HIGHWAY CAPACITY

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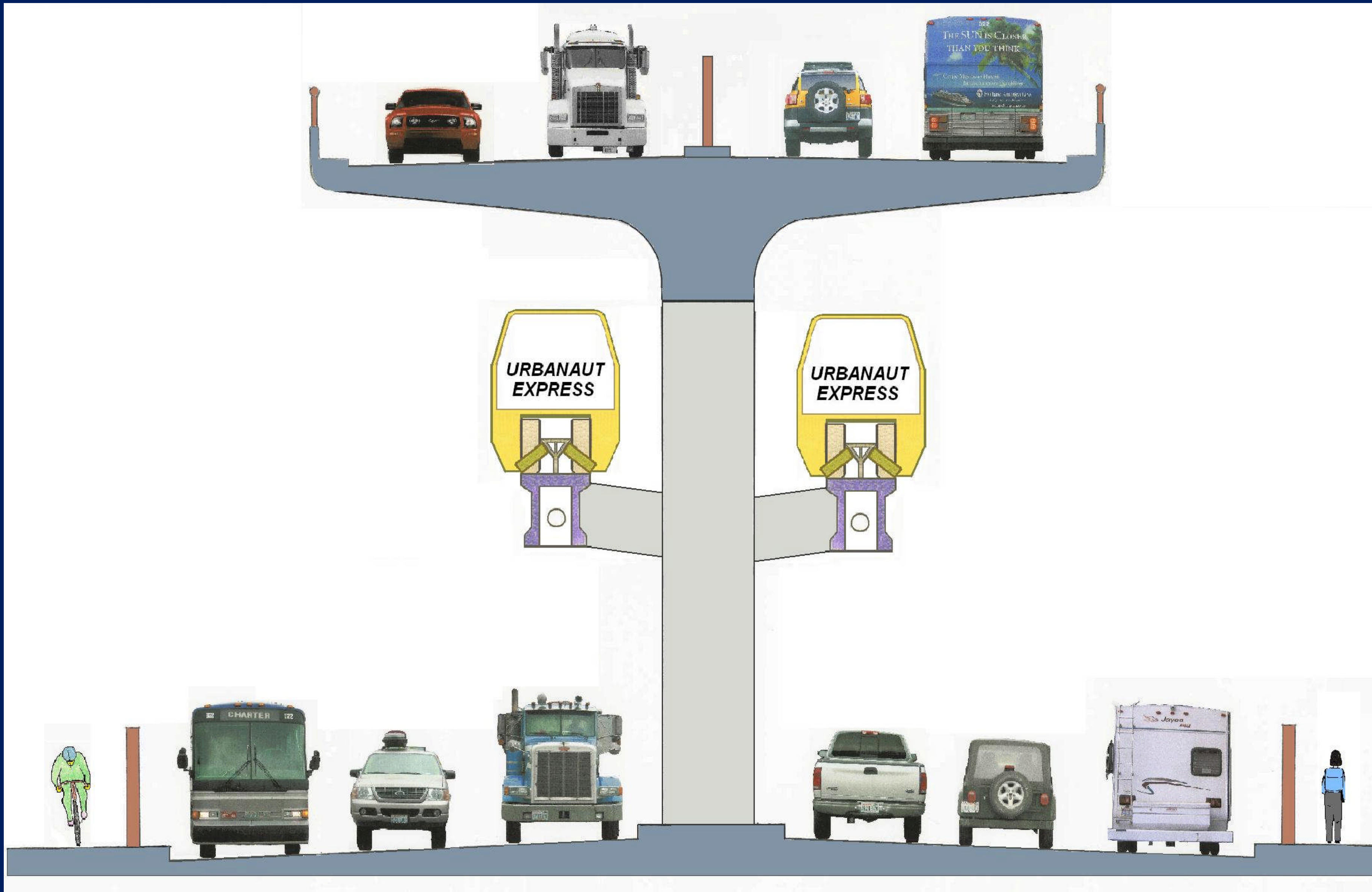
Capacity

- **Capacity:** It is the ability of a road to accommodate traffic volume. It is the maximum hourly rate at which vehicles can reasonably be expected to cross a point on a roadway during a given time period under prevailing traffic roadway and control condition. For multi lane highway it is 2000pcphpl, and for 2-lane highway is 2800pcph (passenger car per hour).
- Units : vph (vehicle per hour or vphpl (vehicle Per hour per lane)

Capacity

- **Basic capacity**: the maximum volume of vehicles per hour that can pass a certain point or section of a road in a given time under the ideal condition (most ideal road way, traffic and control conditions that can possibly be attained). It assume that all the vehicles are travelling at the same speed and minimum spacing is allowed.
- **Possible capacity**: the maximum number of vehicles that can pass a given section during a given period of time under prevailing (most frequent/usual) roadway, traffic and control condition.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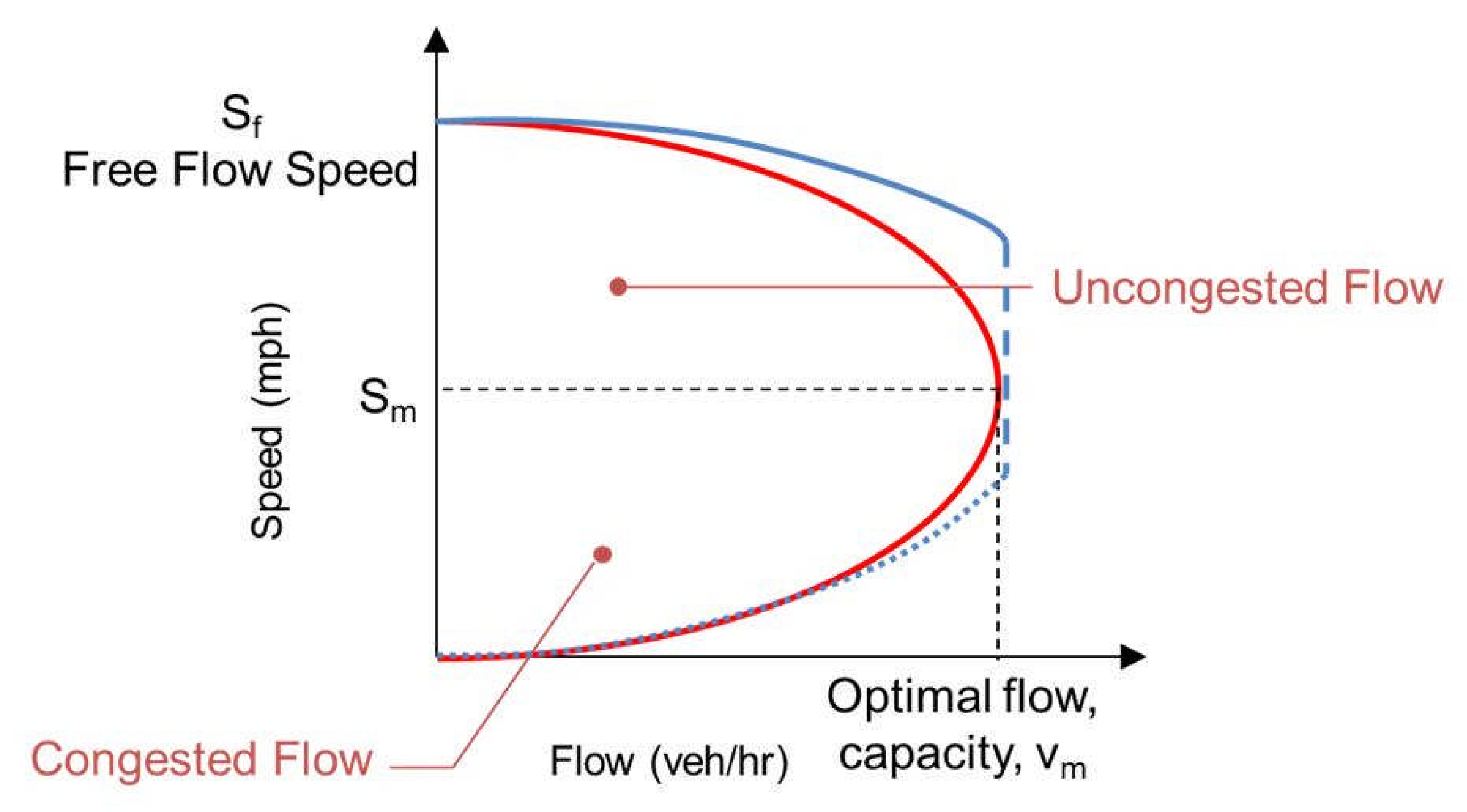
Capacity

- **Practical/design capacity**: Capacity without the traffic density being so great as to cause unreasonable delays, hazard or restriction to the drivers freedom under the prevailing condition of road way, traffic and control.
- Basic capacity>possible capacity>design capacity
- **Volume**: Number of vehicles crossing a point on the road during a specific time period. It is carried out for :
- Design and extension of existence road,

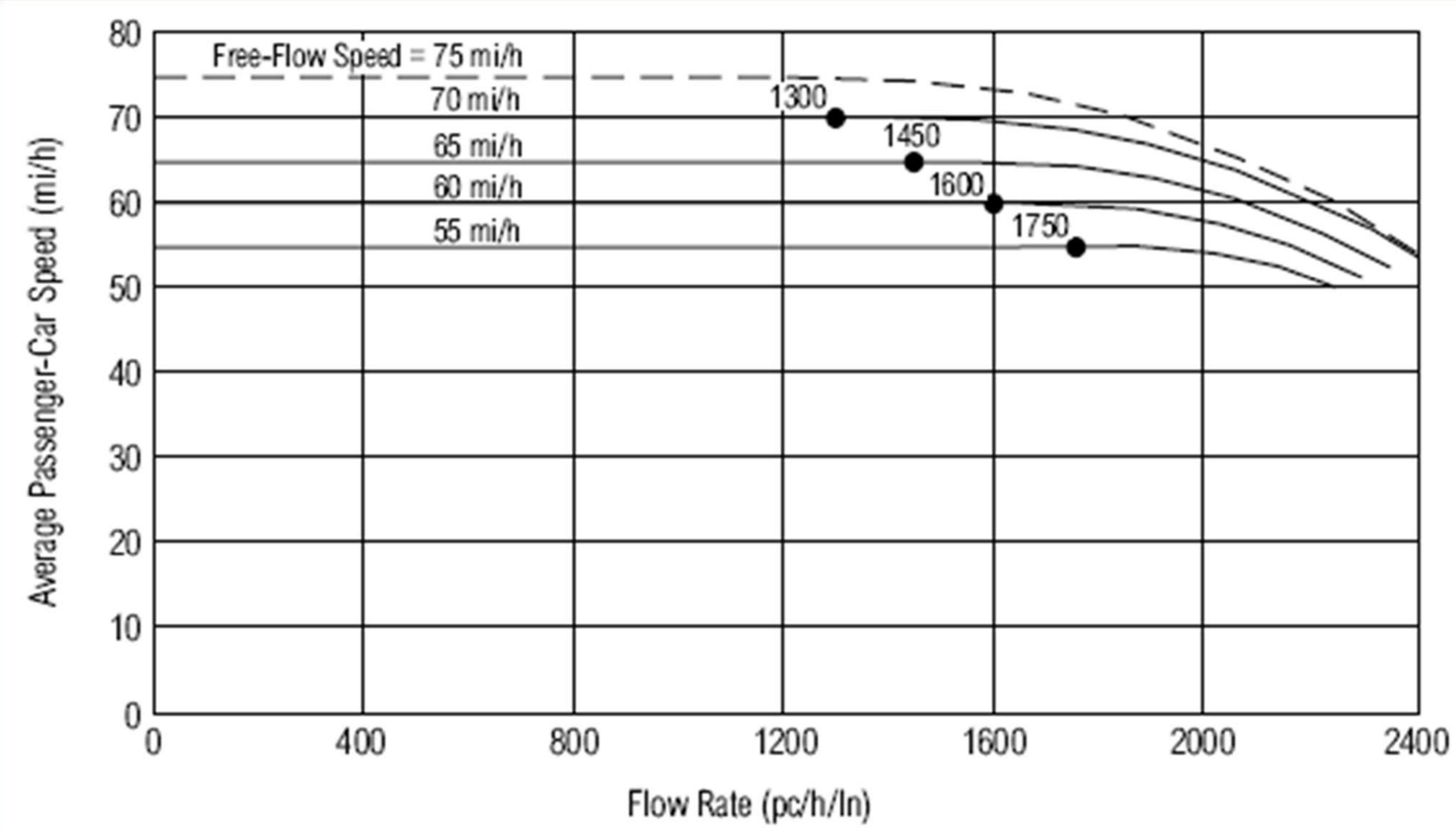
Volume

- Traffic trend and pattern,
- Geometric and structural design of new road,
- Design of footpath, cross wall,
- Pedestrian signals,
- Plan of one way traffic
- Other regulatory measures on the road

Effect of speed



Uncongested Flow



PCU

- **Passenger car unit**: It is a vehicle unit used for expressing highway capacity. One car is considered as a single unit, cycle, motorcycle is considered as half car unit.
- Bus , truck causes a lot of inconvenience because of its large size and is considered equivalent to 3 cars or 3 PCU.

PCU

Type of vehicle	PCU
Car, taxi, pick up	1.0
Cycle, motor cycle	0.5
Bus, truck,	3.0 (4.o in some cases)
Horse drawn cart	4.0
Bullock cart	6.0
Bullock cart (Large)	8.0

Factors affecting capacity

- Lane width
- Width of shoulder
- Lateral clearance
- Commercial vehicles
- Road alignment and geometry (curves, Superelevation etc)
- Existence of intersections.
- One way or two way traffic and number of lanes

Factors affecting capacity

- Drivers and vehicular characteristics
- Single type or mixed traffic
- Flow speed
- Weather condition
- Parking
- Presence of pedestrians

Level of service

- **Level of service (LOS):** LOS is a scale which defines the operating conditions on highway. It is a measure of the restrictive effects of the increased volume, level of service as proposed by manual ranges from A to F, A is ideal level and F is worst level of service.

Multilane Highway LOS

LOS

LOS	Max. Density (PC/mi /lane)
A	12
B	20
C	30
D	42
E	67
F	>67

Freeway LOS

LOS

- **LOS A**: density is low enough that closeness of vehicle do not effect vehicle movement
- **LOS E**: No usable gap between vehicles, speed is slow,, condition can easily cross over into LOS F region.
- **LOS F**: Breakdown condition, number of vehicles arriving > number of vehicles leaving, speed is zero

LOS F

Levels of Service

- LOS A

- LOS C

Levels of Service

- LOS D

- LOS E

LOS

- **Elements to evaluate LOS:**
- Travel speed and travel time
- Volume to capacity ration (V/C) ratio
- Density (number of vehicles per unit length on highway, D=F/S, where S is speed and F is flow in pcph)
- Delay (at intersection, signals)

If V/C =1 (level E)

V/C >1 level of service is low

- **Service flow**=SF=V/PHF=Peak hour volume/PHF
- **Peak hour factor (PHF):** The ratio between flow for entire peak hr and the maximum hourly rate of the flow during 15 minute of that hour

LOS

$$SF = C_J (V/C) * N * f_W * f_{HV} * f_P$$

Where f_W = correction factor for road width

- f_{HV} = correction factor for heavy vehicle
- f_p =correction factor for driver population

$$f_{HV} = 1/((1 + P_t(E_t - 1) + P_b(E_b - 1) + P_R(E_R - 1))$$

LOS

E_t, E_b, E_R Passenger car equivalent for truck, bus and recreational vehicles

P_t, P_b, P_R Proportion of respective class vehicles

N is the number of lanes in one direction

CJ is the capacity per lane (pcphpl)

Example

- Find service flow rate (capacity), level of service (LOS), for an existing facility of 6 lanes, peak hr traffic=3000vph (10% trucks, 3% buses), PHF=0.9
- **Solution:** As PHF=peak hr volume/service flow
- SF=peak hr volume/PHF=3000/0.9=3333vph
- Cj=2000pcphpl, fw=0.93,fp=1

$$SF = C_J (V / C) * N * f_W * f_{HV} * f_P$$

Example

$$f_{HV} = 1/((1 + P_t(E_t - 1) + P_b(E_b - 1) + P_R(E_R - 1))$$

Et=4, Eb=4, Pt=0.1, Pb=0.03

fHV=1/(1+0.1(4-1)+0.03(4-1))=0.74

V/C=3333/(2000*3*0.93*1.0*0.74)=0.81

From table, B=0.54,C=0.77, D=0.93, so LOS is D

Density =31 pc/mile/lane, speed is 52mph

Example

- 31=0.1*4*D+0.03*3*D+0.87*1*D
- D=23 veh/mile/lane
- F=S*D
- S=3333/(23*3)=48mph

Example 2 (Design)

- A rural freeway is being designed, the vertical profile design indicate a 3 mile segment of level terrain followed by a continuous 2 mile at 4% upgrade. The peak hr demand is 2500vph in one direction. There are 15% trucks and 10% buses. The PHF is 0.85. level of service C is desired, how many lanes will be needed to provide for this.
- Solution::Assume lane width is 12 feet, fw=1.0,fp=1.0, fHV=?

Example 2

- PB=0.1, PT=0.15
- Part (1) zero grade:
- ET=1.7, EB=1.5
- FHV=1/(1+0.15(1.7-1)+0.1(1.5-1))=0.87
- SF=2500/0.85=2000*0.65*1.0*1.0*N*0.87
- V/C for 70mph is 0.54-0.77 for LOS C, let take V/C=0.65
- N=2.6, say 3.0, and with N=3, V/C=0.56

Example 2

- Part (2), 4% up grade:
- For up grade, trucks are extremely heavy so Et=8, Eb=1.6,
- FHV=1/((1+0.15(8-1)+0.10(1.6-1))
- =0.47 (up grade), Now N=?
- SF=2500/0.85=2000*0.65*1.0*1.0*N*0.47
- Or N=4.0 Lanes

Problem 3

- A four lanes freeway runs through an area of level terrain. The freeway has 12 feet lanes, 8 foot clear shoulders and a 70 mph design speed. Traffic consists of 10% trucks and has PHF of 0.91. Compute the service flow rates for each level of service for this facility.
- Solution:

$$SF = C_J (V/C) * N * f_W * f_{HV} * f_P$$

Solution

- Cj=2000pcphpl (for design speed of 70 mph)
- N=2 lanes per direction
- Fw=1.00 (ideal condition)
- Fp=1.00 (regular user)
- V/C ratio different for each level of service
- LOS A=0.35
- LOS B=0.54
- LOS C=0.77
- LOS D=0.93
- LOS E=1.00

Solution

- The heavy vehicles factor is determined from

$$f_{HV} = 1/((1 + P_t(E_t - 1) + P_b(E_b - 1) + P_R(E_R - 1))$$

- =0.93
- Service flow rate for each level of service may now be computed as:
- SF(A)=2000*2*0.35*1.0*1.0*0.93=1308 vph
- SF (B)=2000*2*0.54*1.0*1.0*0.93=2019 vph

Solution

- SF (C)=2000*2*0.77*1.0*1.0*0.93=2879 vph
- SF (D)=2000*2*0.93*1.0*1.0*0.93=3477 vph
- SF (E)=2000*2*1.0*1.0*1.0*0.93=3738 vph
- these are service flow values during 15 minutes of peak hour.

- The service volumes during peak hour will be:
- SV(A)=1308*0.91 (PHF)=1191 vph
- SV (B)=2019*0.91=1837 vph
- SV (C)=2879*0.91=2619 vph
- SV (D)=3477*0.91=3164 vph
- SV (E)=3738*0.91=3402 vph

Problem 4

- A long viaduct on a freeway is currently operating with three 12 feet lanes and 6 ft lateral clearances on both sides. Due to some congestion, two alternatives are suggested, four 10 ft lanes with 4 ft clearance on the left and right and four 12 ft lanes with no lateral clearance on either side. Compare the capacity of existing facility and the two proposed improvements. f (HV)= 0.74

Problem 4

- Solution: Capacity is the service flow rate at LOS E, by definition. The capacity for each of three cases can be determined from:

$$SF = C_J * N * f_W * f_{HV} * f_P$$

- V/C is 1.0 for LOS E, Cj is 2000 pcphpl, Fp=1.0, N=3 or 4 depend on case. The lateral width factor fw for 12 ft lanes, 6 ft clearances= 1.0
- for 10 ft lanes, 4 ft clearances=0.87
- For 12 ft lanes, 0 ft clearances =0.91

Problem 4

- SF(E) for 3 12 ft lanes=2000*3*1.0*1.0*0.74
- =4412 vph
- SF (E) for 4 10 ft lanes and 4 ft clearance on both sides=2000*4*0.87*1.0*0.74
- =5118 vph
- SF (E) for 4 12 ft lanes and no clearance=2000*4*0.91*1.0*0.74
- =5353 vph
- The 4 lanes increase the capacity , though the clearance is not ideal

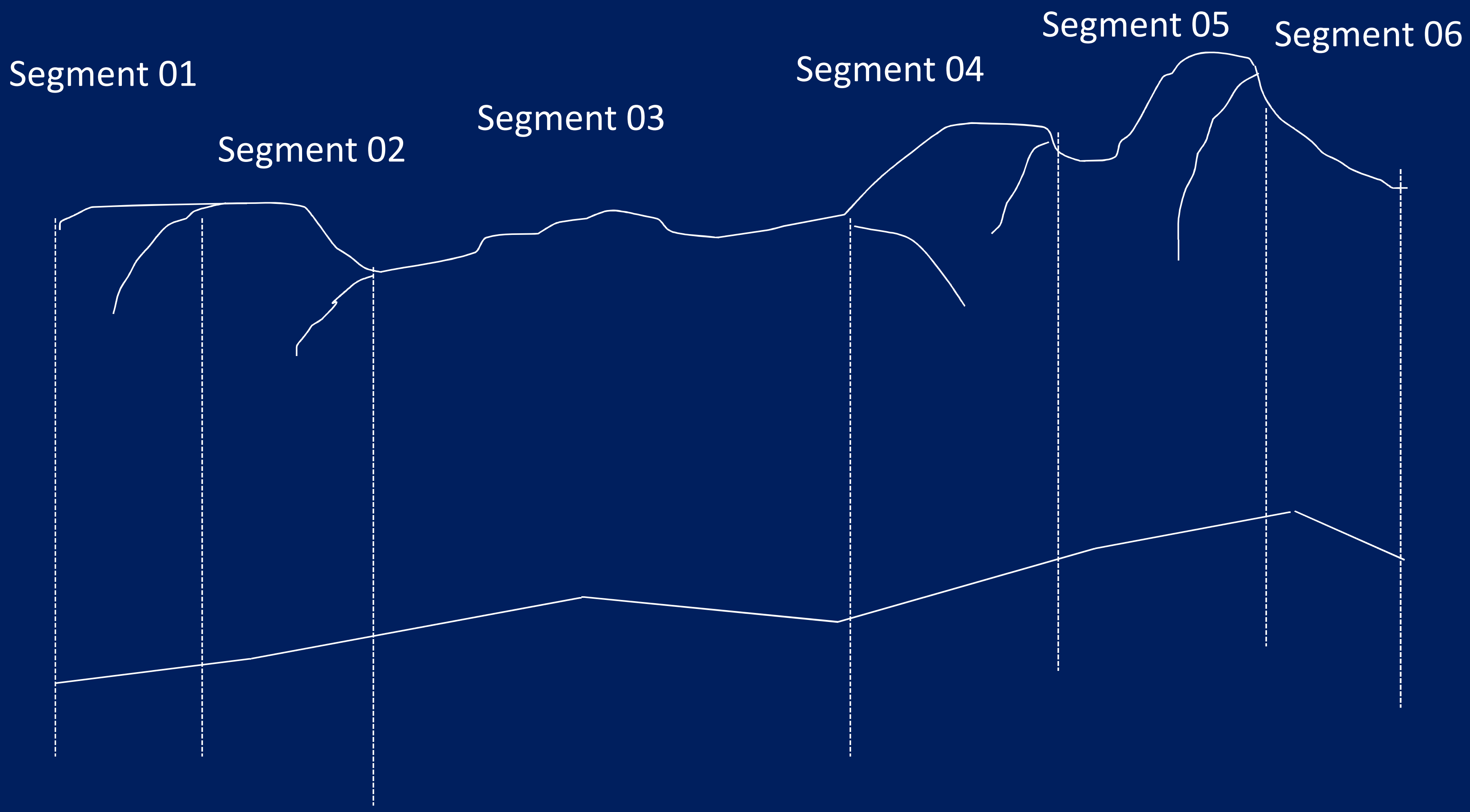
Problem 5

- A 10 miles section of a freeway undergoing design analysis. It is desired to provide LOS D along the entire length of the road.
- Solution: using same technique of service flow and service volume as

$$SF = C_J (V/C) * N * f_W * f_{HV} * f_P$$

- and SV=SF*PHF, Cj=2000 pcphpl, N=2,3,4
- V/C ratio for the given LOS, fw=1.0,fp=1.0

Problem 5


Segment 01
Segment 02
Segment 03
Segment 04
Segment 05
Segment 06

Problem 5

- Pt=0.10 (given), Et from table for the equivalent composite grade and length of the grade. $f_{HV} = 1/((1 + P_t(E_t - 1))$
- Service volume for LOS D

No of lanes	Seg. 1	Seg. 2	Seg. 3	Seg. 4	Seg. 5	Seg. 6
2	2575	1969	1779	1779	1779	2016
3	3863	3348	3348	2835	2835	3240
4	5151	4464	4464	3780	3780	4320

Service volume for various LOS

LOS	Seg. 1 3 lanes	Seg. 2 4 lanes	Seg. 3 4 lanes	Seg. 4 4 lanes	Seg. 5 4 lanes	Seg. 6 4 lanes
A	1454	1680	1680	0	0	0
B	2243	2592	2592	2205	2205	2520
C	3198	3696	3696	3105	3105	3549
D	3863	4464	4464	3780	3780	4320
E	4154	4800	4800	4500	4500	5143

- The proposed design is therefore adequate