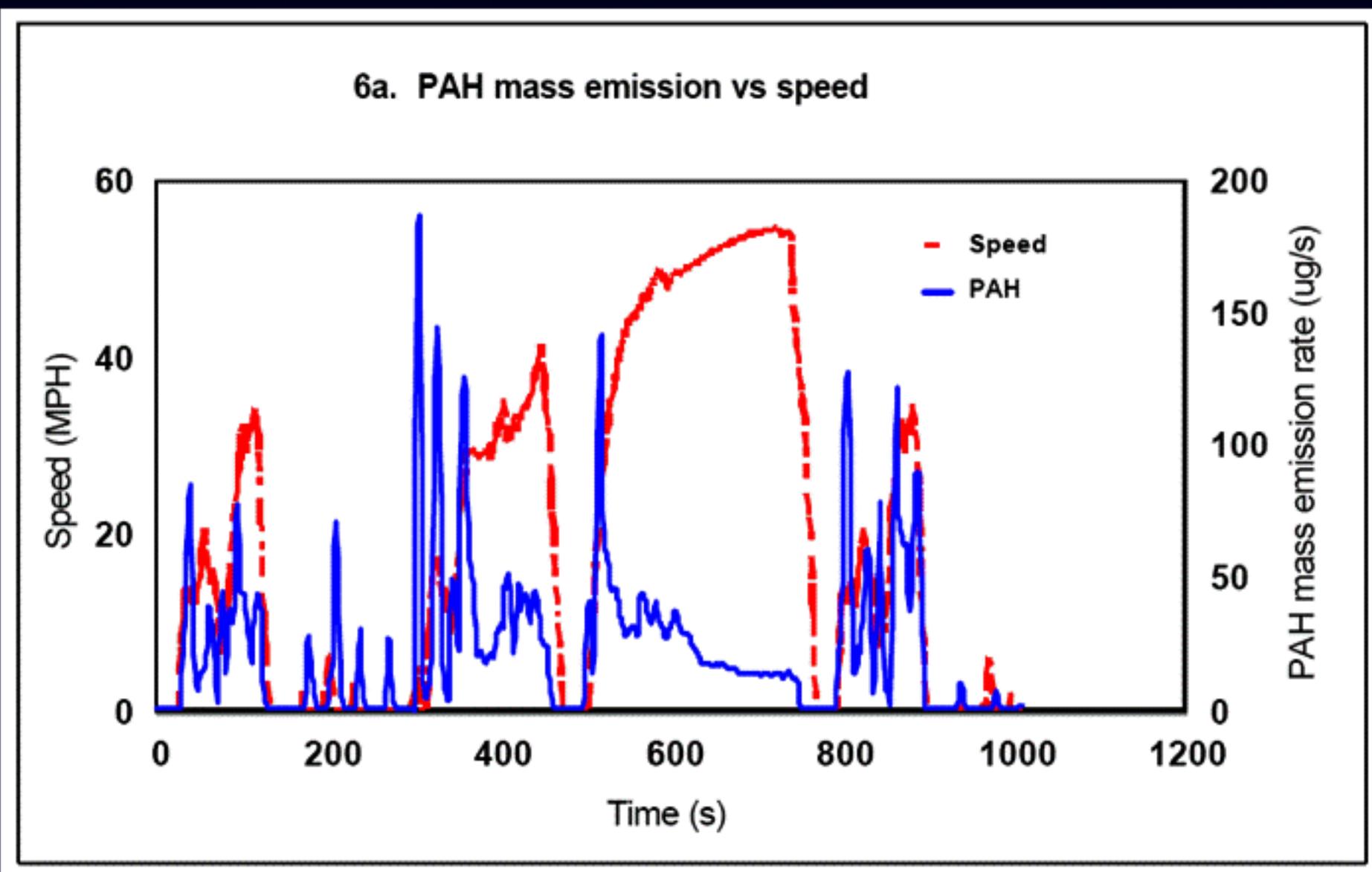
These types of projects are aimed to smooth the flow. By increasing the smoothness of traffic operations (reduce accelerations), emissions would go down.

The assumption is that the number of access points (one side of the roadway) along a roadway segment is directly proportional to the number of acceleration operations.



6. Traffic Flow Improvement Projects

Methods for Smoothing Traffic Flow



Sources: Shida Tang and others, NYDEC, 2004



1. Emissions Analysis

The April 2006 FHWA CMAQ Program Guidance

**The Congestion Mitigation and Air Quality (CMAQ) Improvement
Program**

under the

**Safe, Accountable, Flexible, Efficient Transportation Equity Act: A
Legacy for Users**

INTERIM PROGRAM GUIDANCE

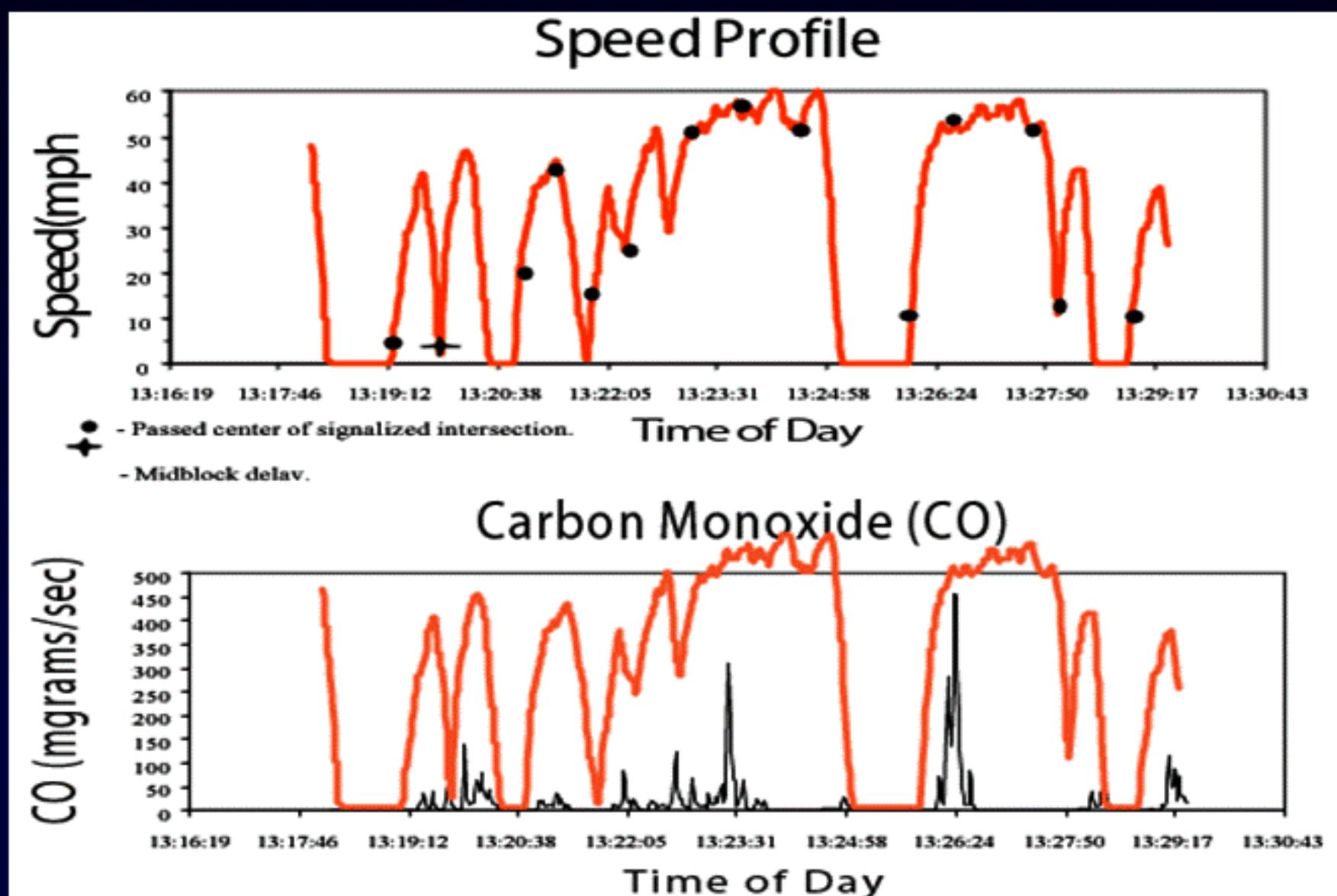
October 31, 2006

<http://www.fhwa.dot.gov/environment/cmaq99gm.htm>



6. Traffic Flow Improvement Projects

Methods for Smoothing Traffic Flow

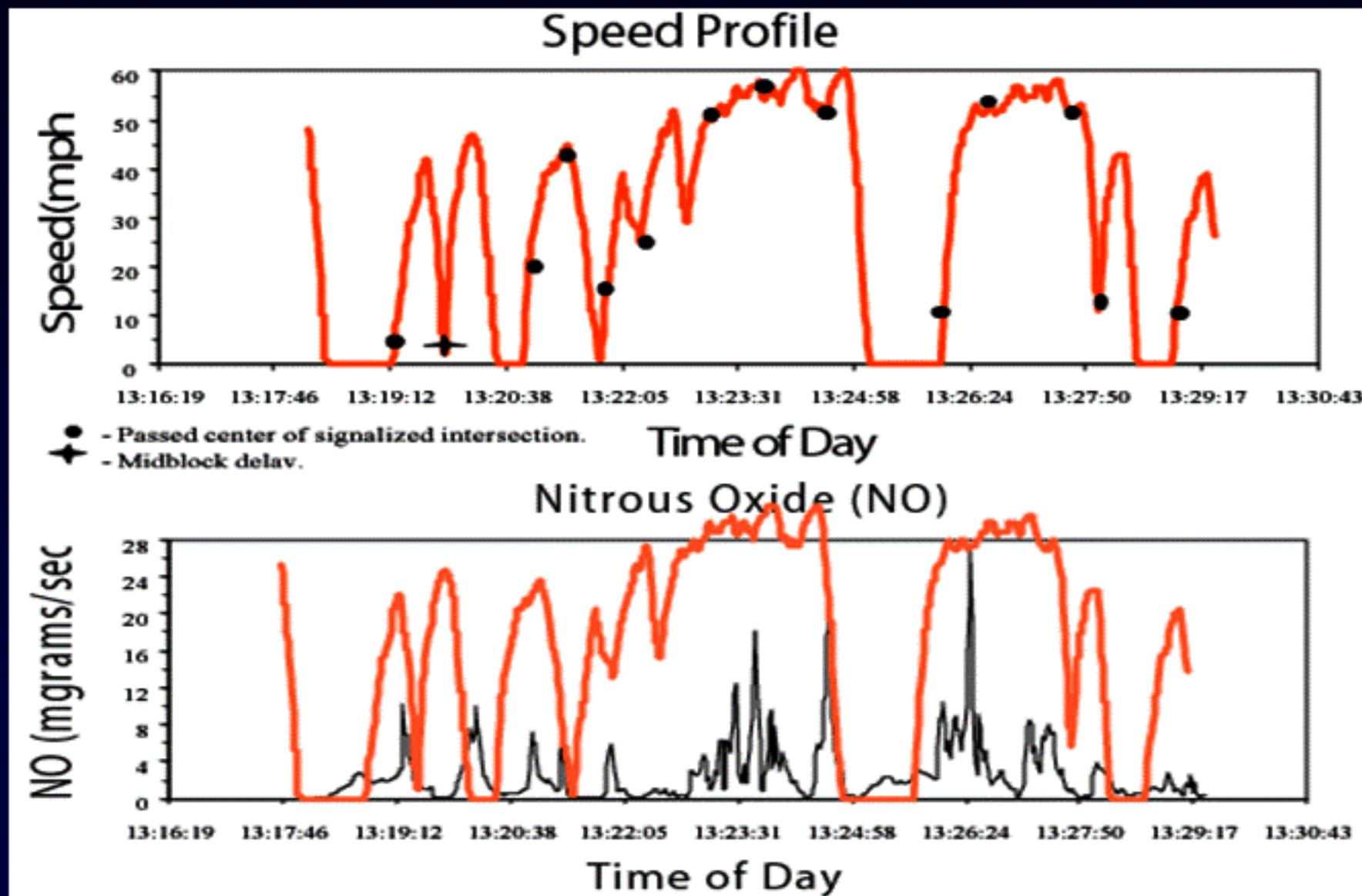


Sources: N M Rouphail, et al., NC State University, 80th TRB, 2000



6. Traffic Flow Improvement Projects

Methods for Smoothing Traffic Flow

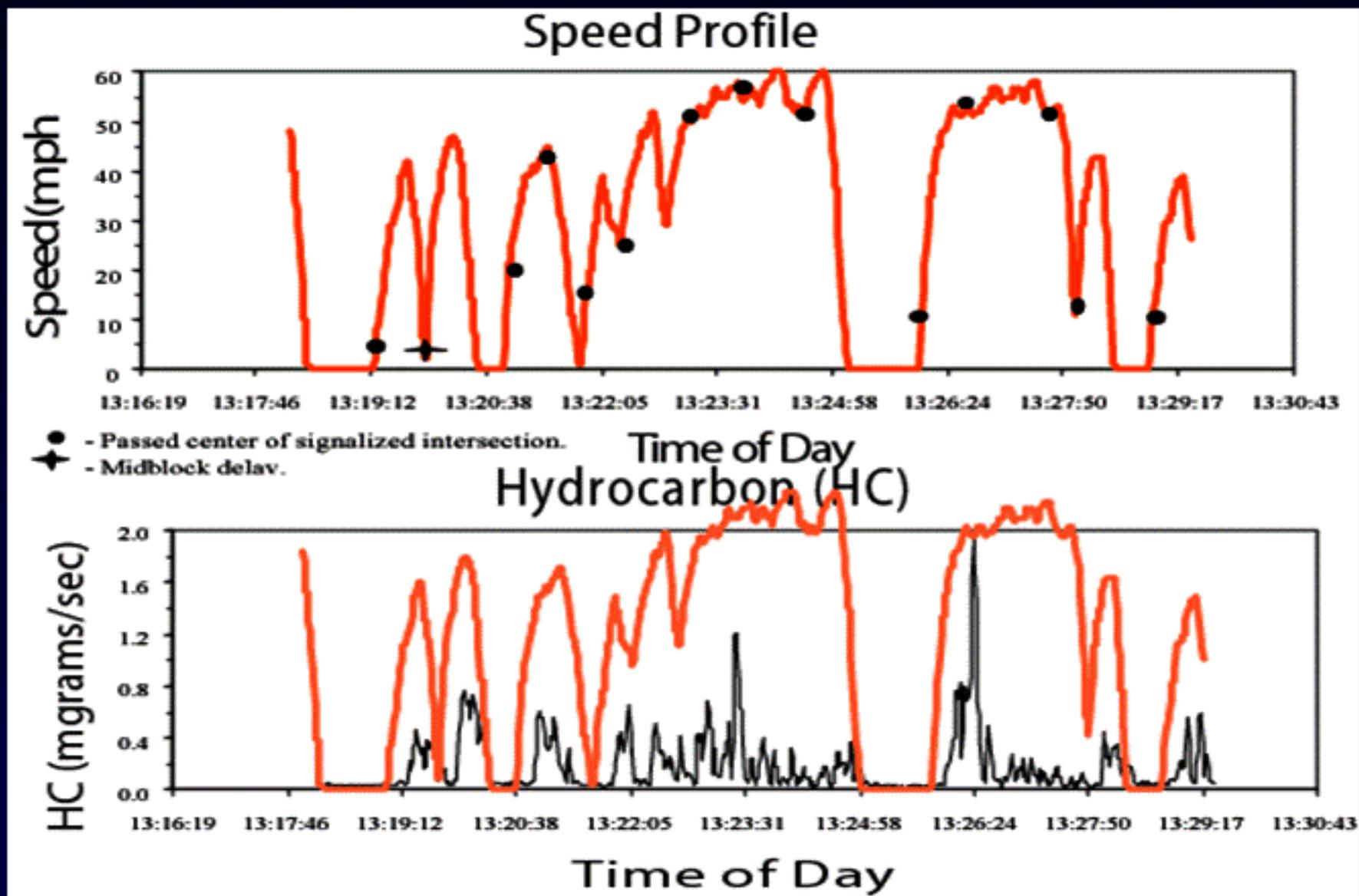


Sources: N M Rouphail, et al., NC State University, 80th TRB, 2000



6. Traffic Flow Improvement Projects

Methods for Smoothing Traffic Flow



Sources: N M Rouphail, et al., NC State University, 80th TRB, 2000



6. Traffic Flow Improvement Projects

Access Management Projects

CO acceleration emission (mg/s) / cruise emission (mg/s) = 1.8 (CO: A/C=1.8)

HC acceleration emission (mg/s) / cruise emission (mg/s) = 2.0 (HC: A/C=2.0)

NO acceleration emission (mg/s) / cruise emission (mg/s) = 2.4 (NO: A/C=2.4)

Data Sources: The above data are results calculated by the author from the original data collected and presented by N M Rouphail et al., NC State University, 80th TRB, 2000. The author will continue to update and improve the processed data as new data are becoming available.



6. Traffic Flow Improvement Projects

Access Management Projects

- Step 1: Determine the average speed (S) and length (L) for the roadway segment under study.
- Step 2: Run MOBILE6.2 with the AVERAGE Speed command to obtain running emission factor (EF)
- Step 3: Determine the original number of access points for the segment (OAP)
- Step 4: Determine the proposed number of access points for the segment (PAP)
- Step 5: Solve the simultaneous equations as listed in the next slide:



6. Traffic Flow Improvement Projects

Access Management Projects

Step 5: EF is running emission factor from MOBILE6 run
A = acceleration emission factor
C = cruise emission factor
A/C ratio (fixed) data are from the previous slide.

For HC:

$$EF = A + C, A/C = 2.0$$

For CO:

$$EF = A + C, A/C = 1.8$$

For NO_x:

$$EF = A + C, A/C = 2.4$$

By solving the above equation, A & C are obtained for each pollutant.



6. Traffic Flow Improvement Projects

Access Management Projects

Step 6: $new|A = A \times PAP / OAP$

Step 7: Benefits of reduction of access point:

$$benefit = A - new|A$$

Step 8: Total benefit computation:

$$L \times ADT \times benefit$$



6. Traffic Flow Improvement Projects

Example: Access Management Projects

A 1.6 mile segment of State Road 20 has 35 access points from abutting businesses from each side of the roadway. The DOT is proposing to change this free access roadway to a controlled access facility by eliminating 21 access points through combined access usages. The posted speed for this facility is 25 mph. The AADT is 5460. Based on past experiences, the DOT is not expecting a rise in speed. However, safety (crash rate will go down at a minimum of 30%) for motorist will be improved. How much air quality benefit can we expect from this project?



6. Traffic Flow Improvement Projects

Example: Access Management Projects

Step 1: $S = 25$ mph, $L = 1.6$ miles

Step 2: Run MOBILE6:

CO EF = 21.351 g/mile; HC EF = 1.123 g/mi; NO_x EF = 1.923 g/mi

Step 3: $OAP = 35$

Step 4: $PAP = 14$

Step 5: CO : $A + C = 21.351$, $A/C = 1.8$ ----- $A = 13.790$, $C = 7.661$

HC : $A + C = 1.123$, $A/C = 2$ ----- $A = 0.749$, $C = 0.3743$

NO_x : $A + C = 1.923$, $A/C = 2.4$ ----- $A = 1.357$, $C = 0.566$

Step 6: CO new| $A = 13.790 \times 14/35 = 5.516$; HC new| $A = 0.749 \times 14/35 = 0.300$; NO_x new| $A = 1.357 \times 14/35 = 0.543$

Step 7: Benefit: $CO = 13.790 - 5.516 = 8.274$; $HC = 0.449$; $NO_x = 0.814$

Step 8: Net daily emissions reduction:

CO : $1.6 \times 5460 \times 8.274 = 72281$ g

HC : $1.6 \times 5460 \times 0.449 = 3922$ g

NO_x : $1.6 \times 5460 \times 0.814 = 7111$ g



7. Transit Projects

Main Project/program Types

- 1) Transit vehicles: modify conventional vehicles, add new CNG vehicles
- 2) Fuel facility: CNG fuel station
- 3) Transit facility: bus stop shelters, benches, inter-modal facilities, maintenance facility
- 4) Technology equipment: bus locators, fare collection system, radio...
- 5) Education and outreach activities



1. Emissions Analysis

Basic Formula

Emissions = Vehicle Activities X EM Rates

Travel Activities (vehicle types/ages, VMT, # of starts)

Fuel Used (gas, diesel, RVP, RFG etc.)

Operating Characteristics (speed, facilities)

Environmental Factors (temperature, humidity)

Control Strategies (I/M, stage II refueling)



7. Transit Projects

Modification and new CNG Vehicles

Replace old technology vehicles with new technology vehicles:

Often this is a replacement of urban diesel buses with cleaner fuel vehicles such as CNG buses.



7. Transit Projects

Modification and new CNG Vehicles

- 1) Determine the daily bus service frequency (F : one-way) and route length (L)
- 2) Run MOBILE6 by using EXPAND BUS command to obtain the conventional bus emission factor (CBEF) on a gram/mile basis.
- 3) Run MOBILE by using NGV FRACTION command and the associated external file in addition to the EXPAND BUS command to obtain CNG bus emission factor (CNGBEF).
- 4) Emission benefits = $F \times L \times (CBEF - CNGBEF)$



7. Transit Projects



Scenario 1: Provide services only to fixed route vehicles

- 1) Bus route vehicle types
- 2) For each bus route it serves, follow the procedure outlined for the advanced technology transit vehicle procedure.
- 3) Summarize air benefits for all routes.



7. Transit Projects



Scenario 2: Provide services for vehicles not operating on a fixed routes.

- 1) Determine the types of vehicle it serves (TV).
- 2) Determine potential miles each vehicle travels (VMT).
- 3) Determine percentage of mile traveled under CNG fuel (P).
- 4) Run MOBILE and use EXPAND command to obtain emission factors for both CNG operation and regular fuel operation (CNG_EF, and EF).
- 5) For a given vehicle, air quality benefits = $VMT \times P \times (EF - CNG_EF)$
- 6) Total emission benefits: summarize all individual vehicle benefits.



7. Transit Projects

Bus shelter, fare collection system, radio, education and outreach

These types of projects are aimed to increase the number of riders. The key here is to quantify how many more riders the program will get.

- 1) Estimate the number of passenger/rider increases due to these program (N).
- 2) Convert these numbers to passenger vehicle trips: $PVT = N / OR$
- 3) Estimate average rider on bus travel distance: L
- 4) Run MOBILE6 to obtain emission factor for passenger vehicle (EF)
- 5) Air quality benefit = $PVT \times EF \times L$



8. Demand Management Measures

Main Project/program Types

- 1) Telecommuting
- 2) Ozone day alert program
- 3) Telecommuting center
- 4) Education and outreach activities
- 5) Others



8. Demand Management Measures

Main Project/program Types

- 1) The estimation of air quality benefits for these types of program is time consuming and full of uncertainties. If such a program is not carried out on a regional level, use one of the many other simple methods described makes more sense.
- 2) For a regional program, the estimation of travel activity may be carried out over the travel demand forecasting modeling program.
- 3) Once such VMT data are obtained for the pre and post conditions, MOBILE6.2 can be performed and the emission factor(EF) can be computed.
- 4) Total air quality benefits can be obtained by using the equation of $EF \times VMT$. The VMT is the difference between pre and post conditions.



9. I/M and Other Control Measures

Main Project/program Types

- 1) I/M programs
- 2) Anti-Tampering Programs
- 3) Stage II Refueling Programs
- 4) Fuel RVP
- 5) Oxygenated Fuel
- 6) RFG
- 7) Fuel Sulfur Level
- 8) Others



9. I/M and Other Control Measures

Main Project/program Types

- 1) Determine the vehicle types and daily VMT impacted by the chosen control measure
- 2) Run MOBILE6.2 without the control measure proposed to be implemented (before): CMb_{EF}
- 3) Run MOBILE6.2 with the control measure proposed to be implemented (after): CMa_{EF}
- 4) Emission benefits = $VMT \times (CMb_{EF} - CMa_{EF})$



10. Cost Effectiveness

Time Value of Money

There are many ways to do cost benefit analysis. Concepts used in engineering analysis often include the present value, future value, and annualized cost (A). For TCM air quality analysis, since the benefit is tons per day or year, it is easy to adopt the annualized cost method.



2. Variables to Consider

Vehicle Types

Single or Mixed Vehicle Classes

Induced Mode Changes (Carpool, Vanpool, Transit, Parking related Projects, (Ref: Methodologies for Estimating Emissions & Travel Activity Effects of TCMs, by SAI, July 1994)

Travel Time

Cost

Convenience

Reliability etc.

Utility Factor (based on the combination of the above variables)

COMMUTER Model



10. Cost Effectiveness

Project Life Span - Time Value of Money

To make such an annualized cost determination, three parameters are needed:

- 1: present value (present investment \$): P
- 2: annual interest rate (in decimal format): i
- 3: project life span (# of years): n
- 4: annualized cost: A

$$(A/P, i, n) = P \times i (1 + i)^n / ((1 + i)^n - 1)$$



10. Cost Effectiveness

Example: Project Life Span - Time Value of Money

e.g.,

We are planning to use \$1.2 million CMAQ fund to buy 12 CNG buses. The projected bus service life is 15 years. Each year total air quality benefits is 12 tons of VOC reduction. How much will it cost us for every ton of VOC reduction on an annual basis?



10. Cost Effectiveness

Project Life Span - Time Value of Money

- 1: Present value (present investment): $P = \$1.2$ million
- 2: Assume interest rate - 6% : $i = 0.06$
- 3: Project life span - 15: $n = 15$ years

Use the fund recovering equation

$$(A/P, i, n) = P \times i (1 + i)^n / ((1 + i)^n - 1)$$

$$\begin{aligned} A &= \$1,200,000 \times 0.06 \times (1+0.06)^{15} / ((1+0.06)^{15} - 1) \\ &= \$123,555 \text{ per year} \end{aligned}$$

Cost/benefit on an annual basis
 $\$123,555 / 12 \text{ ton} = \$10,290 / \text{Ton/Year}$



10. Cost Effectiveness

Project Life Span - Time Value of Money

Key Considerations:

- 1: Project Life span estimation
- 2: Use same interest rate for all options
- 3: Final unit: \$/ton/year



11. COMMUTER Model

What is the COMMUTER model?

- ✓ A spreadsheet-based computer model
- ✓ Estimates the travel and emissions impacts of transportation air quality programs focused on commuting



11. COMMUTER Model

Who will use COMMUTER Model?

- ✓ based on the Federal Highway Administration's **Travel Demand Management Evaluation Model** developed by the COMSIS Corporation in 1993.
- ✓ follow a set of procedures in "EPA's **Guidance for Quantifying Emission Reductions from Best Workplaces for Commuters Programs for Use in State Implementation Plans and Transportation Conformity Determinations (EPA420-8-07-015)**".



Who will use **COMMUTER?**

Methodologies & Procedures

- ✓ **MPOs and state DOTs**
Impacts can be incorporated into SIP
- ✓ **Individual employers** who are assessing the likely effectiveness of various commuter benefit packages and other measures to facilitate use of commute alternatives.



11. COMMUTER Model

What programs can I evaluate?

- ✓ Transit fare decreases or other incentives that reduce the **cost** of using transit,
- ✓ Transit service improvements (faster or more **frequent service**),
- ✓ Ridesharing programs, in which employers support carpooling and/or vanpooling through on-site programs, **financial incentives, or preferential parking**,



11. COMMUTER Model

What programs can I evaluate?
(Continued)

- ✓ Actions, such as increased parking charges or cash-out programs, that change the **time and/or cost of traveling** by any particular mode,
- ✓ Non-motorized (e.g., bicycle and pedestrian) commuting programs,
- ✓ **Alternative work schedules**, including flex-time, compressed work weeks, and staggered work hours, and
- ✓ **Telecommuting**



11. COMMUTER Model

When to use it, and
When not to use it?

- ✓ Useful for smaller TCM
 - Calculating SIP credit or for conformity determinations
 - A single worksite, employment center, or sub-area for sketch-level analysis purposes
- ✓ **Will NOT perform** as well for larger programs
 - Large enough to impact travel speeds throughout an area
 - Likely to have a regionally significant effect on travel patterns