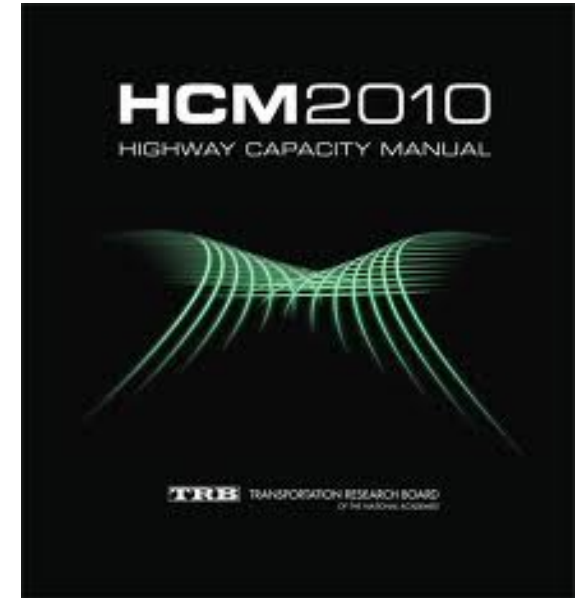


# HCM 2010: FREEWAY FACILITIES



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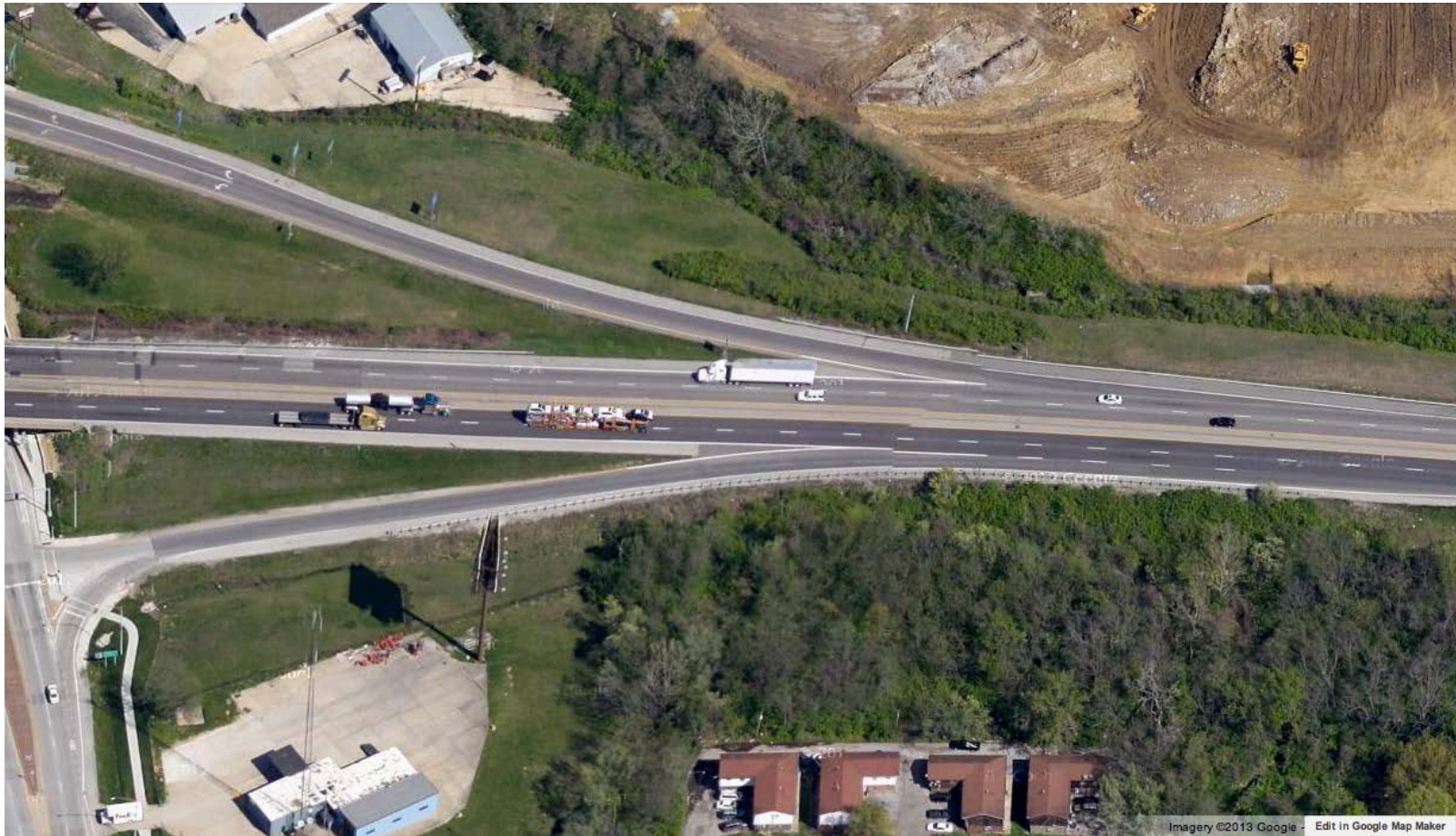
# OUTLINE

- ◆ Freeway facility components
- ◆ Methodology for analyzing freeway facilities
  - ◆ 7-step procedure to compute facility LOS
- ◆ Exercise problem

# FREEWAY SEGMENTS

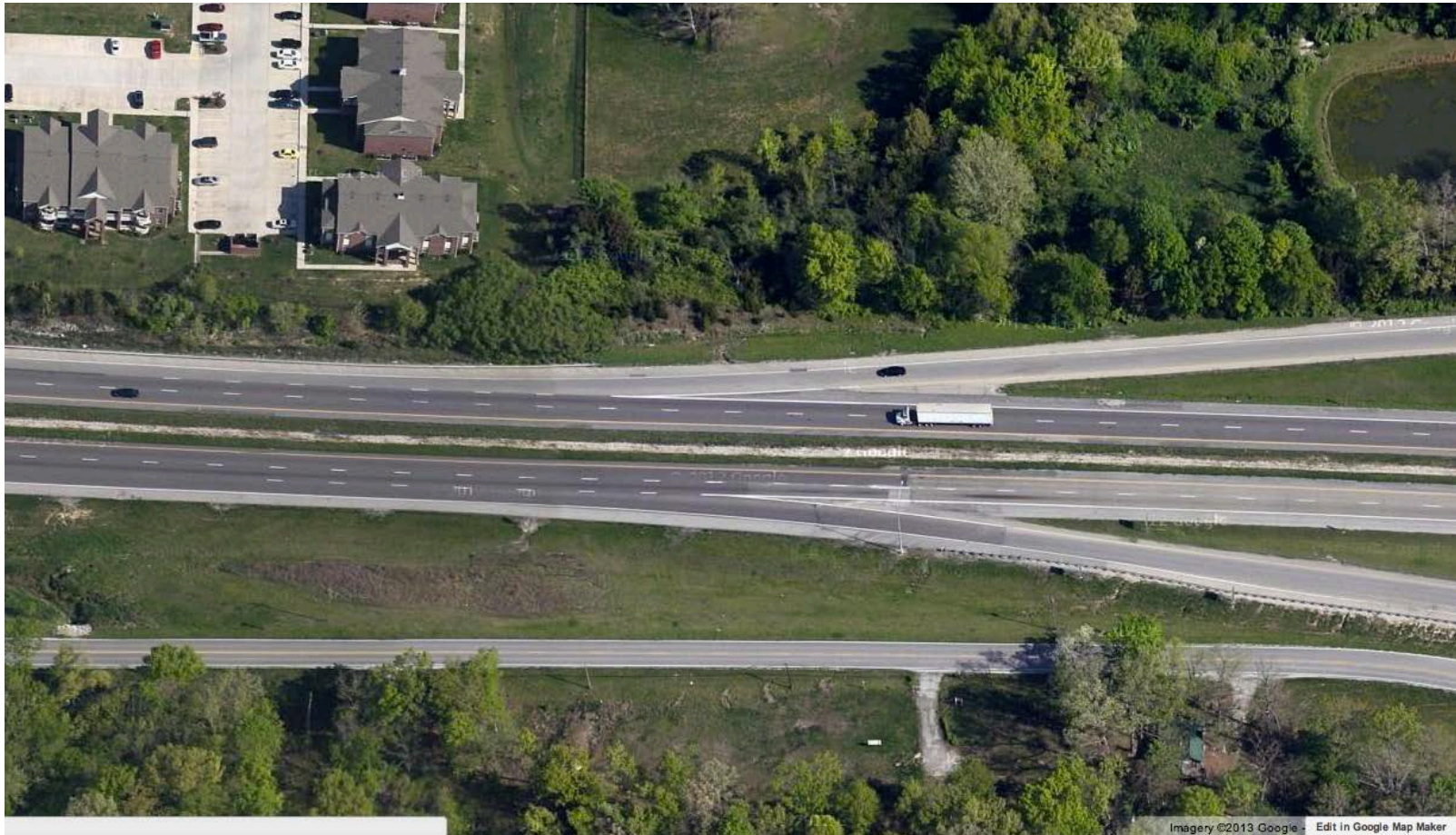
- ◆ Three types of freeway segments
  - ◆ Freeway merge and diverge segment
  - ◆ Freeway weaving segment
  - ◆ Basic freeway segment
  
- ◆ Merge and diverge segments: “*Segments in which two or more traffic streams combine to form a single traffic stream (merge) or a single traffic stream divides to form two or more separate traffic streams (diverge).*”

# MERGE SEGMENT (I-70@ RANGELINE ST IN COLUMBIA, MO)



# DIVERGE SEGMENT

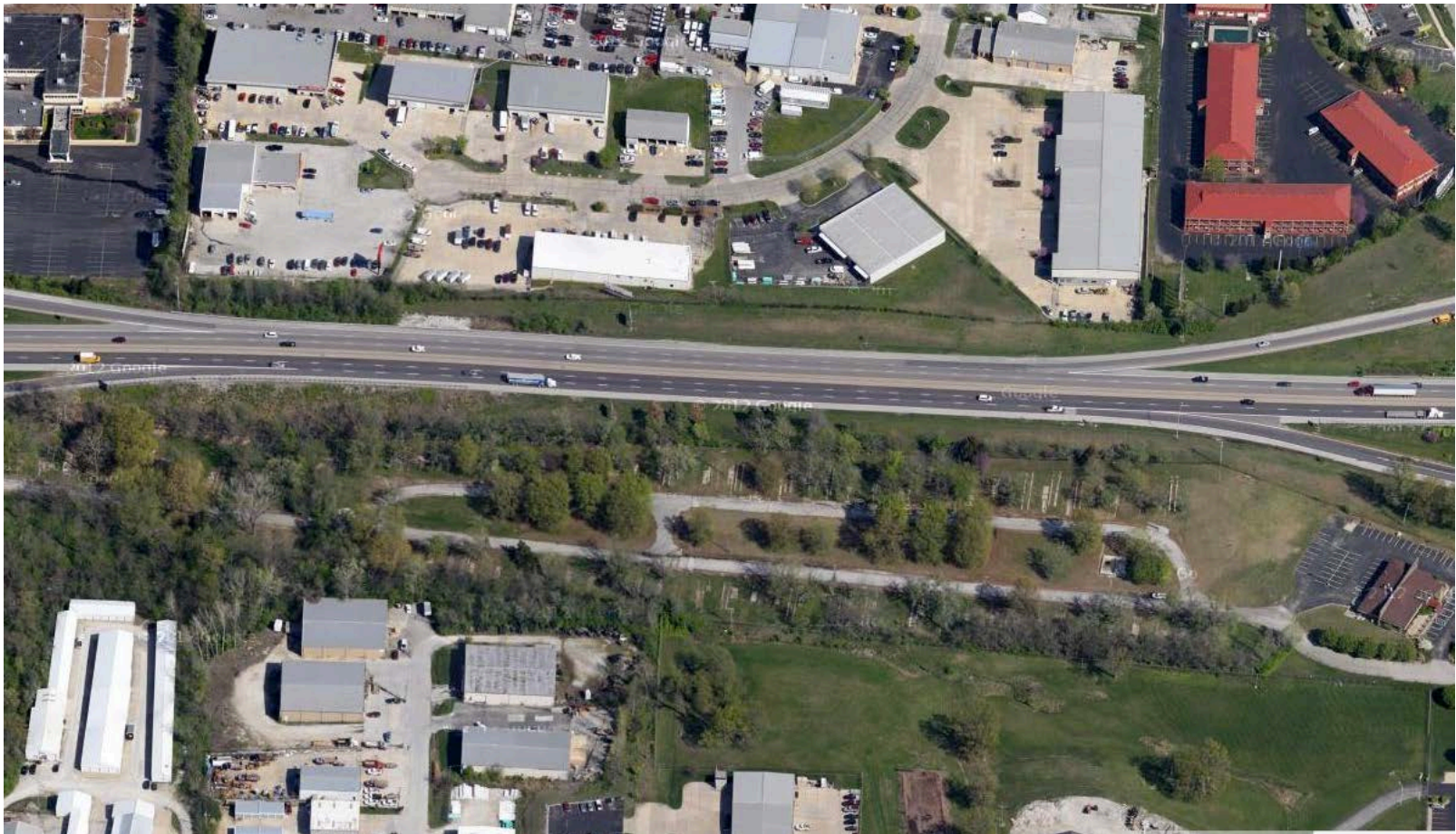
(I-70@ ST. CHARLES RD IN COLUMBIA, MO)



# FREEWAY SEGMENTS

- ◆ Weaving segments: “Segments in which two or more traffic streams traveling in the same general direction cross paths along a significant length of freeway without the aid of traffic control devices (except for guide signs).”
- ◆ Formed when
  - ◆ A diverge segment closely follows a merge segment or
  - ◆ A one-lane off-ramp closely follows a one-lane on-ramp and the two are connected by a continuous auxiliary lane.
- ◆ Basic freeway segments: “All segments that are not merge, diverge, or weaving segments.”

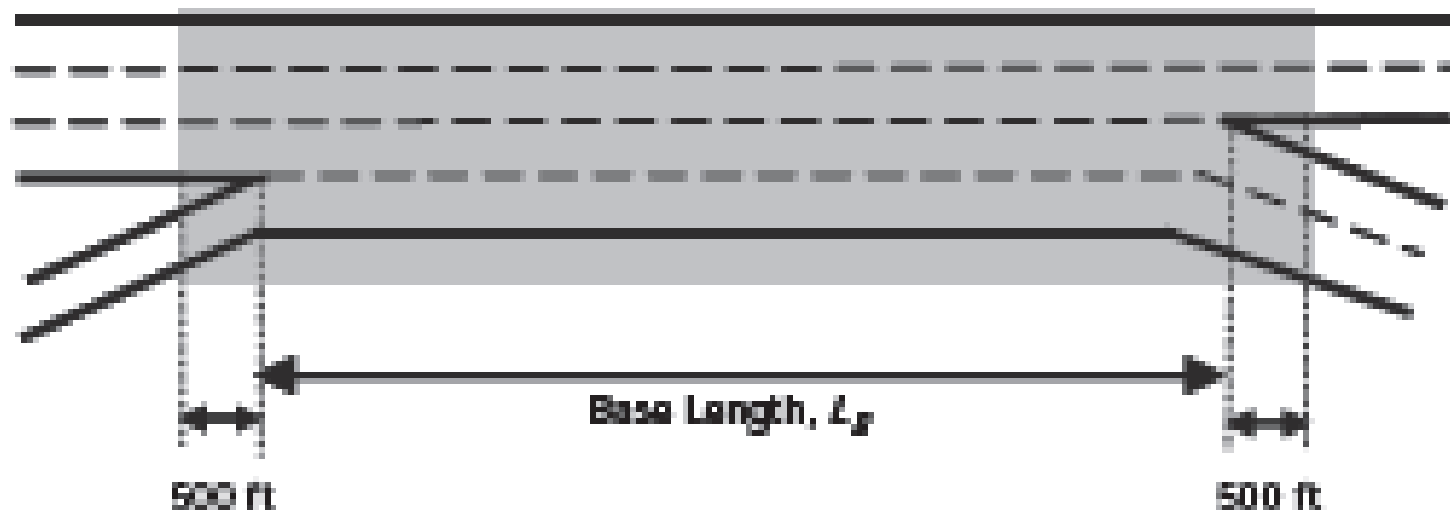
# WEAVING SEGMENT (I-70 BETWEEN STADIUM BLVD. AND RANGELINE ST. IN COLUMBIA, MO)





# INFLUENCE AREAS: WEAIVING

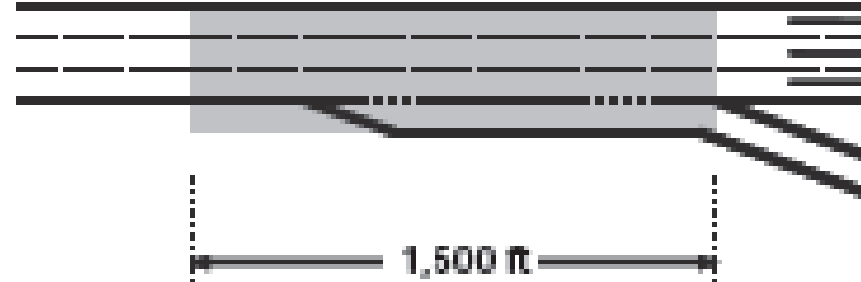
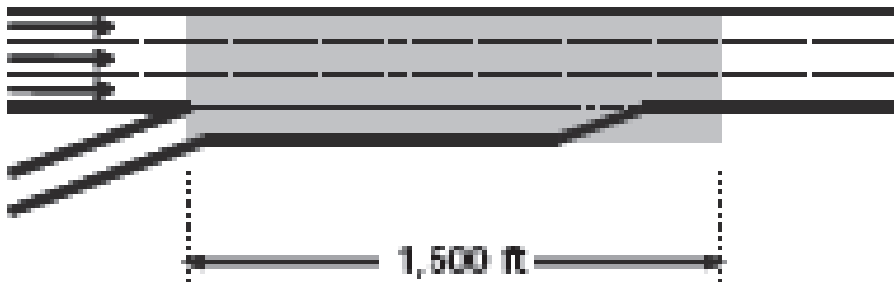
- ◆ Weaving influence area: Base length of weaving segment + 500 ft upstream of entry + 500 ft downstream of exit point of weaving segment





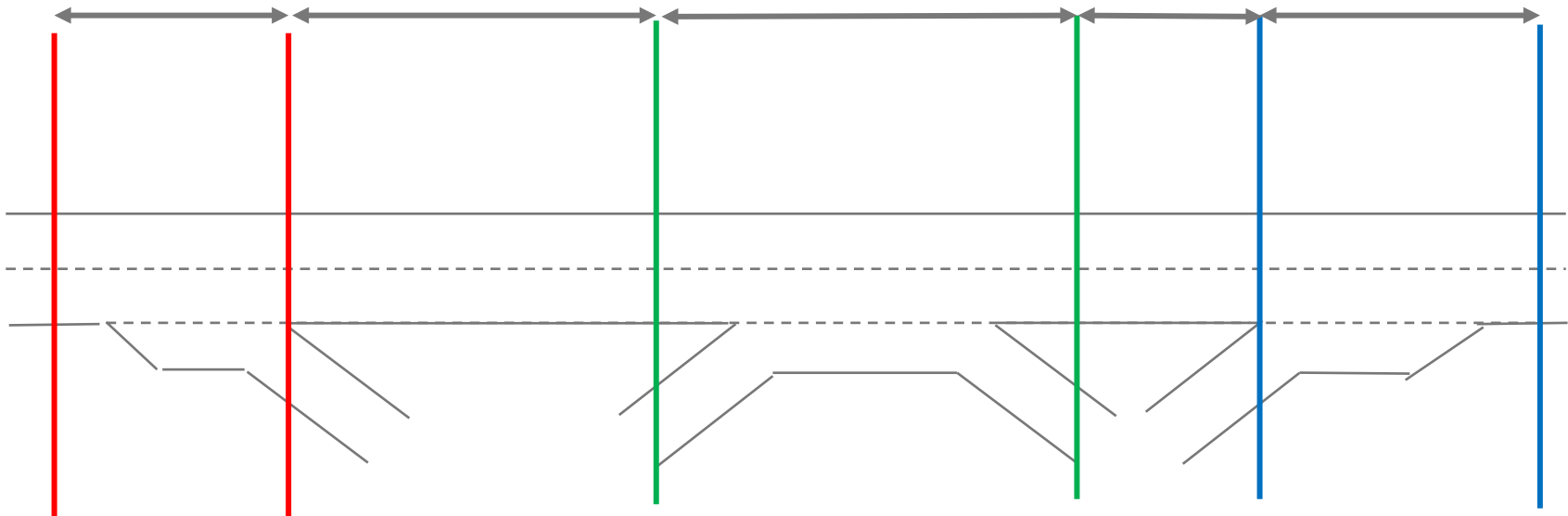
# INFLUENCE AREAS: MERGE AND DIVERGE

- ◆ Merge influence area: From the point where edges of travel lanes of merging roadways meet + 1500 ft downstream of that point
- ◆ Diverge influence area: From the point where edges of travel lanes of merging roadways meet + 1500 ft upstream of that point



# EXERCISE PROBLEM

- ◆ Identify the different freeway segments in the below figure
- ◆ Identify their influence areas



# METHODOLOGY FOR ANALYZING FREEWAY FACILITIES

## ◆ 7-step procedure

- ◆ Step 1: Input data (demand, geometry, time-space domain)
- ◆ Step 2: Adjust demand data
- ◆ Step 3: Compute segment capacities
- ◆ Step 4: Adjust segment capacities
- ◆ Step 5: Compute demand-to-capacity ratios
- ◆ Step 6: Compute service measures, LOS for segments
- ◆ Step 7: Compute freeway facility service measures and LOS

# STEP 1: INPUT DATA

## ◆ Demand

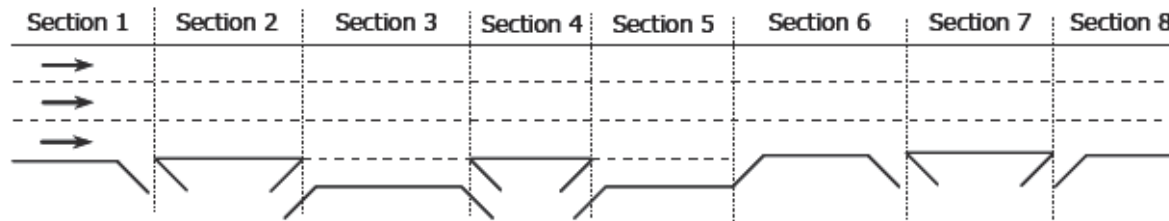
- ◆ Demand flow rates for each segment and time period
- ◆ Analysis based on multiple consecutive 15-min periods
- ◆ Demand needed for entering freeway mainline, on-ramp, and off-ramp flow
- ◆ Percent trucks, RVs and driver population factor also needed

## ◆ Geometrics

- ◆ Number of lanes, average lane width, lateral clearance, terrain, FFS
- ◆ Geometrics of merge, diverge, and weaving segments

# STEP 1: INPUT DATA

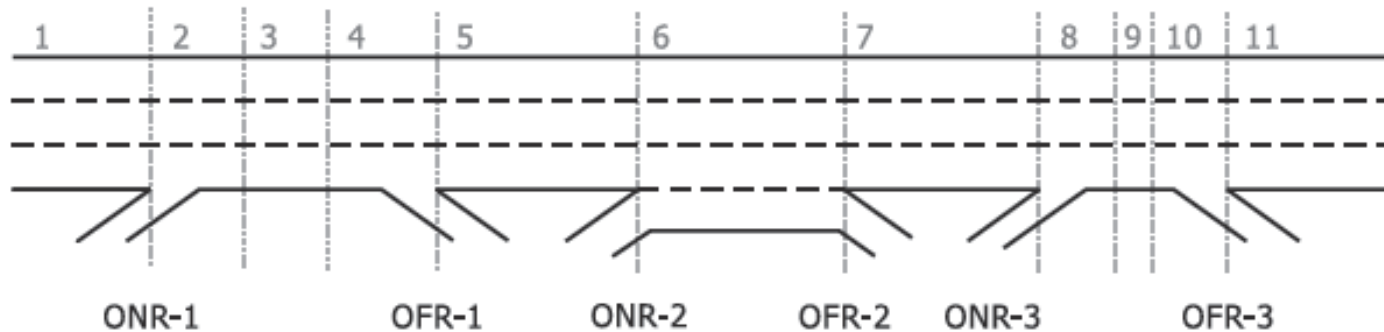
- ◆ Time-space domain is established for analysis
  - ◆ Specify the freeway *sections* included in the defined facility
  - ◆ A freeway *section* boundary occurs whenever a change in demand occurs (on-ramp, lane addition, etc)
  - ◆ Specify the *time intervals* for which analysis is conducted



Time Step	Section 1	Section 2	Section 3	Section 4	Section 5	Section 6	Section 7	Section 8
1								
2								
3								
4								
5								
6								
7								
8								

# STEP 1: INPUT DATA

- ◆ Converting *sections* to *analysis segments*
  - ◆ Basic freeway, merging, diverging, weaving segment
  - ◆ An example of identifying analysis segments:



The facility has three on-ramps and three off-ramps. Geometric details are given in Exhibit 10-26.

Segment No.	1	2	3	4	5	6	7	8	9	10	11
Segment type	B	ONR	B	OFR	B	B or W	B	ONR	R	OFR	B
Segment length (ft)	5,280	1,500	2,280	1,500	5,280	2,640	5,280	1,140	360	1,140	5,280
No. of lanes	3	3	3	3	3	4	3	3	3	3	3

Note: B = basic freeway segment, W = weaving segment, ONR = on-ramp (merge) segment, OFR = off-ramp (diverge) segment, R = overlapping ramp segment.



# STEPS 3 AND 4: SEGMENT CAPACITIES

- ◆ Step 3: Chapters 11 to 13 are used to determine capacities for basic freeway segment, weaving segment, and merge/diverge segments
- ◆ Step 4: Adjust segment capacities
  - ◆ Capacity reduction due to work zones (short-term and long-term)
  - ◆ Capacity reduction due to lane width reduction
  - ◆ Capacity reduction due to weather and other environmental conditions
  - ◆ Capacity reduction due to traffic accidents and vehicle breakdowns

# STEP 5: COMPUTE DEMAND-TO-CAPACITY RATIOS

- ◆ Demand-to-capacity ( $\frac{V_d}{C}$ ) ratio is calculated for each cell in the time-space table
- ◆ Cell values carefully reviewed for any  $\frac{V_d}{C} > 1.00$
- ◆ If any boundary cells have a  $\frac{V_d}{C} > 1.00$  any further analysis may be flawed
- ◆ If any interior cells have a  $\frac{V_d}{C} > 1.00$ 
  - ◆ Both undersaturated and oversaturated conditions exist inside the facility
  - ◆ Analysis of oversaturated conditions is more complex due to interactions between freeway segments and shifting of demand in both time and space





# STEP 6: COMPUTE SEGMENT SERVICE MEASURES

- ◆ In this workshop, we'll do an example on undersaturated conditions
- ◆ Step 6a in the methodology
  - ◆ No cells have  $\frac{v_d}{c} > 1.00$
  - ◆ Each segment analysis using methods described in chapters 11 to 13 to compute density  $D$  and space mean speed  $S$
  - ◆ LOS determined based on the density value for each time interval

Level of Service	Density (pc/mi/ln)
A	$\leq 11$
B	$> 11-18$
C	$> 18-26$
D	$> 26-35$
E	$> 35-45$
F	$> 45$ or any component $v_d/c$ ratio $> 1.00$



# STEP 7: COMPUTE FACILITY SERVICE MEASURES AND LOS

Average density for the freeway facility is estimated based on segment densities for each time interval

$$D_F = \frac{\sum_{i=1}^n D_i \times L_i \times N_i}{\sum_{i=1}^n L_i \times N_i}$$

$D_F$  = average density for the facility (pc/mi/ln),

$D_i$  = density for segment  $i$  (pc/mi/ln),

$L_i$  = length of segment  $i$  (ft),

$N_i$  = number of lanes in segment  $i$ , and

$n$  = number of segments in the defined facility.

# STEP 7: COMPUTE FACILITY SERVICE MEASURES AND LOS

- ◆ Facility space mean speed  $S$

$$S(t = 1) = \frac{\sum_{i=1}^{11} SF(i,1) \times L(i)}{\sum_{i=1}^{11} SF(i,1) \times \frac{L(i)}{U(i,1)}}$$

$SF(i, t)$  = flow in segment  $i$  in interval  $t$

$L(i)$  = length of segment  $i$

$U(i, t)$  = space mean speeds in segment  $i$  in interval  $t$

# EXERCISE PROBLEM

- ◆ Evaluation of an undersaturated facility
- ◆ A 6-mile urban freeway facility consisting of 11 analysis segments
- ◆ **What is the operational performance and LOS of the facility?**

Segment No.	1	2	3	4	5	6	7	8	9	10	11
Segment type	B	ONR	B	OFR	B	B or W	B	ONR	R	OFR	B
Segment length (ft)	5,280	1,500	2,280	1,500	5,280	2,640	5,280	1,140	360	1,140	5,280
No. of lanes	3	3	3	3	3	4	3	3	3	3	3

Note: B = basic freeway segment, W = weaving segment, ONR = on-ramp (merge) segment, OFR = off-ramp (diverge) segment, R = overlapping ramp segment.

