PROFESSIONAL TRAFFIC OPERATIONS ENGINEER CERTIFICATION PROGRAM REFRESHER COURSE

Module 1: Traffic Engineering Studies

1

Housekeeping

- Be prepared to respond to polls.
- All participant phone lines are muted to avoid distractions during presentations.
- Questions can be asked via the Question Pod. Only the instructor and moderator will see the questions submitted.
- Questions & Answer session at the end of the presentation or at specific time during the presentation.
- Citrix /Go-To-Webinar Customer Service: 1-800-263-6317. Select Go-to-Webinar (#2)Technical Support for login assistance or help during the Webinar.

2

Course Credit

Successful completion of this Web seminar includes:

- Verification of attendance
- Completion of course evaluation
- Verification of learning objectives (online quiz)

At the **conclusion** of the last module you will receive an email with directions to the online quiz. An additional fee may apply.

3

Meet Your Instructor

Robert K. Seyfried, PE, PTOE

President

R.K. Seyfried and Associates, Inc.

r-seyfried@northwestern.edu

4

Learning Objectives

At the conclusion of the module, participants should be able to:

1) Understand and apply basic statistical concepts and calculate sample means, and standard deviations
2) Recognize standard terminology related to traffic studies
3) Understand the importance of and be able to apply traffic volume adjustment factors
4) Understand how to design a traffic speed study and interpret traffic speed study data, including calculation of 85th percentile speeds
5) Understand and apply concepts of speed zoning
6) Calculate advisory speeds for horizontal curves and be able to determine appropriate warning signs for curves
7) Understand how to conduct travel time and intersection delay studies
8) Conduct and interpret parking studies

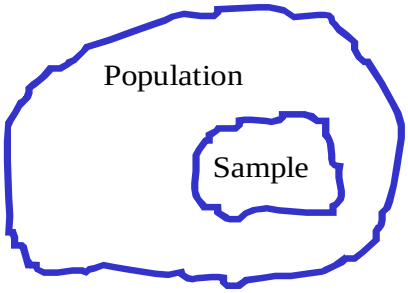
5

Traffic Engineering Studies

- Basic statistical tools
- Volume studies and characteristics
- Spot speed studies
- Travel time and delay studies
- Parking studies
- Pedestrian studies

6

Basic Statistical Tools



7

Common Statistical Tools

- Measures of central tendency
- Measures of dispersion
- Estimating sample sizes

8

Central Tendency

Sample of n observations $x_1, x_2, x_3, \ldots, x_n$

- The sample **mean** is given by:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$$

- **Median -** the middle value
- **Mode** - most frequently occurring value

9

Dispersion

- Standard deviation, s

$$s = \sqrt{\frac{\sum_{i=1}^{n} x_i^2 - n\bar{x}^2}{n-1}}$$

- Variance, s^2
- Standard error, $s_{\bar{x}}$

$$s_{\bar{x}} = s/\sqrt{n}$$

10

Sample Sizes

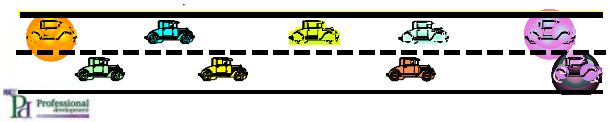
- When s can be estimated, use standard error equation

$$s_{\bar{x}} = s/\sqrt{n} \rightarrow n = s^2/s_{\bar{x}}^2$$

11

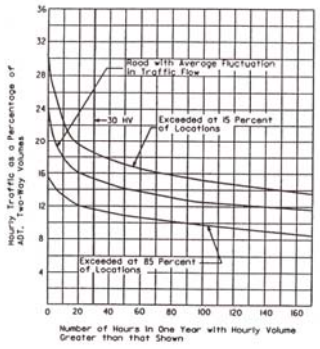
Traffic Volume Studies

- Terminology
  - Annual average daily traffic (AADT)
  - Average daily traffic (ADT)
  - Average weekday traffic (AWT)
  - Design hourly volume (DHV)



12

30th Highest Hour



13

Typical Counting Periods

- 24-hour: 1 or more 24-hour periods
- 16-hour: 6 am – 10 pm (90-95% of daily traffic)
- 12-hour: 7 am – 7 pm (about 75% of daily traffic)
- Peak-periods: 7 am – 9 am and 4 pm – 6 pm
- Weekend: 6 pm Friday – 6 am Monday

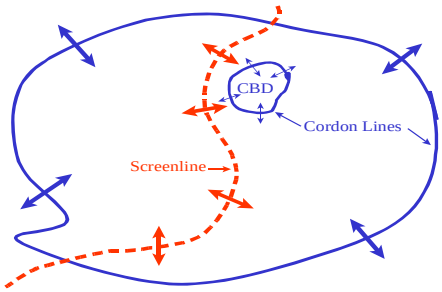
14

Types Of Volume Studies

- Area-wide counting programs
  - ✓Generate continuing estimates of traffic volumes on extensive highway systems
  - ✓Sampling procedure used to update volumes
    - ➢Permanent count stations: count continuously
    - ➢Control count stations: count one week per month or one week per year
    - ➢Coverage count stations: count one day per year or one day each 2 to 4 years

15

Cordon and Screenline Counts



16

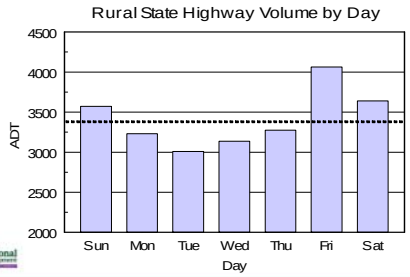
Types Of Volume Studies

- Street counts; directional counts
- Turning movement counts
- Classification counts
- Occupancy counts
- Pedestrian counts

17

Volume Adjustment Factors

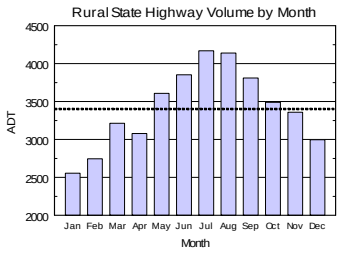
$$f_{Tues} = \frac{ADT}{Tuesday\ Volume} = \frac{3419}{3011} = 1.14$$



18

Volume Adjustment Factors

$$f_{April} = \frac{AADT}{April\ ADT} = \frac{3419}{3078} = 1.11$$



19

Spot Speed Studies

- Typical purposes of speed studies
  - Speed trends over time
  - Traffic control planning
  - *Before-and-after* studies
  - Crash analyses
  - Geometric design
  - Research studies

20

Study Locations

- Consistent with study purpose
- Not where vehicles are accelerating or decelerating
- Data collectors must not influence vehicle speeds
- Factors that influence speeds
  - Physical conditions
  - Environment
  - Heavy traffic
  - Enforcement activity

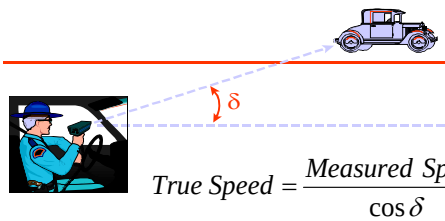
21

Selecting the Sample

- Random but representative
- At least 100 vehicles per lane
- Free-flowing vehicles only
- Common sampling errors
  - Always selecting platoon leader
  - Too many trucks
  - High proportion of *speeders*
  - Other events

22

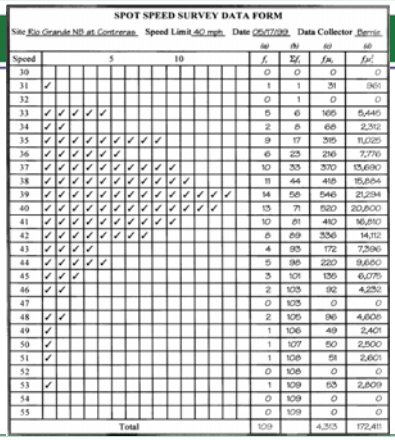
Cosine Correction



$$True\ Speed = \frac{Measured\ Speed}{\cos\delta}$$

Minimize cosine error by keeping angle <7° on freeways, <9° on urban streets

23



SPOT SPEED SURVEY DATA FORM

Site Rio Grande NB at Contreras Speed Limit 40 mph Date 05/17/00 Data Collector Bernie

Speed	5	10	(a) f	(b) Σf	(c) fm	(d) fm²
30			0	0	0	0
31	✓		1	1	31	961
32			0	1	0	0
33	✓✓✓✓✓		5	6	165	5,445
34	✓✓		2	8	68	2,312
35	✓✓✓✓✓✓✓✓✓		9	17	315	11,025
36	✓✓✓✓✓✓		6	23	216	7,776
37	✓✓✓✓✓✓✓✓✓✓		10	33	370	13,690
38	✓✓✓✓✓✓✓✓✓✓✓		11	44	418	15,884
39	✓✓✓✓✓✓✓✓✓✓✓✓✓✓		14	58	546	21,294
40	✓✓✓✓✓✓✓✓✓✓✓✓✓		13	71	520	20,800
41	✓✓✓✓✓✓✓✓✓✓		10	81	410	16,810
42	✓✓✓✓✓✓✓✓		8	89	336	14,112
43	✓✓✓✓		4	93	172	7,396
44	✓✓✓✓✓		5	98	220	9,680
45	✓✓✓		3	101	135	6,075
46	✓✓		2	103	92	4,232
47			0	103	0	0
48	✓✓		2	105	96	4,608
49	✓		1	106	49	2,401
50	✓		1	107	50	2,500
51	✓		1	108	51	2,601
52			0	108	0	0
53	✓		1	109	53	2,809
54			0	109	0	0
55			0	109	0	0
Total			109		4,313	172,481

24

Typical Speed Parameters

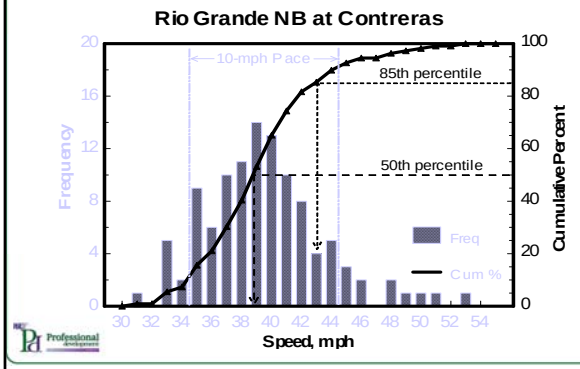
- Calculations
  - Mean and median
  - Standard deviation
  - Standard error
- Graphical
  - 85th percentile
  - 10-mph pace

$$\bar{u}_i = \frac{\sum_i f_i u_i}{n}$$

$$s = \sqrt{\frac{\sum f_i u_i^2 - n\bar{u}^2}{n-1}}$$

$$s_{\bar{u}} = \frac{s}{\sqrt{n}}$$

25



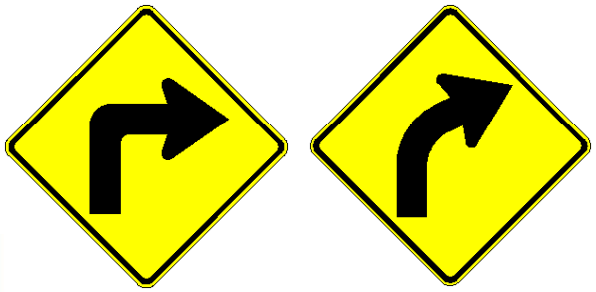
26

Establishing Speed Limits

- Should be based on the prevailing speed of traffic on the roadway
  - ➢85th percentile speed
  - ➢Upper limit of 10-mph pace
- Assumes that most drivers are able to select a safe and reasonable speed under the circumstances

27

Advisory Speeds forTurns and Curves



28

Curve Advisory Speed Can Be Calculated:

$$V = \sqrt{15R(0.01e + f)} \qquad (U.S.\,units)$$

$$V = \sqrt{127R(0.01e + f)} \qquad (metric\,units)$$

V = Design speed (mph or km/h)

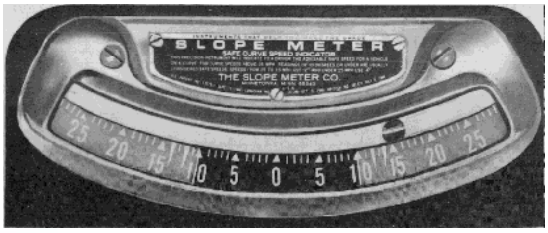
R = Curve radius (ft or m)

e = Superelevation (percent)

f = Side friction factor (f=0.27 at 20 mph to 0.08 at 80 mph)

29

Curve Advisory Speed Can Be Determined in the Field Using a Ball Bank Indicator



30

EXAMPLE OF BALL BANK INDICATOR TEST

CURVE ADVISORY SPEED FIELD FORM

Location:_____ Direction: _____

Date: _____ Weather: _____ Recorder: _____

Posted Speed Limit: 40 mph

Recommended Maximum Readings at Indicated Speeds		Field Readings			
		Curve 1	Curve 2	Curve 3	Curve 4
16°	10 mph				
	15 mph				
	20 mph	**8**	**2**		
14°	25 mph	**12**	**6**		
	30 mph	**15**	**8**		
12°	35 mph	**17**	**10**		
	40 mph	**19**	**12**		
	45 mph		**14**		

31

Travel Time and Delay Studies

- Typical purposes of these studies
  - Congestion evaluation
  - Traffic signal timing evaluation
  - *Before-and-After* studies
  - Traffic assignment
  - Economic studies
  - Trends over time

32

Terminology

- Travel time (*tt*, sec) and travel speed (*ts*, mph)
- Running time (*rt*) and running speed (*rs*)
- Delay
  - Stopped
  - Control
  - Total
- Measure travel times using test cars or license plate matching

33

Time Mean Speed vs. Space Mean Speed

For each run (i), determine tt_i (seconds) for each section and for the entire route

$$ts_i = \frac{3600 * L}{tt_i}$$

$$\overline{ts} = \frac{3600 * n * L}{\sum_i tt_i} \neq \frac{\sum_i ts_i}{n}$$

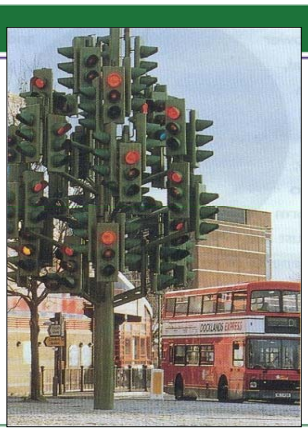
34

Intersection Delay

- Intersections - primary source of arterial delay
- Parameters of interest
  - How many vehicles are stopped
  - How long are they stopped
  - And ultimately, control delay (veh-h)
- Typical data collection
  - Count queued vehicles at ??-s intervals
  - Adjust measured values

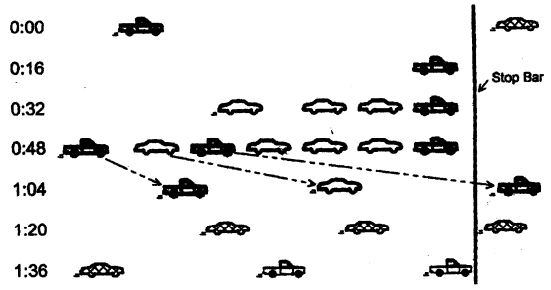
35

Motorists' perception of most intersections



36

Control Delay



37

Intersection Delay Study

Intersection Delay Data										Stopped Vehicles	
Vehicle in queue counts										# Stop	Not Stop
0	1	3	6	1	0	0	2	6	6	69	29
2	0	0	1	2	7	5	0	0	0		
2	6	2	0	0	1	3	4	0	0		
0	2	7	8	3	0	0	2	5	9		
5	0	1	1	6	9	6	0	0	3		
5	7	3	0	0	2	4	5	2	0		

1 Total vehicles in the queue = 155	2 Sampling interval = 16 sec
3 Total volume = 69 + 29 = 98	4 Fraction stopping = 69/98 = 0.70
5 Acceleration/deceleration correction factor = +5 sec	
6 Average time in queue = 0.9×{2}×{1}/{3} = 22.8 sec/veh	
7 Average control delay = {6} + {4}×{5} = 26.3 sec/veh	

38

Parking Studies

Merchants or residents complain that parking demand exceeds parking supply

- Undertake space inventory
  - Assign numbers or addresses
  - Include *illegal* spaces
- Design usage study
  - Determine circulation interval
  - Disaggregate by *block face*

39

Sample License Plate Survey Form

Street College Avenue Side South Study Date 05/25/99
From US Route 1 To Yale Avenue Dir. of Travel EB Data Collector Bernie

Space No.	Space Desc.	Time at the beginning of the patrol									
		9:00	9:15	9:30	9:45	10:00	10:15	10:30	10:45	11:00	11:15
109	Meter	338	✓	437E		T325	820	✓	✓		501E
110	Meter	289			746	✓		834	572	✓	
111	Meter		202	✓				191			
12	Meter							004	✓	✓	✓
T3	Meter										836
114	Meter		T499		846		378		532		925

40

Parking Duration

Number of Observations x Interval
Number of Vehicles

$$Duration_{109} = \frac{8 \times 15}{5} = 24.0 \text{ min } ./ \text{ veh.}$$

41

Parking Turnover

Number of Parked Veh.
Number of Parking Spaces

$$Turnover_{109-112} = \frac{12}{4} = 3.0 veh / space$$

42

Pedestrian Studies

- Volumes
  - May include age, sex, physical disabilities, etc.
- Walking Speeds
  - Time vs. measured distance
- Gap Studies
  - Number of gaps in vehicle traffic adequate for pedestrian crossings

43

Minimum Gap Size

G = W/S + (N – 1) x H + R

G = Minimum gap size (sec)
W = Crossing width (ft or m)
S = Walking speed (ft/sec or m/sec)
N = Number of rows in 85th % group
H = Time headway between rows (usually 2.0 sec)
R = Pedestrian startup time (usually 3.0 sec)

44

Sample Study Question

A city traffic engineer has found from past experience that the standard deviation of speeds on its urban arterials is approximately 4.5 mph. If the engineer requires that the standard error of the sample mean be no more than 0.5 mph, how large of a speed sample should be collected?

45

Sample Study Question

The sample size for a spot speed study can be estimated using the equation:

$$n = \frac{s^2}{s_{\bar{x}}^2}$$

If s = 4.5 mph and $s_{\bar{x}}$ = 0.5 mph, the needed sample size is:

$n = (4.5)^2/(0.5)^2 = 81$ vehicles

46

Sample Study Question

Using the given travel time study data, what is the average travel speed for the 2.75-mile route?

Test Run	Travel Time
1	5 min. 40 sec.
2	6 min. 10 sec.
3	7 min. 0 sec.
4	5 min. 0 sec.
5	7 min. 20 sec.
6	5 min. 30 sec.

47

Sample Study Question

The average travel speed is calculated as:

$$\overline{ts} = \frac{3600 \times n \times L}{\sum tt_i}$$

Where n = 6

L = 2.75 mi.

$\sum tt_i$ = 340 + 370 + 420 + 300 + 440 + 330 = 2200 sec.

$$\overline{ts} = \frac{3600 \times 6 \times 2.75}{2200} = 27.00 \; mph$$

48

Questions

49

Thank You

Questions/Comments
Professional Development Department
ITE
1627 I Street, NW, Ste 600
Washington, DC 20006
202-785-0060; pdinfo@ite.org

50