Analyses of Unsignalized Intersections

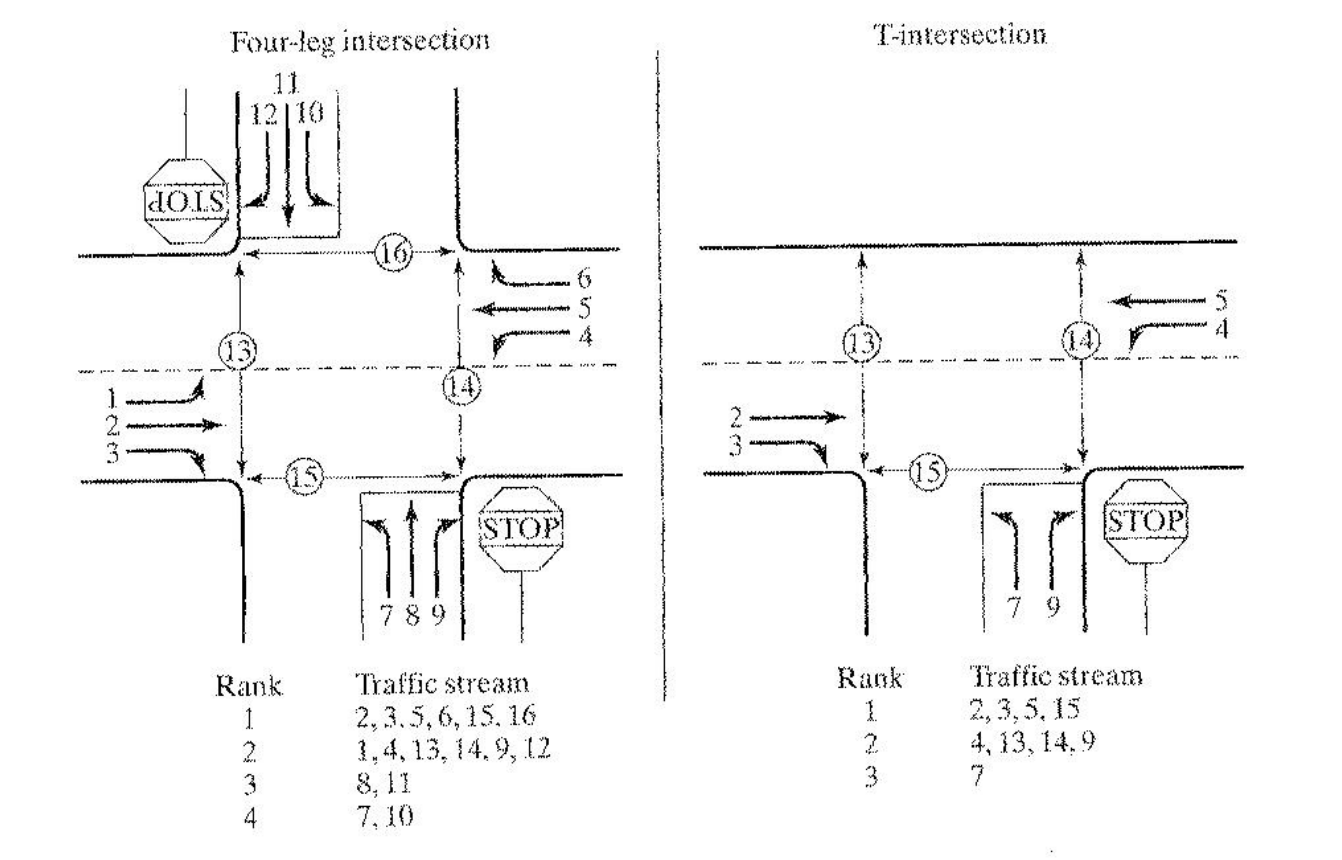
Types of Unsignalized Intersections

- Uncontrolled
- Stop Sign Controlled
  - TWSC
  - AWSC
- Yield Sign Controlled
- Roundabout



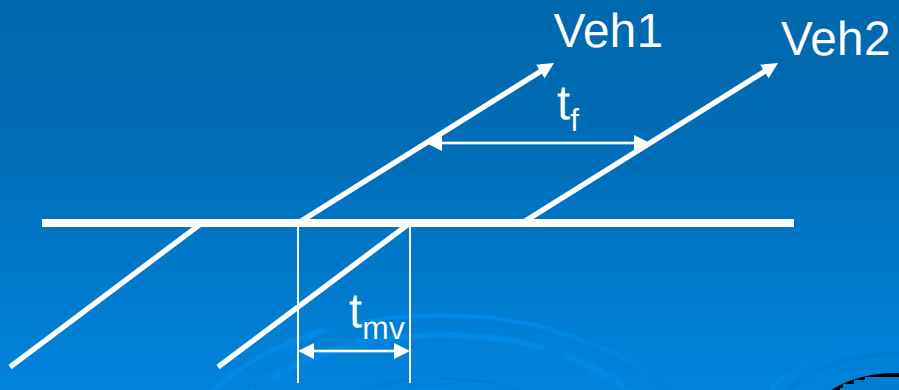
TWSC Intersections

- Priority movements



Gap Acceptance

- Critical gap, t_c
  - Minimum gap in the major stream that a minor street driver can accept
  - Cannot be measured directly in the field
  - Drivers behave differently
- Follow-up time, t_f
  - Minimum headway between two consecutive vehicles in the minor stream
  - Can be measured directly in the field



t_c and t_f

Movement	t_{cb}, sec		t_{fb}, sec
	Two-lane Major Street	Four-lane Major Street	
Major LT	4.1	4.1	2.2
Minor RT	6.2	6.9	3.3
Minor TH	6.5	6.5	4.0
Minor LT	7.1	7.5	3.5

$$t_c = t_{cb} + t_{cHV} P_{HV} + t_{cG} G - t_{cT} - t_{3LT}$$

$$t_f = t_{fb} + t_{fHV} P_{HV}$$

Adjustments on t_c and t_f

Adjustment	Values
t_{cHV}	1.0, Two-lane major street 2.0, Four-lane major street
t_{cG}	0.1, Movements 9 and 12 0.2, Movements 7, 8, 10 and 11 1.0, Otherwise
t_{cT}	1.0, With two stage process 0.0, With single stage process
t_{3LT}	0.7, Minor-street LT at T-intersection 0.0, Otherwise
t_{fHV}	0.9, Two-lane major street 1.0, Four-lane major street

$$t_c = t_{cb} + t_{cHV} P_{HV} + t_{cG} G - t_{cT} - t_{3LT}$$

$$t_f = t_{fb} + t_{fHV} P_{HV}$$

Capacity

- Conflicting volume, v_{cx}
  - Figure 23.3 (page 670)
- Potential capacity, c_{px}

$$c_{px} = v_{cx}\left[\frac{e^{-(v_{cx}t_{cx}/3600)}}{1-e^{-(v_{cx}t_{fx}/3600)}}\right]$$

- Movement capacity, c_{mx}

$$c_{mx} = f_x c_{px}$$

$$f_7 = p_{0,4}p_{p,7}$$

For minor street LT at T intersection

Delay and LOS

$$d_x = \frac{3600}{c_{mx}} + 900T\left[(\frac{v_x}{c_{mx}} - 1) + \sqrt{(\frac{v_x}{c_{mx}} - 1)^2 + \frac{(\frac{3600}{c_{mx}})(\frac{v_x}{c_{mx}})}{450T}}\right] + 5$$

LOS	Average Control Delay, sec/veh
A	0-10 (0-10)
B	>10-15 (10-20)
C	>15-25 (20-35)
D	>25-35 (35-55)
E	>35-50 (55-80)
F	>50 (>80)

* (xx) for signalized intersections

Exercise

Using HCS to solve the sample problem given. After the model is set up, try to answer the following questions.

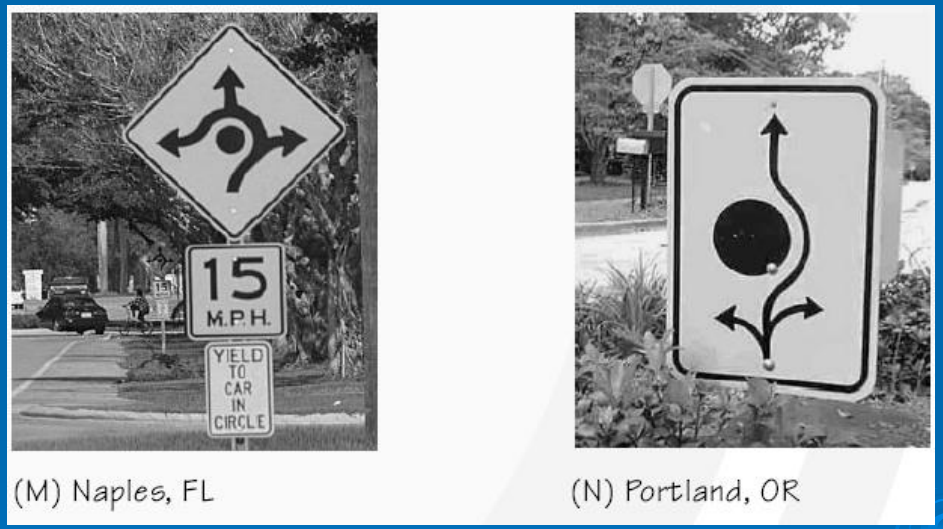
1. Can you duplicate the results given in the example?
2. How many minor movements are involved in the example?
3. Which minor movements have the same potential capacity and movement capacity, i.e., which minor movements are not impeded by higher priority minor movements?
4. What is the basic critical gap and final critical gap for the minor street LT movement?
5. What is the conflicting flow rate for minor street LT movement? Verify the result manually.
6. What is the probability of major street LT movement not blocking the minor street LT movement (i.e., probability of queue free for major street LT movement)?
7. what is the impedance factor for minor street LT movement? How is this factor used for the calculation?
8. What are the movement capacities for the minor street LT and RT movements?
9. What is the capacity for the minor street approach (shared LT and RT lane)
10. What is the control delay for the minor street approach?

Complexities

- * Upstream Signal Effect
- Two-stage crossing
- Flared approach

Roundabout

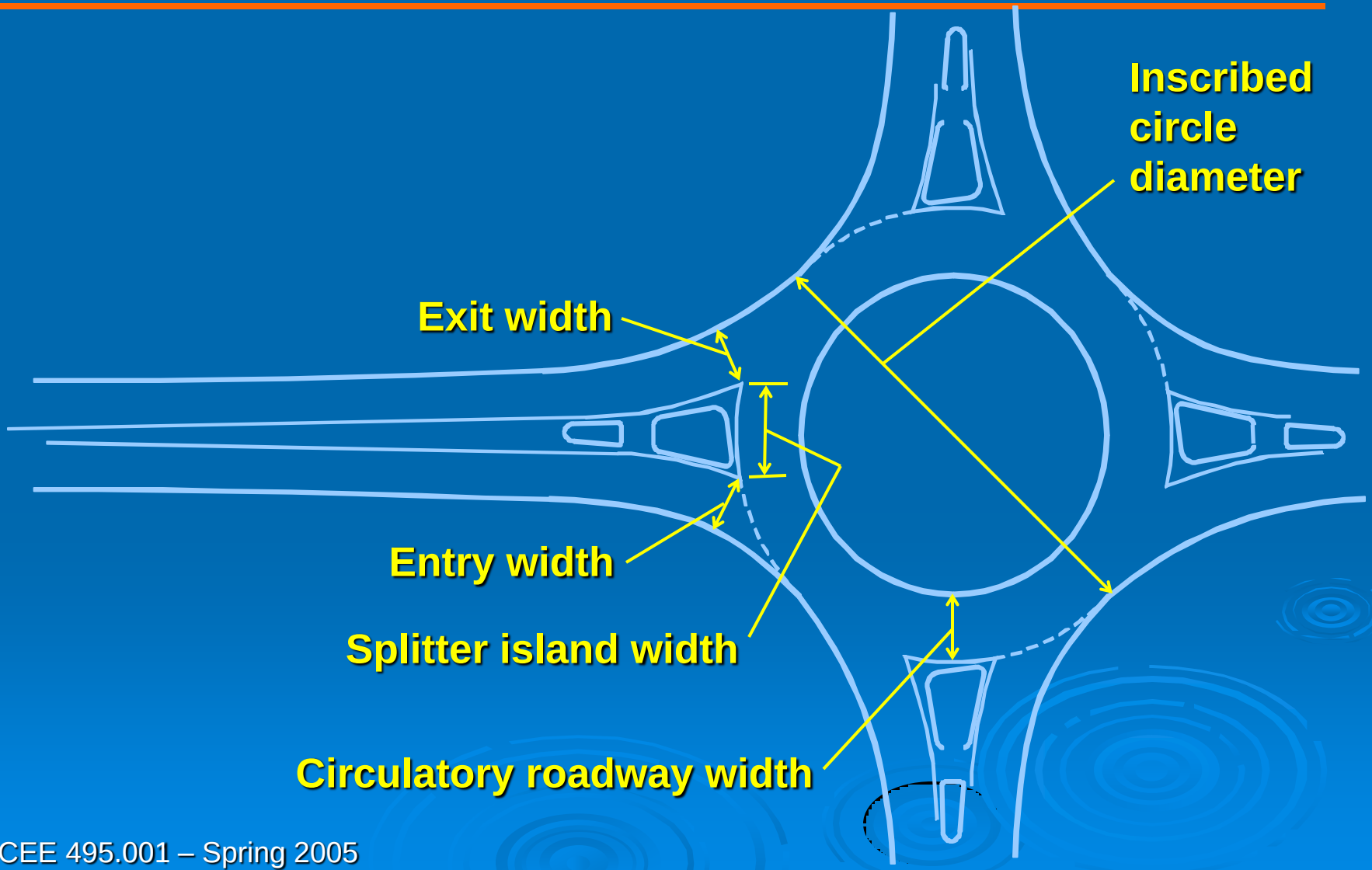
- Roundabout is a special type of *traffic circle*
- Major differences between roundabout and traffic circle
  - Speed
  - Traffic control
  - Priority of circulating traffic
  - Design vehicle
  - Pedestrian access
  - Parking
  - Direction of circulation
- Types of roundabout
  - Mini
  - Urban: compact, single-lane, double-lane
  - Rural: single-lane, double-lane



(M) Naples, FL

(N) Portland, OR

Roundabout Design Elements



Roundabout Operations - HCM

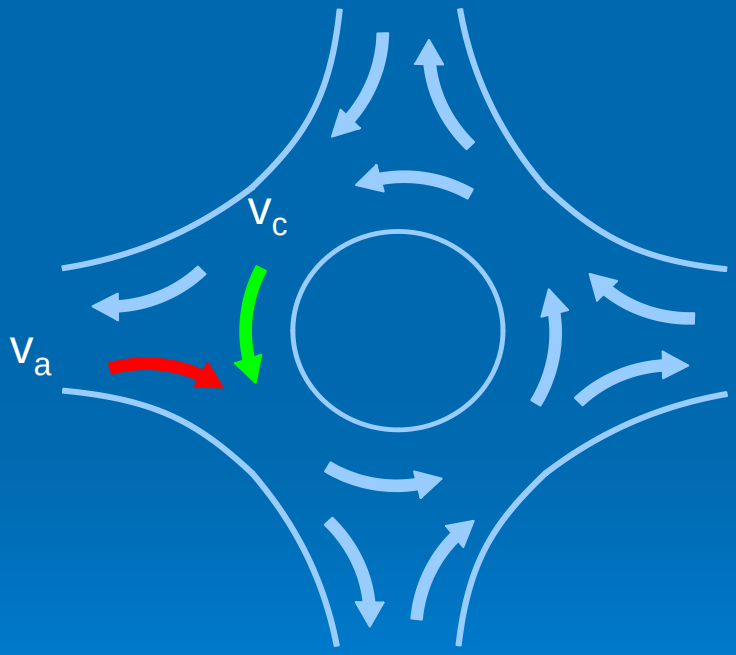
- Roundabouts introduced in 1997 HCM
- Method unchanged in HCM 2000
- Uses analytical method
- Only estimates capacity; no guidance on delay or level of service
- Measured in PCE

	Critical gap (sec)	Follow-up Time (sec)
Upper-bound solution	4.1	2.6
Lower-bound solution	4.6	3.1

$$c_a = v_c \left[\frac{e^{-(v_c t_c / 3600)}}{1 - e^{-(v_c t_f / 3600)}} \right]$$

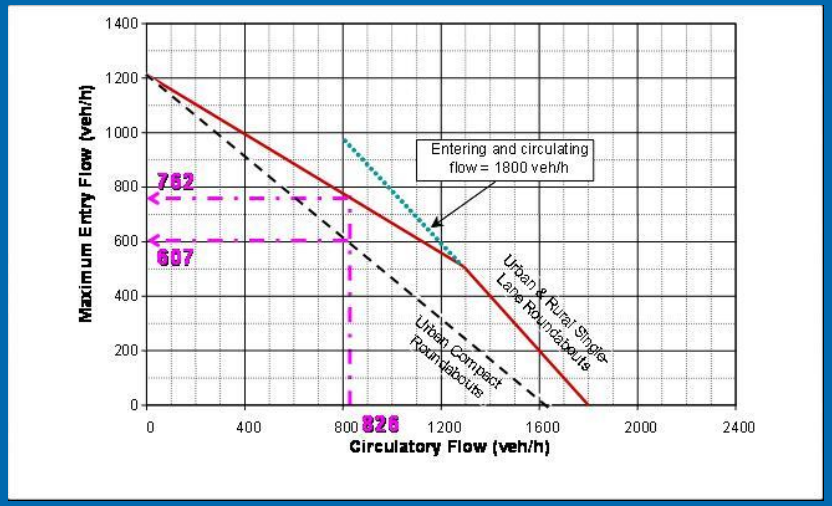
FHWA Method

- Consideration of vehicle types (cars, trucks, motorcycles)
- Empirical regression model
- Delay and LOS

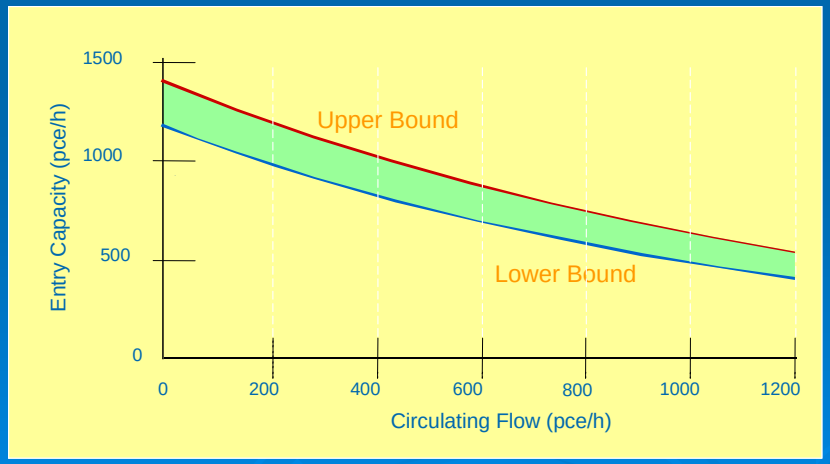


http://www.tfhrc.gov/safety/00068.pdf

FHWA Method vs. HCM



FHWA

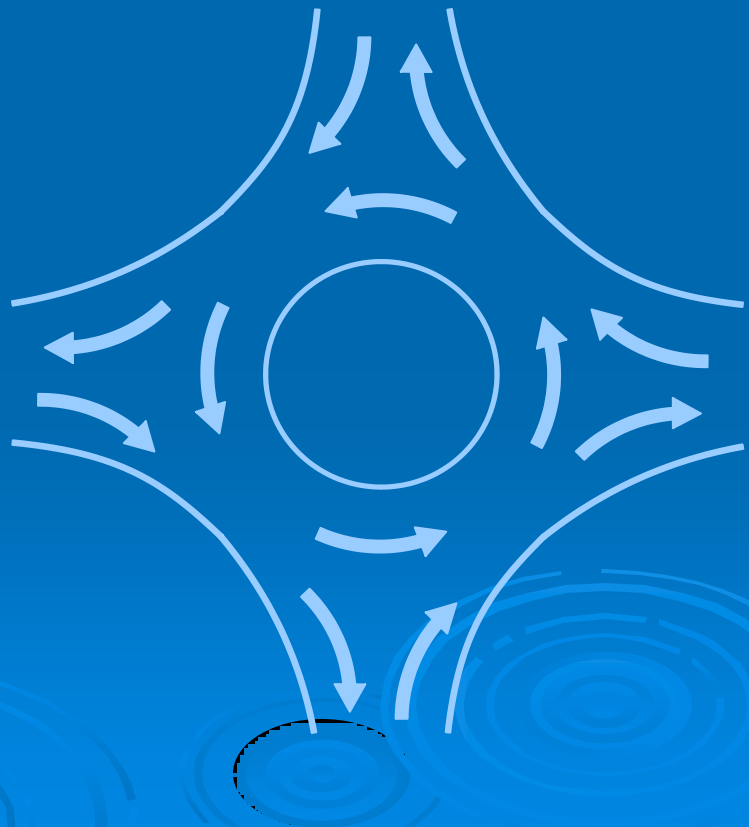


HCM

Steps to Calculate Roundabout Volumes

Turning movements → **Roundabout volumes**





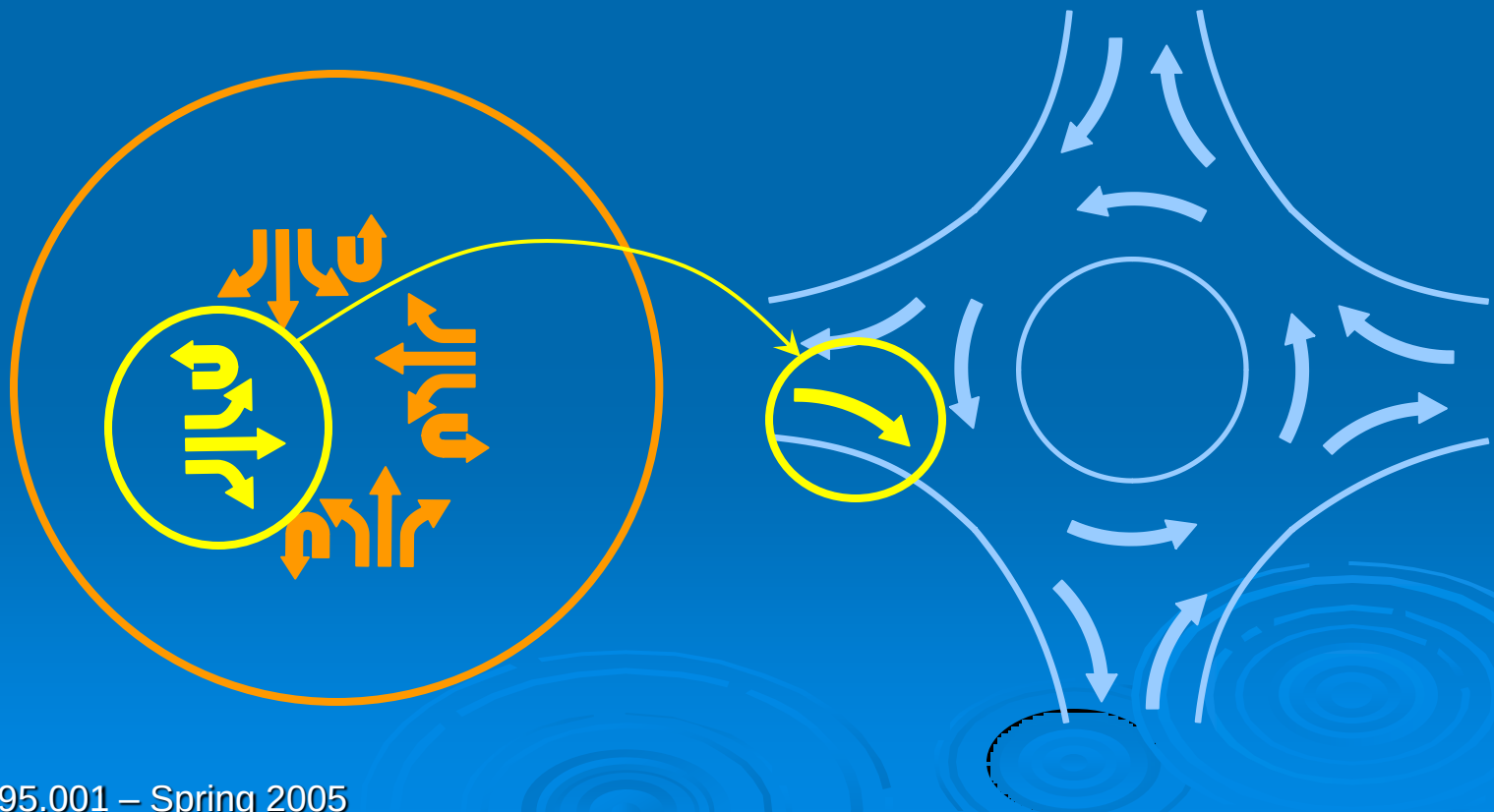
Steps

- Step 1: Convert trucks and other vehicle types to passenger car equivalents (pce)
- Step 2: PHF volume adjustment
- Step 3: Entry volume
- Step 4: Exit volume
- Step 5: Circulating volume

Vehicle Type	Passenger Car Equivalent (pce)
Car	1.0
Single-unit truck or bus	1.5
Truck with trailer	2.0
Bicycle or motorcycle	0.5

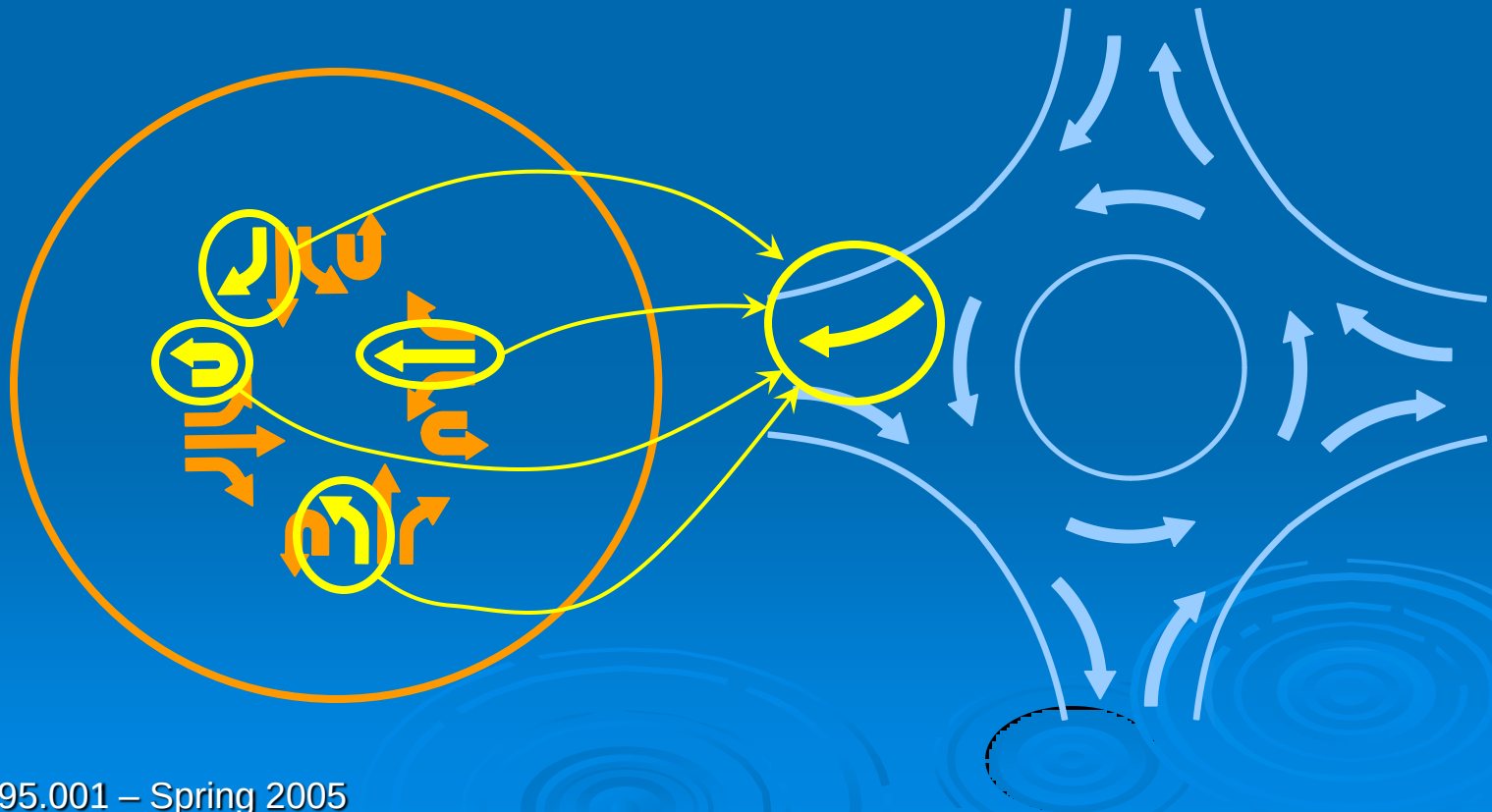
Entry Volume

- Entry volume = sum of entering turning movements



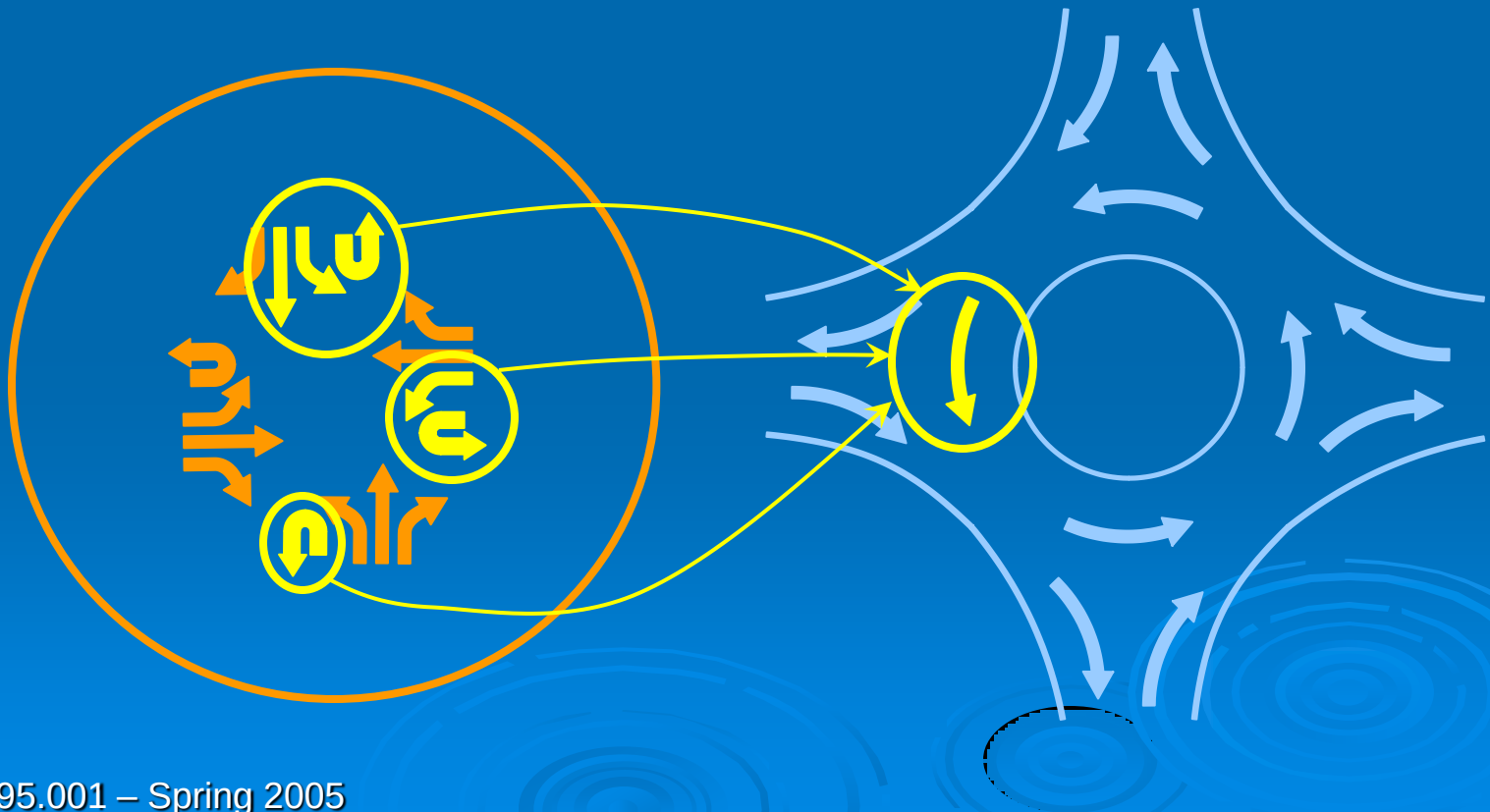
Exit Volume

- Exit volume = sum of turning movements as shown



Circulating Volume

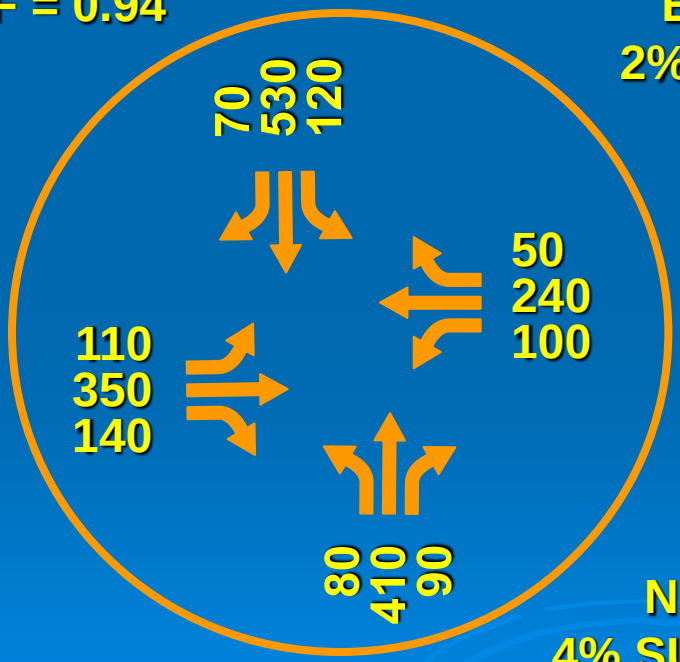
- Circulating volume = sum of turning movements as shown



Example: Volume Conversion

Turning movements → **Roundabout volumes**

PHF = 0.94



East/west:
2% SU trucks/ buses



North/south:
4% SU trucks/buses,
2% combo trucks

Example Step 1: PCE Calculation

- SB TH: 530 veh (4% SU/bus, 2% combo)

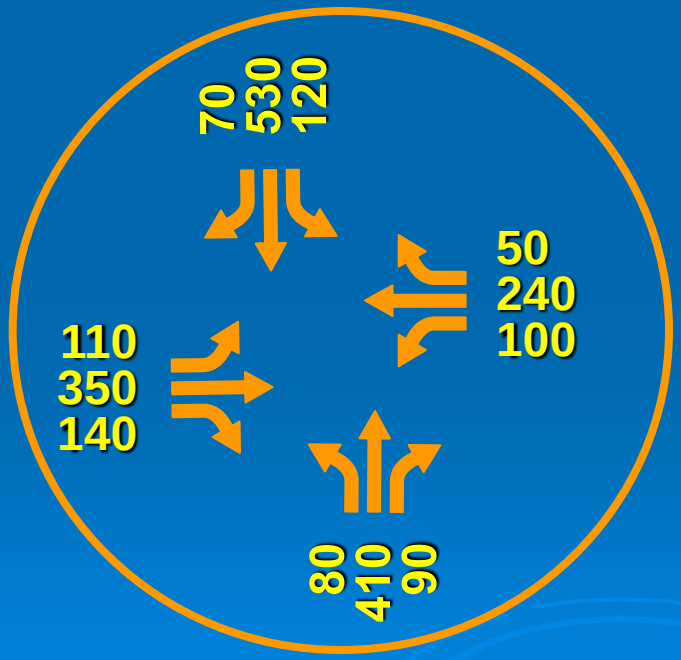
% cars (0.94) × 1.0 pce/veh	=	0.94
% SU/bus (0.04) × 1.5 pce/veh	=	0.06
% combo (0.02) × 2.0 pce/veh	=	0.04

f_{hv}	=	1.04
		× 530 veh
		551 pce

Vehicle Type	Passenger Car Equivalent (pce)
Car	1.0
Single-unit truck or bus	1.5
Truck with trailer	2.0
Bicycle or motorcycle	0.5

Example Step 1: Completed PCE Calculation

Raw Counts → **PCEs**

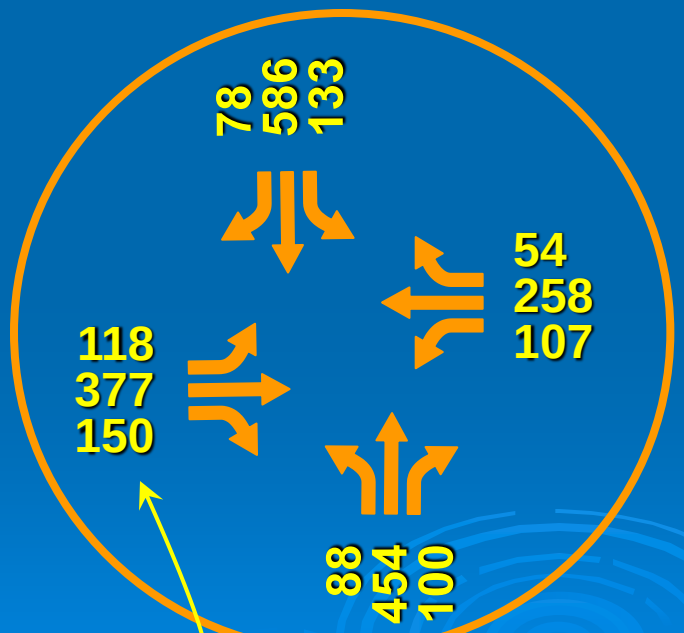




Example Step 2: PHF Factor

PCEs (hourly) → **PCEs (peak 15 minutes)**



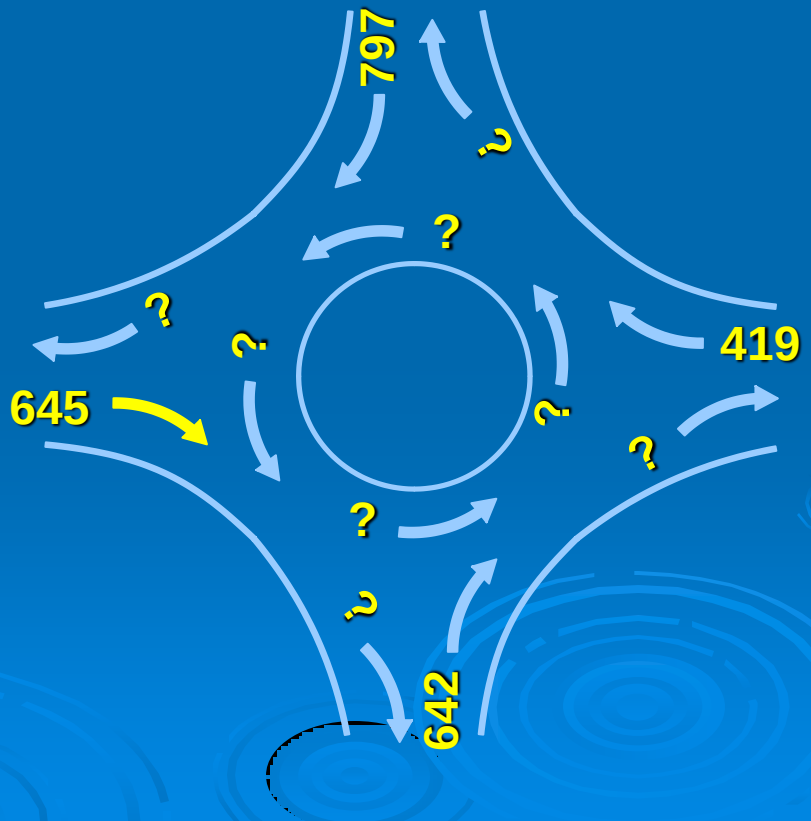


141 / 0.94 = 150

Example Step 3: Calculate Entry Volume

- Entry volume = sum of entering turning movements

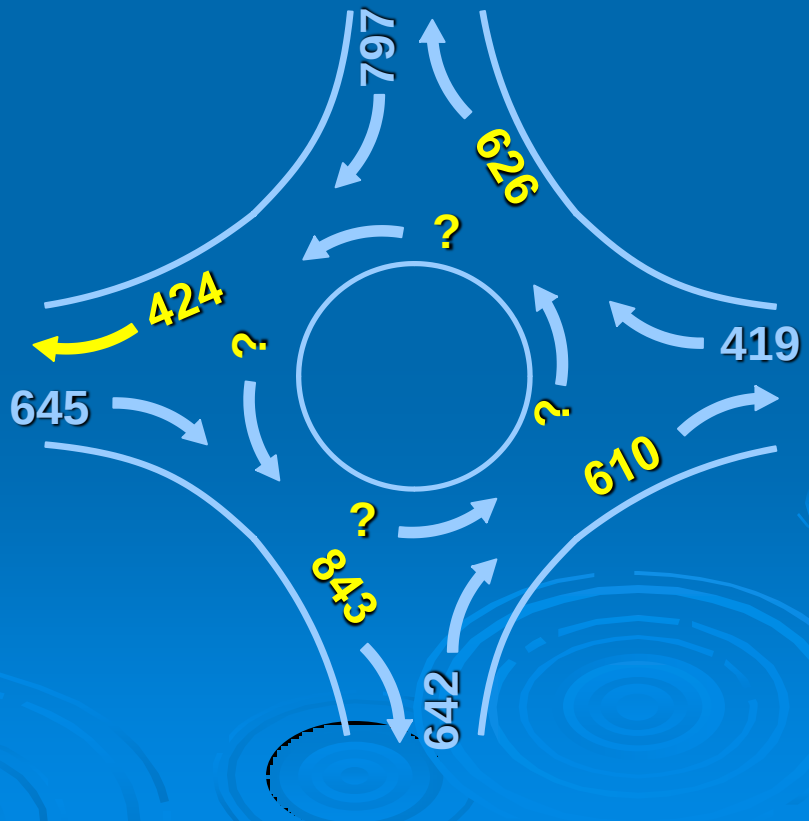




Example Step 4: Calculate Exit Volume

- Exit volume = sum of turning movements as shown

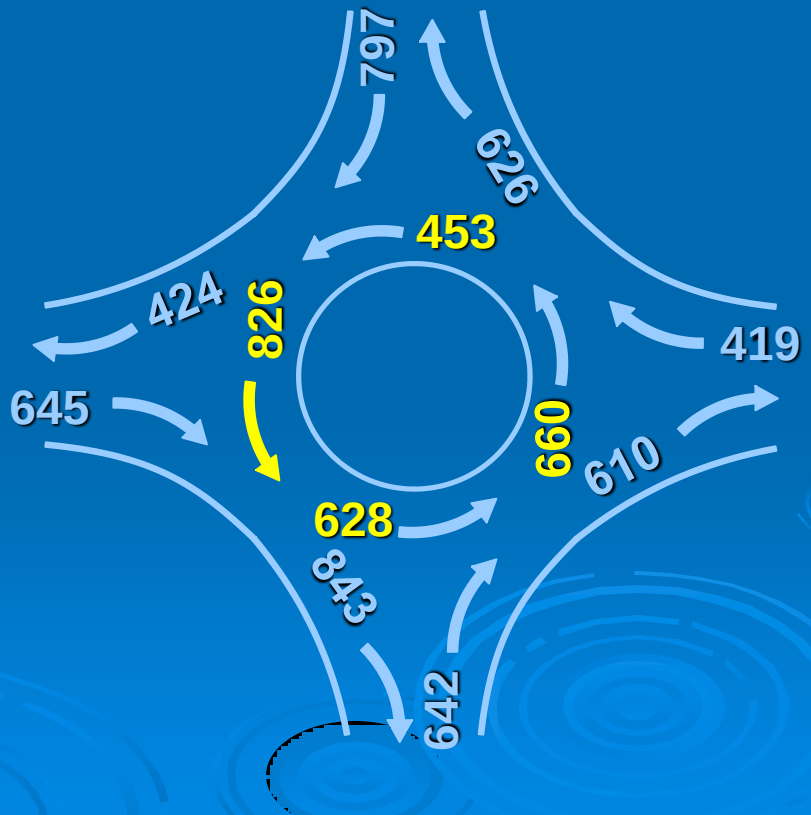




Example Step 5: Calculate Circulating Volume

- Circulating volume = sum of turning movements as shown

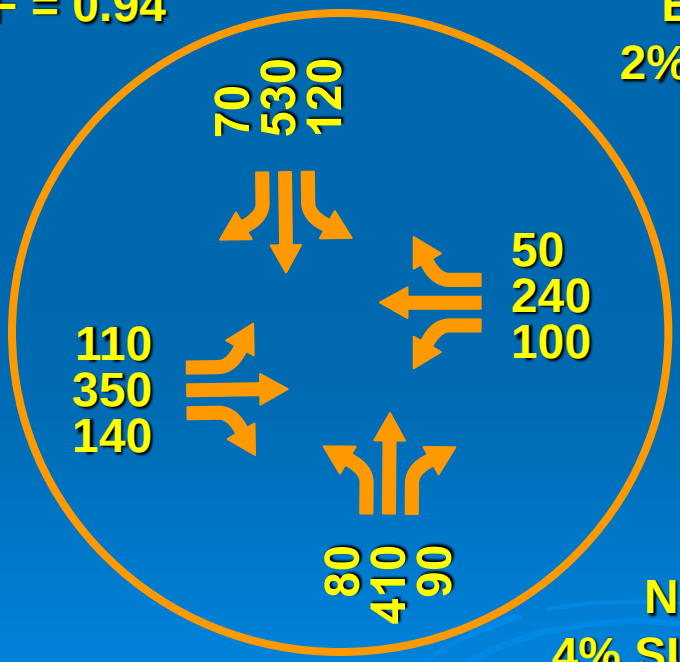




Example: Solution

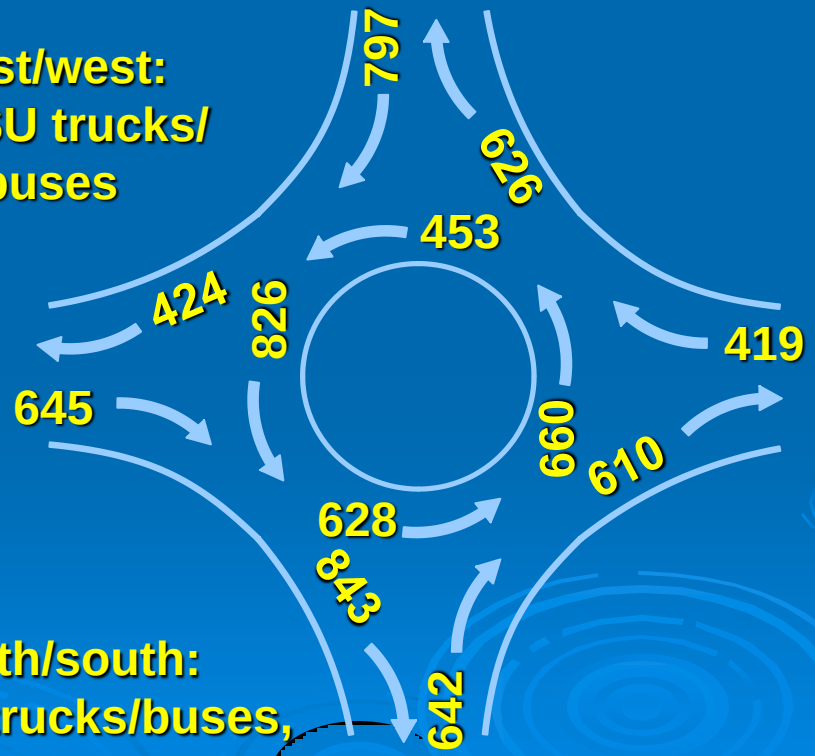
Turning movements → **Roundabout volumes**

PHF = 0.94



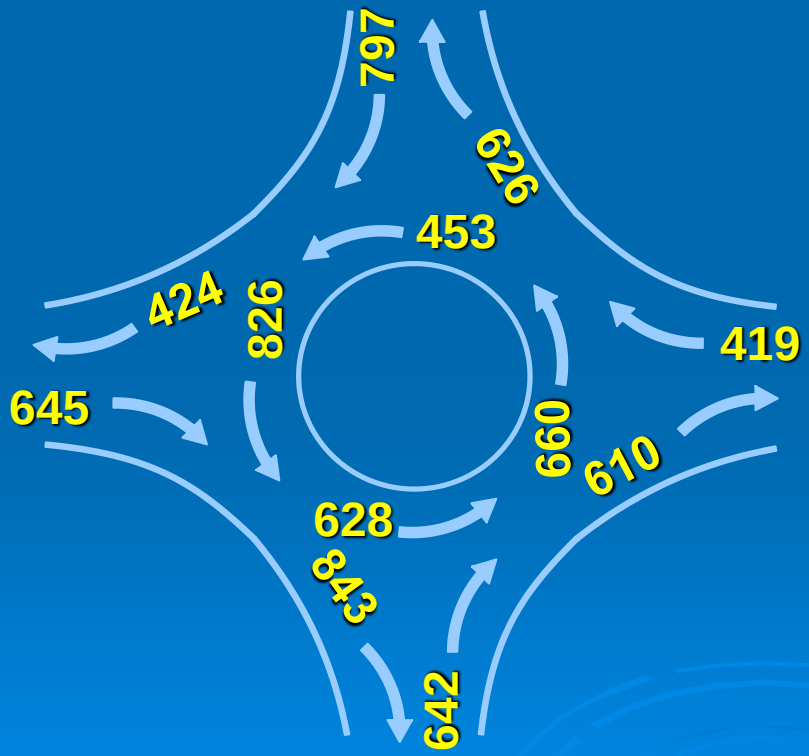
East/west:
2% SU trucks/ buses

North/south:
4% SU trucks/buses,
2% combo trucks



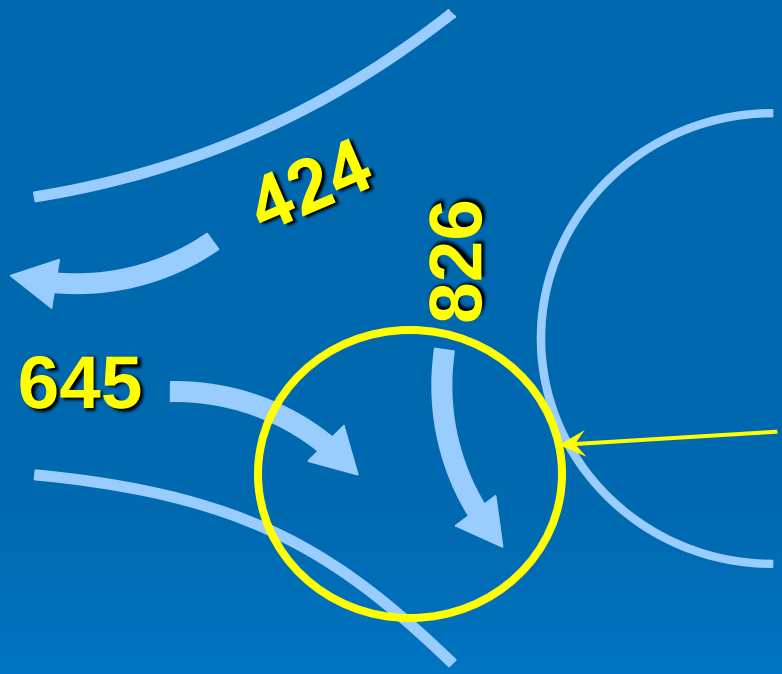
Example: Capacity Calculation

Roundabout volumes → **Roundabout category?**



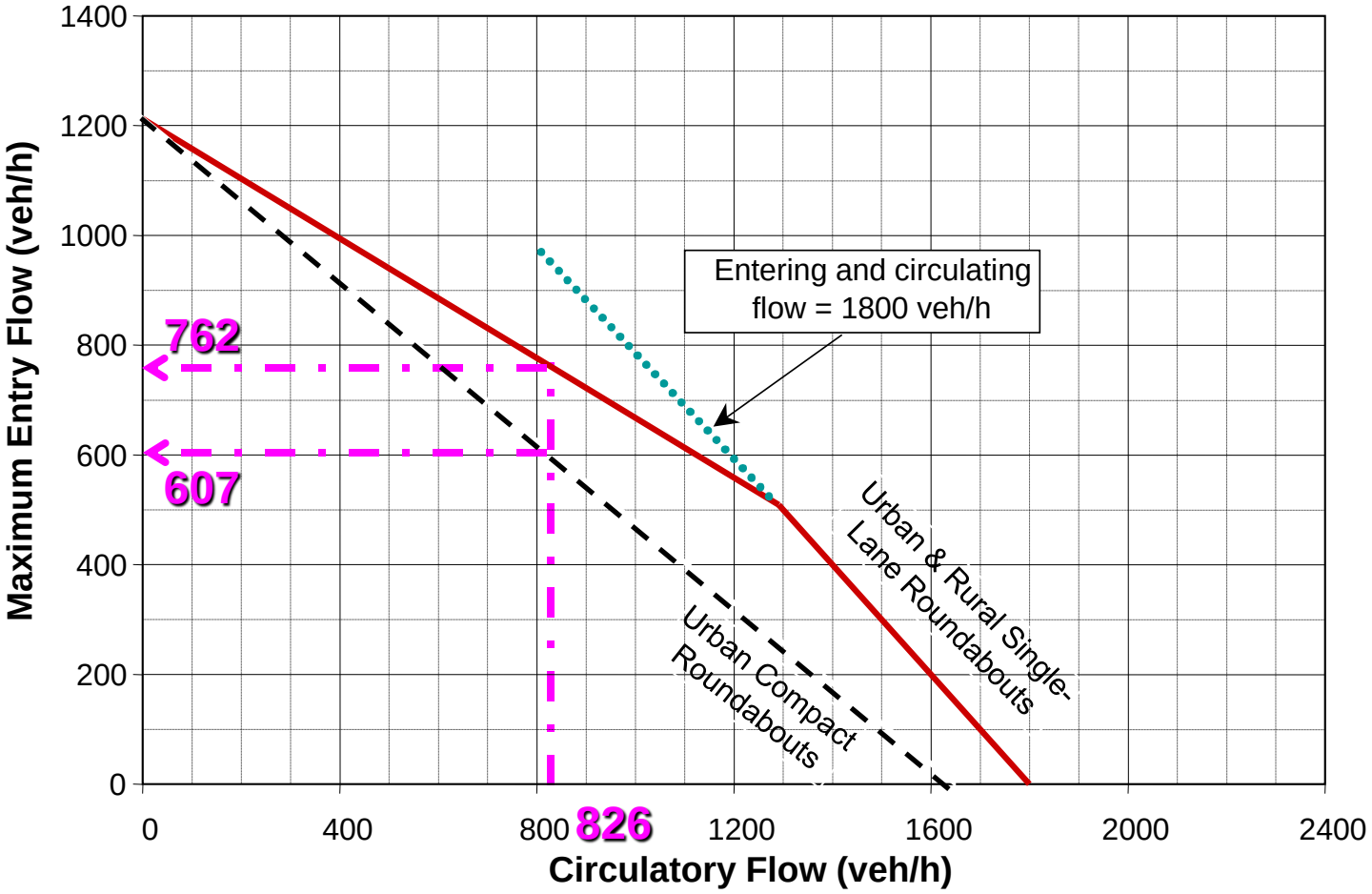


Example: Capacity Calculation



Check capacity of each entry

Example: Capacity check



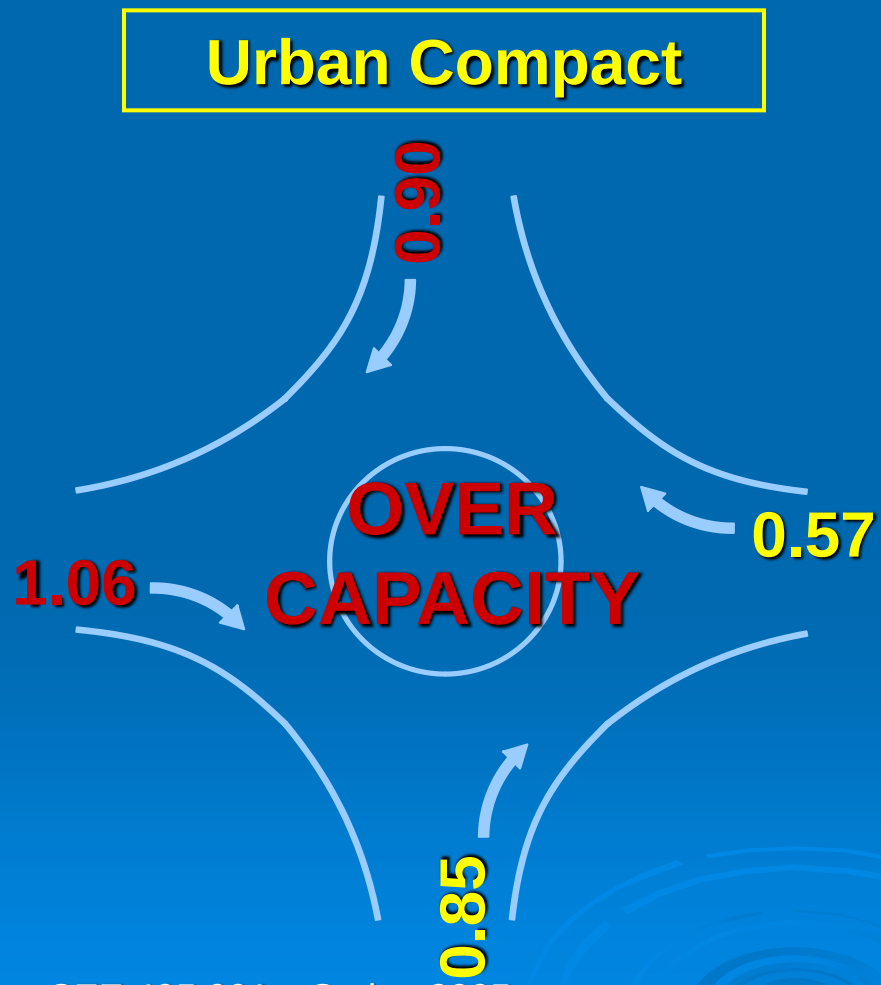
Example: Capacity Check

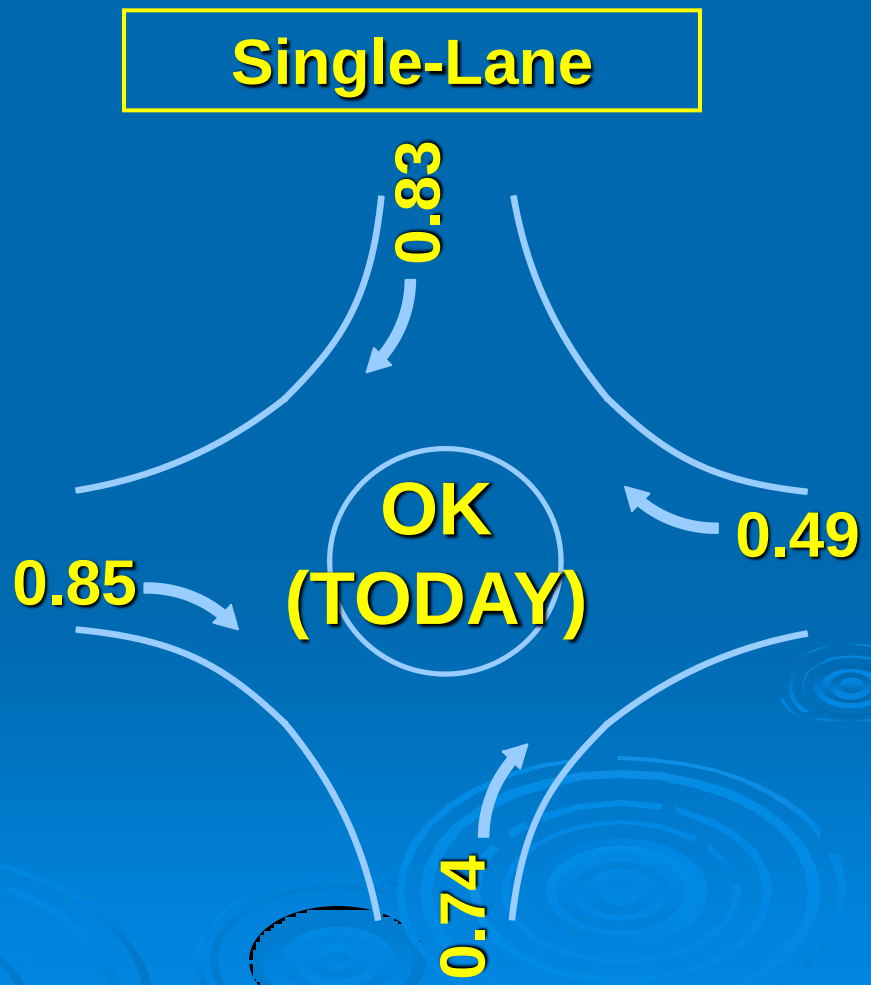
- Entering volume = 645 pce/h
- Capacity of entry:
  - Single-lane: 762 pce/h
  - Urban compact: 607 pce/h
- Volume-to-capacity ratio:
  - Single-lane: 645 / 762 = 0.85 AT
  - Urban compact: 645 / 607 = 1.06 OVER
- What to do when v/c >1.0?
- Repeat calculation for other approaches

What to do when v/c >1.0?



Solution: Capacity Calculation





Delay

- Control delay
  - Includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay
- Geometric delay
  - Delay experienced by a single vehicle with no conflicting flows
  - Caused by geometric features
- Total delay = Control + Geometric
- Typical measure used: control delay