FDOT HCS 2010

Introductions

- Tim White
- Brian Smalkoski
- Class participants
  - What module(s) in the HCS do you use most often?
  - What module(s) in the HCS do you rarely use?

2

FDOT HCS 2010

Housekeeping

- Set phones to vibrate/silent
- Questions—ask lots of them at any time!
- Snacks available in the room
- Break
  - 2:30 – 2:45 pm

3

FDOT HCS 2010

Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control
  - All-Way Stop Control
- Roundabouts

4

FDOT HCS 2010

Day 2 – Interrupted Flow

- Signalized Intersections
- Urban Streets
  - Segments
  - Facilities

5

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges (uninterrupted flow)
- Freeways
  - Basic, weave, merge, and diverge segments
- Multi-lane highway segments
- Two-lane highway segments

6

FDOT HCS 2010

Training Objectives

- To move beyond the basic concepts of traffic flow theory to hands-on capacity analysis, focusing on planning and operations
- To gain proficiency in capacity analysis through a range of exercises—from simple to complex
- To identify constraints of *HCS* through the analysis of over-capacity conditions
- To understand the factors that have the greatest impact on the results
- To identify some key changes between *HCM 2010* and *HCM 2000*

7

FDOT HCS 2010

Format for Each Module

- Introduction to the module
- *HCM 2010* versus *HCM 2000*
- Required Data
- Limitations of the module
- Measures of Effectiveness (MOEs)
- Methodology
- Sample problem(s)
- Workshops

8

FDOT HCS 2010

Highway Capacity Manual 2010

- Published by the Transportation Research Board (TRB) in March 2011
- Previous editions: 1950, 1965, 1985 and 2000
  - Updated in 1994 and 1997
  - Estimate capacity
  - Estimate quality of service

9

FDOT HCS 2010

Types of Analyses

- Operational
  - All or nearly all of the required model inputs
  - More data input provides more accurate, more robust results
- Planning
  - Default values for nearly all of the model inputs
  - Less data input provides less detailed results
- Design
  - Used to establish the detailed physical features

- This course will focus on Operations and Planning

10

FDOT HCS 2010

Highway Capacity Software (HCS 2010)

- Implements *HCM 2010* procedures & methodologies
- Follows *HCS2000*, *HCS+* and *HCS+T7F*
- Features *CORSIM* Quick Animation
- Major overhauls
  - New Roundabouts module
  - Updated Weaving module
  - New Visual Mode in Streets module
  - New Interchanges module

11

FDOT HCS 2010

HCS 2010 Version 6.50 Updates

- Implements *HCM 2010* Chapter 22 procedures ("Interchange Ramp Terminals") within Streets module
- Added Quick Entry feature to Roundabouts module; similar to Quick Phases in Streets
- Implements *HCM* procedures for three-lane approaches in TWSC and AWSC modules
- Quick Streets – allows for importing of turning movement count data through an Excel template

12

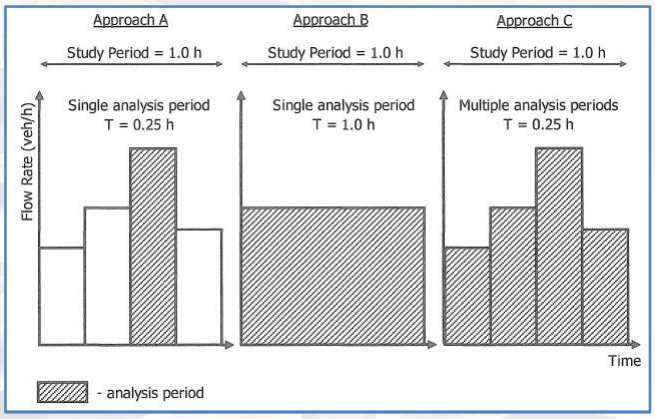
Study Period vs Analysis Period

- Study period
  - Time interval represented by the performance evaluation
  - Consists of one or more consecutive analysis periods
- Analysis period
  - Time interval evaluated by a single application of the methodology
  - Range: 0.25 to 1.0 hours
  - Longer durations sometimes used for planning analyses
  - Avoid analysis periods that exceed 1.0 hr, because traffic conditions are not steady for long time periods
  - If evaluation of multiple analysis periods is important, then results from each period should be reported

13

Study Period vs Analysis Period

- Approach A is the recommended approach, which is based on the evaluation of the peak 15-minute period

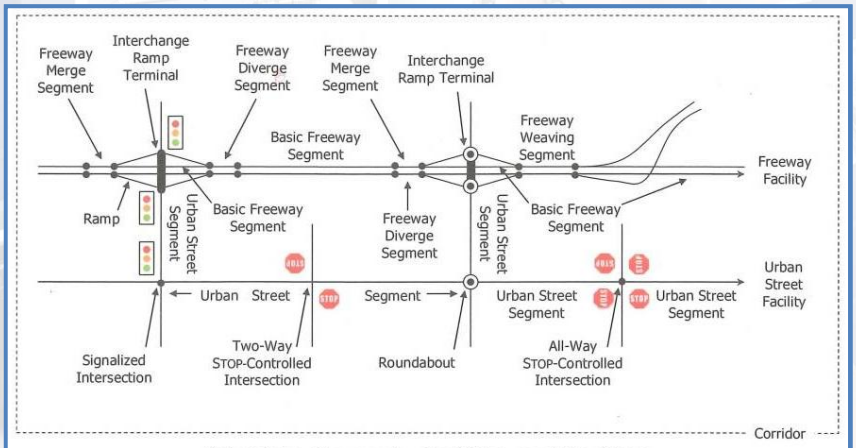


14

FDOT HCS 2010

Types of Roadway System Elements

- *HCM 2010* Exhibit 2-1a (Roadway System Elements)



(a) Points, Segments, Facilities, and Corridors

15

FDOT HCS 2010

Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control ◄
  - All-Way Stop Control
- Roundabouts

16

FDOT HCS 2010

Two-Way Stop Control (TWSC)

- Chapter 19 – *HCM 2010*
- Major Street/Minor Street
- Isolated intersections
- Level of Service criteria
  - Minor-street movements
  - Major-street left turns
- Applicable to automobiles, pedestrians & bicyclists
- New in 2010: gap acceptance parameters for 6-lane streets have been added

17

FDOT HCS 2010

TWSC

- *HCM 2010* Exhibit 19-1 (LOS for Automobiles)

Control Delay (s/vehicle)	LOS by Volume-to-Capacity Ratio $v/c \leq 1.0$	$v/c > 1.0$
0–10	A	F
>10–15	B	F
>15–25	C	F
>25–35	D	F
>35–50	E	F
>50	F	F

Note: The LOS criteria apply to each lane on a given approach and to each approach on the minor street. LOS is not calculated for major-street approaches or for the intersection as a whole.

- *HCM 2010* Exhibit 19-2 (LOS for Pedestrians)

LOS	Control Delay (s/pedestrian)	Comments
A	0–5	Usually no conflicting traffic
B	5–10	Occasionally some delay due to conflicting traffic
C	10–20	Delay noticeable to pedestrians, but not inconveniencing
D	20–30	Delay noticeable and irritating, increased likelihood of risk taking
E	30–45	Delay approaches tolerance level, risk-taking behavior likely
F	>45	Delay exceeds tolerance level, high likelihood of pedestrian risk taking

Note: Control delay may be interpreted as s/pedestrian group if groups of pedestrians were counted as opposed to individual pedestrians.

18

FDOT HCS 2010

TWSC

Required Data

- Lane configurations
- Special factors (channelization, median storage, grades, and upstream signals)
- Peak hour turning movement volumes
- Peak hour factors
- Percentage of heavy vehicles

19

FDOT HCS 2010

TWSC

Limitations

- Maximum of three through lanes on major-street approaches
- Maximum of one lane per right or left turn movement
- Accounting for the effects of adjacent intersections
- Yield-controlled delay
- Pedestrian LOS not applicable for undivided roads with more than 4 lanes
- No LOS standards for Bicycle Mode

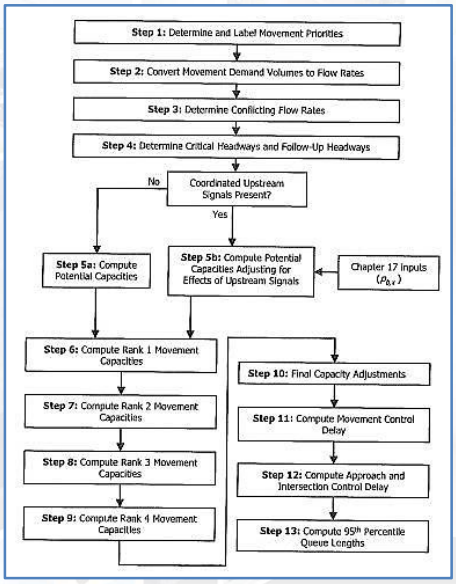
20

FDOT HCS 2010

TWSC

Methodology

- *HCM 2010*
  Exhibit 19-4



21

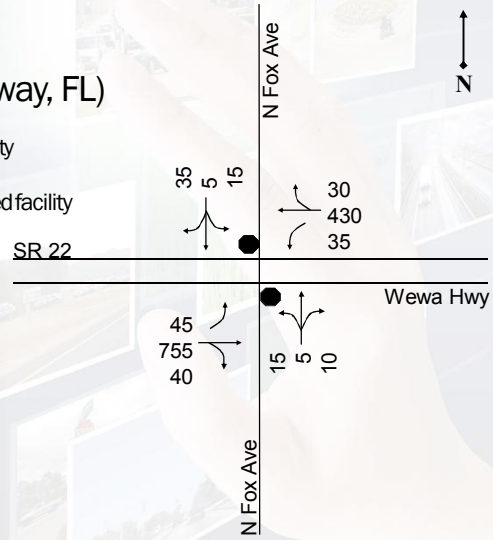
FDOT HCS 2010

TWSC

Example #1:

SR 22 at Fox Avenue (Callaway, FL)

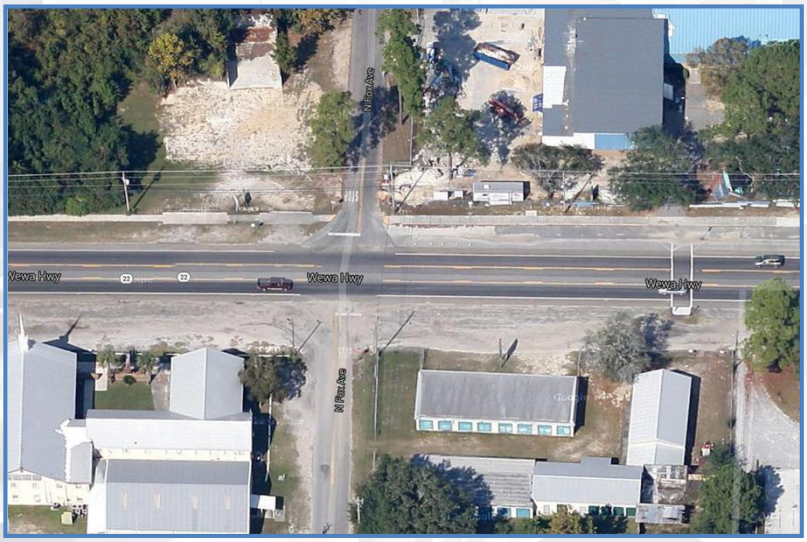
- Major street (SR 22): 2-lane divided facility
  - Two way left turn lane median
- Minor street (N. Fox Ave): 2-lane undivided facility
  - Flared right turn
  - Storage for one vehicle on each approach
- PHF – 0.92 for all movements
- 6% heavy vehicles on all movements
- Level terrain on N. Fox Ave
- 10 peds/hr crossing NB/SB approaches



22

FDOT HCS 2010

TWSC



23

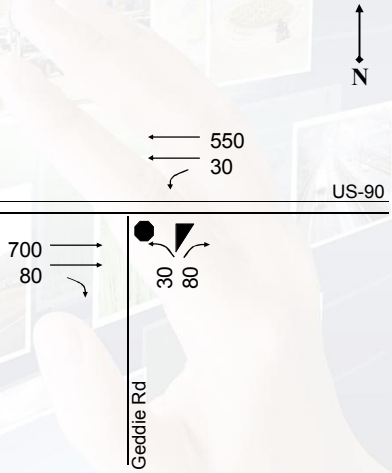
FDOT HCS 2010

TWSC

Workshop #1:

US-90 at Geddie Road (Tallahassee, FL)

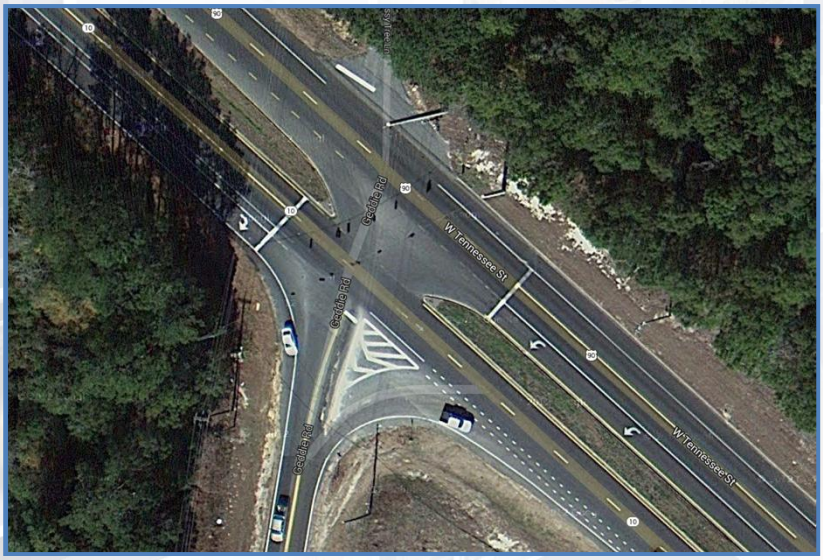
- Major Street (US-90): 4-lane divided facility
  - Raised curb median
  - Storage in median for 1 vehicle
- Minor Street (Geddie Rd): 2-lane undivided facility
  - Channelized right turn
- PHF – 0.90 for all movements
- 9% heavy vehicles on all approaches
- Level terrain on Geddie Rd
- No pedestrian activity



24

FDOT HCS 2010

TWSC



25

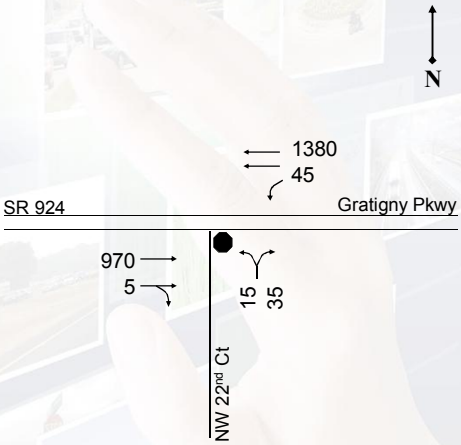
FDOT HCS 2010

TWSC

Workshop #2:

SR 924 at 22nd Court (Miami, FL)

- Major street (SR 924): 4-lane divided facility
  - Raised curb median
  - Storage in median for 1 vehicle
- Minor street (NW 22nd Ct): 2-lane undivided facility
- 0.89 – PHF for all approaches
- 3% heavy vehicles on all movements
- Level terrain on NW 22nd Ct
- No pedestrian activity
- Upstream traffic signal (420' to the west)
  - 35 MPH progression speed
  - 120 second cycle length
  - Progressed volume – 850 vehicles /hr
  - Arrival type 5
  - Effective green – 45 seconds



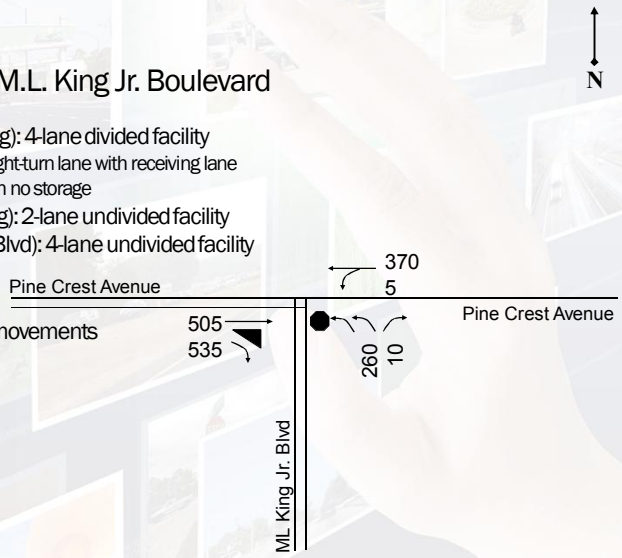
26

TWSC

Workshop #3:

Pine Crest Avenue at M.L. King Jr. Boulevard

- Pine Crest Ave (western leg): 4-lane divided facility
  - Free-flow channelized right-turn lane with receiving lane
  - Raised curb median with no storage
- Pine Crest Ave (eastern leg): 2-lane undivided facility
- Minor Street (ML King Jr. Blvd): 4-lane undivided facility
- PHF – 0.90 for all approaches
- 2% heavy vehicles on all movements
- No grades
- No pedestrian activity



27

Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control
  - All-Way Stop Control ◀
- Roundabouts

28

FDOT HCS 2010

All-Way Stop Control (AWSC)

- Chapter 20 – *HCM 2010*
- Every vehicle required to stop
- Isolated intersections
- New in 2010: a queue estimation model has been added

29

FDOT HCS 2010

AWSC

- *HCM 2010* Exhibit 20-2 (LOS for Automobiles)

Control Delay (s/veh)	LOS by Volume-to-Capacity Ratio*	
	$v/c \leq 1.0$	$v/c > 1.0$
0–10	A	F
>10–15	B	F
>15–25	C	F
>25–35	D	F
>35–50	E	F
>50	F	F

Note: * For approaches and intersectionwide assessment, LOS is defined solely by control delay.

30

FDOT HCS 2010

AWSC

Required Data

- Lane configurations
- Percentage of heavy vehicles
- Peak hour turning movement volumes
- Peak hour factor

31

FDOT HCS 2010

AWSC

Limitations

- One free and two stop-controlled movements
  - Example: Mall entrances
- Maximum of three lanes on each approach
- Accounting for the effects of other intersections
- Intersections with more than 4 approaches
- No LOS standards for pedestrian and bicycle modes

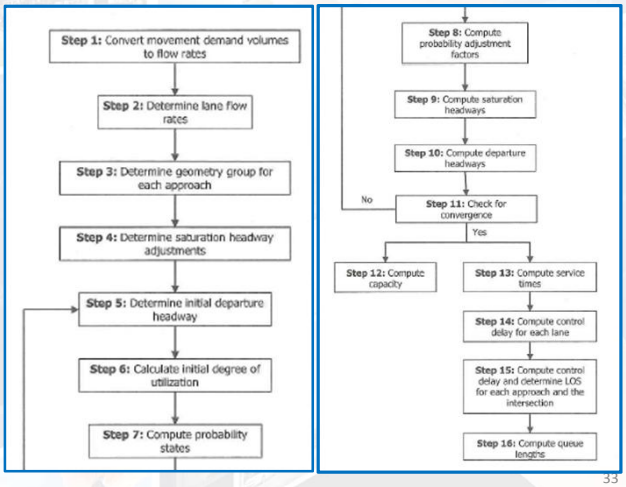
32

FDOT HCS 2010

AWSC

Methodology

- *HCM 2010* Exhibit 20-9



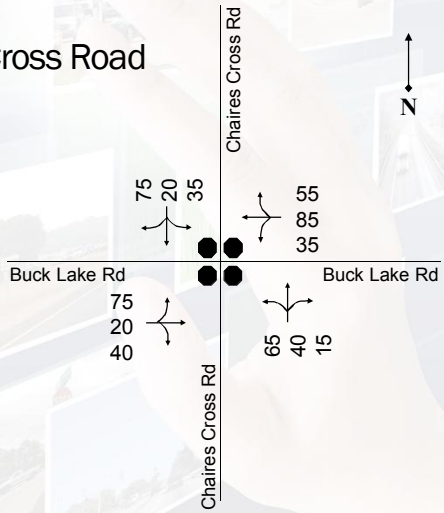
FDOT HCS 2010

AWSC

Example #2:

Buck Lake Road at Chaires Cross Road (Tallahassee, FL)

- Buck Lake Rd: 2-lane undivided facility
- Chaires Cross Rd: 2-lane undivided facility
- PHF – 0.94 for all movements
- 3% heavy vehicles on Chaires Cross Rd
- 5% heavy vehicles on Buck Lake Rd
- No pedestrians



FDOT HCS 2010

AWSC

35

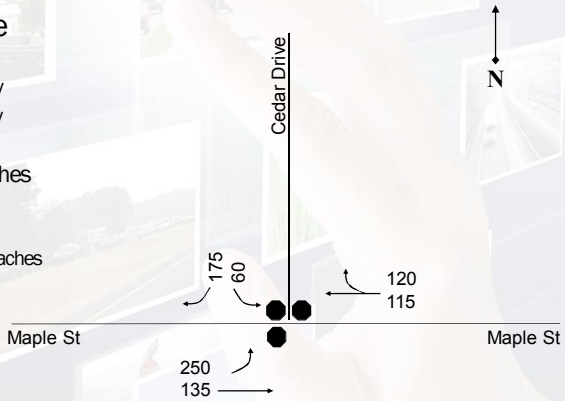
FDOT HCS 2010

AWSC

Workshop #4A:

Maple Street at Cedar Drive

- Maple St: 2-lane undivided facility
- Cedar Dr: 2-lane undivided facility
- PHF – 0.85 for all movements
- 2% heavy vehicles on all approaches
- Level terrain
- Pedestrian activity
  - 25 peds/hr on the EB/SB approaches



36

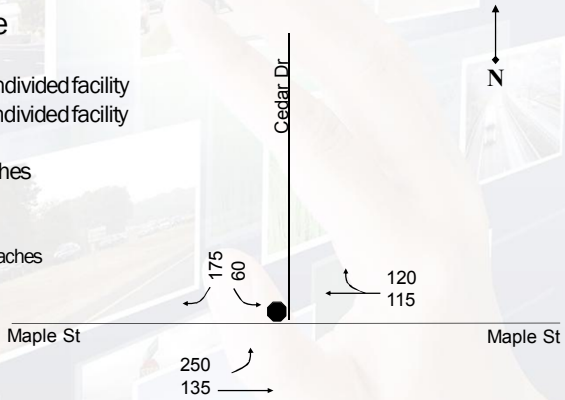
FDOT HCS 2010

TWSC

Workshop #4B:

Maple Street at Cedar Drive

- Major Street (Maple St): 2-lane undivided facility
- Minor Street (Cedar Dr): 2-lane undivided facility
- PHF – 0.85 for all movements
- 2% heavy vehicles on all approaches
- Level terrain on Cedar Dr
- Pedestrian activity
  - 25 peds/hr on the EB/SB approaches
  - Walking speed = 3.5 ft/sec



37

37

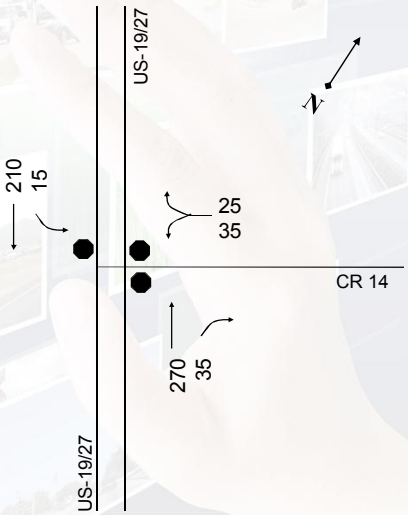
FDOT HCS 2010

AWSC

Workshop #5:

US-19/27 at CR 14 (Greenville, FL)

- Major street (US-19/27): 2-lane divided facility with 50' median
- Minor street (CR 14): 2-lane undivided facility
- PHF – 0.90 for all movements
- 10% heavy vehicles on US-19/27
- 3% heavy vehicles on CR 14



38

FDOT HCS 2010

Day 1 – Interrupted Flow

- Overview
- Unsignalized Intersections
  - Two-Way Stop Control
  - All-Way Stop Control
- Roundabouts ◀

39

FDOT HCS 2010

Roundabouts

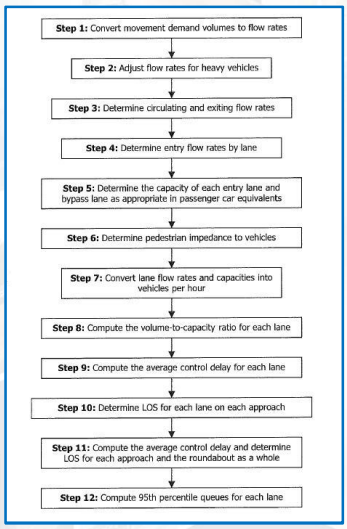
- Chapter 21 – *HCM 2010*
- Single-lane or multi-lane roundabouts
- Automobiles only
  - Pedestrian activity accounted for, but not given LOS
- Level of Service criteria based on *HCM 2010*
  - Control delay
  - Volume/capacity ratio
- New roundabout analysis methodology in *HCM 2010* based on NCHRP 3-65

40

FDOT HCS 2010

Roundabouts

- *HCM 2010* Exhibit 21-9



41

FDOT HCS 2010

Roundabouts

<u>Required Data</u>

- Traffic characteristics
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
    - Includes u-turn volumes
- Geometric configuration
  - Lane configurations
  - Right-turn bypass lanes

42

FDOT HCS 2010

Roundabouts

Limitations

- The effects of upstream intersections
  - Upstream/downstream signalized intersections
  - Nearby roundabouts
- More than two entry lanes on an approach (HCM)
- High level of pedestrian/bicycle activity
- Methodology to determine pedestrian/bicycle LOS

43

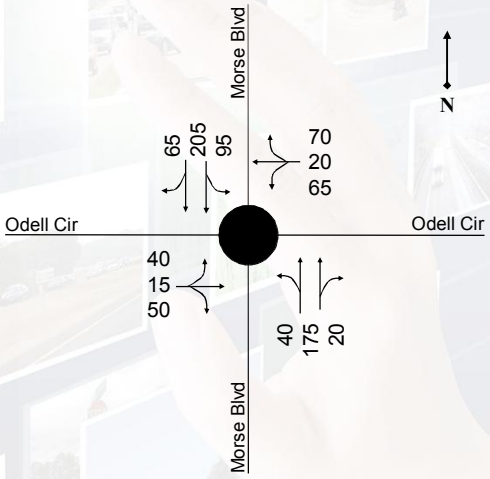
FDOT HCS 2010

Roundabouts

Example #3:

Morse Boulevard at Odell Circle
(The Villages, FL)

- Morse Boulevard
  - 4-lane divided facility
- Odell Circle
  - 2-lane undivided facility
- 2 circulating lanes
- No right-turn bypass lane
- No pedestrians
- PHF – 0.96 for all approaches
- 3% heavy vehicles on all approaches



44

FDOT HCS 2010

Roundabouts

45

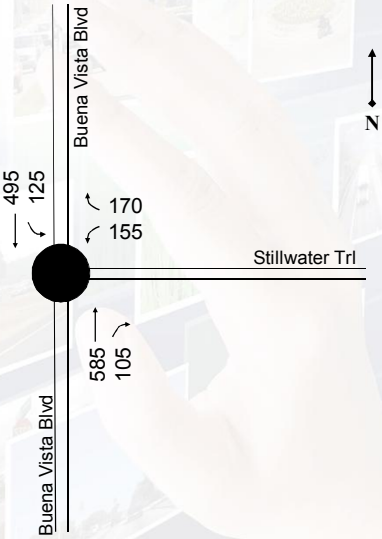
FDOT HCS 2010

Roundabouts

Workshop #6:

Buena Vista Blvd at Stillwater Trail
(The Villages, FL)

- Buena Vista Blvd
  - 4-lane divided facility with 16' median
- Stillwater Trl
  - 4-lane divided facility with 16' median
- 2 circulating lanes
- No right-turn bypass lanes
- No pedestrians
- PHF – 0.92 for all approaches
- 2% heavy vehicles on all movements



46

FDOT HCS 2010

Roundabouts

47

FDOT HCS 2010

Day 2 – Interrupted Flow

- Signalized Intersections ◄
- Urban Streets
  - Segments
  - Facilities

48

FDOT HCS 2010

Housekeeping

- Breaks
  - 10:00 – 10:15 am
  - Lunch 11:30 – 1:00 pm
  - 2:30 – 2:45 pm

49

FDOT HCS 2010

Signalized Intersections

- Chapter 18 – *HCM 2010*
- Three- and four-leg intersections
- Isolated intersections
  - Upstream effects
- Level of Service criteria
  - Volume-to-capacity ratio
  - Automobile delay (intersection and approach)
  - Queue length
  - Storage capacity
  - Pedestrian/bicycle delay
- New in 2010: a revised incremental queue accumulation method, an actuated controller operation modeling procedure, and a left-turn lane overflow check procedure have been added

50

FDOT HCS 2010

Signalized Intersections

- *HCM 2010* Exhibit 18-4 (LOS for Automobiles)

Control Delay (s/veh)	LOS by Volume-to-Capacity Ratio[a] ≤1.0	>1.0
≤10	A	F
>10–20	B	F
>20–35	C	F
>35–55	D	F
>55–80	E	F
>80	F	F

Note: [a] For approach-based and intersectionwide assessments, LOS is defined solely by control delay.

- *HCM 2010* Exhibit 18-5 (LOS for Peds/Bicycles)

LOS	LOS Score
A	≤2.00
B	>2.00–2.75
C	>2.75–3.50
D	>3.50–4.25
E	>4.25–5.00
F	>5.00

51

FDOT HCS 2010

Signalized Intersections

Required Data

- Lane configurations
- Percentage of heavy vehicles
- Peak hour turning movement volumes
- Peak hour factor or 15-minute traffic volumes
- Traffic signal phasing
- Traffic signal timing parameters

52

FDOT HCS 2010

Signalized Intersections

Limitations

- Calibration
- Turn bay overflow
- Demand starvation
- Right turn on red (RTOR) volume
- Effects to/from upstream intersections
- Effects of add/drop lanes near intersection
- Controller functions (overlap, gap reduction)
- Pedestrian/bicycle (grades >2%, railroad crossing)

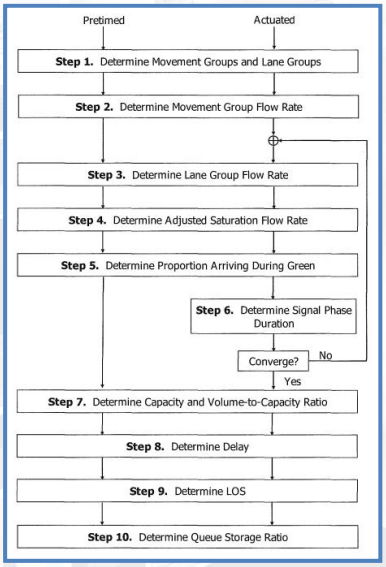
53

FDOT HCS 2010

Signalized Intersections

Methodology

- *HCM 2010*
  Exhibit 18-11



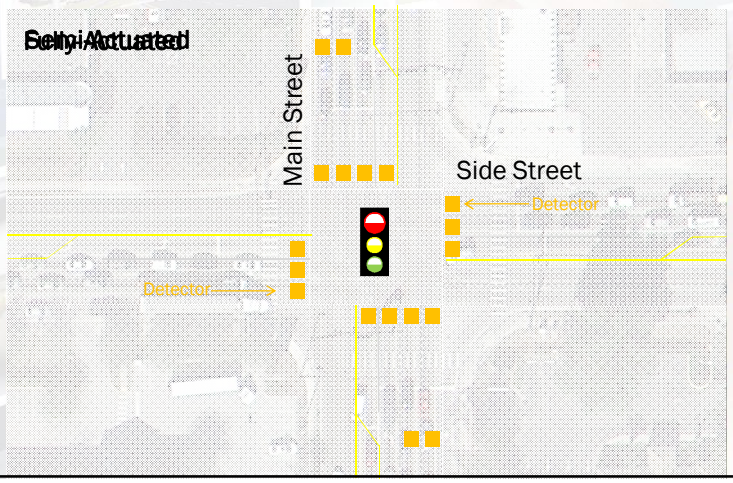
54

FDOT HCS 2010

Signalized Intersections

Actuation

- Vehicle detection for an approach



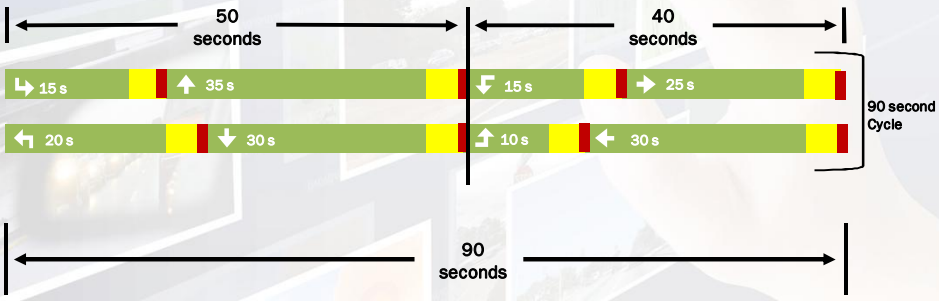
55

FDOT HCS 2010

Signalized Intersections

Terminology

- **Cycle length:** The amount of time (in seconds) that is provided to service all movements at a signalized intersection; a cycle length should provide sufficient capacity at the critical intersection(s) and provide progression through the system



56

FDOT HCS 2010

Signalized Intersections

Terminology

- **Minimum green time:** Minimum amount of green time (in seconds) that a vehicle movement receives. Typically a set standard adopted by each agency.
  - Typically range from 4 to 15 seconds
- **Maximum green time:** Maximum amount of green time (in seconds) that a green signal indication can be displayed in the presence of conflicting demand.
  - Typical ranges:
    - 15 to 30 seconds (left turn phases)
    - 20 to 40 seconds (through phase for minor street approach)
    - 30 to 60 seconds (through phase for major street approach)

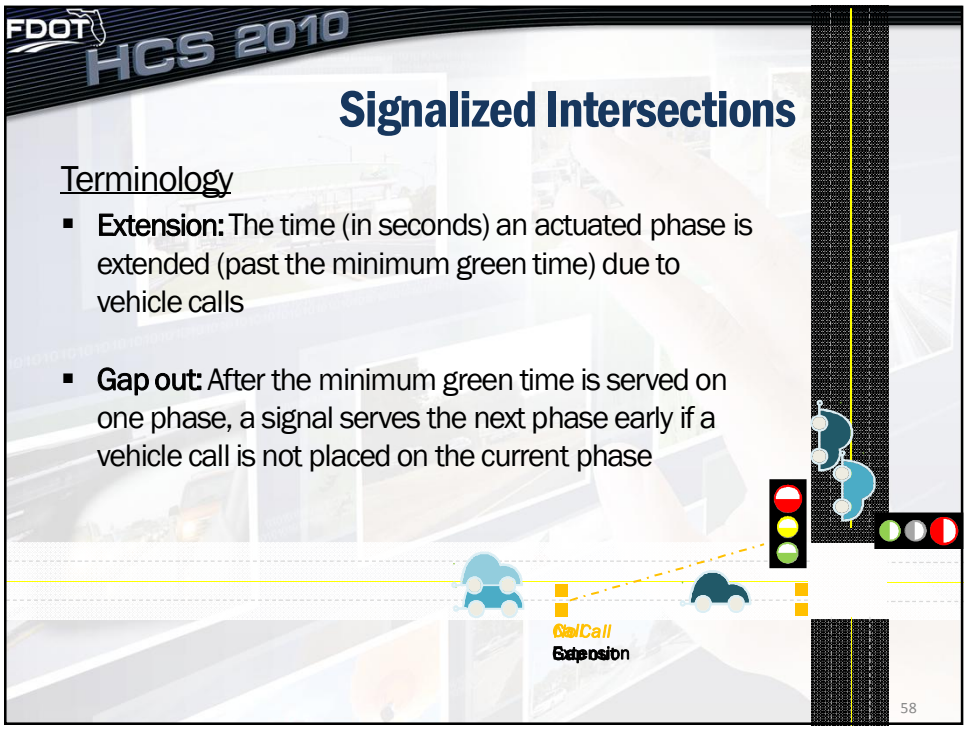
57

FDOT HCS 2010

Signalized Intersections

Terminology

- **Extension:** The time (in seconds) an actuated phase is extended (past the minimum green time) due to vehicle calls
- **Gap out:** After the minimum green time is served on one phase, a signal serves the next phase early if a vehicle call is not placed on the current phase



58

FDOT HCS 2010

Signalized Intersections

Terminology

- **Vehicle clearance time:** Yellow time + all-red time
  - Yellow time is based on the approach speed & grade
  - All-red time is based on the approach speed & intersection width

- **Platoon:** Group of vehicles traveling together through a coordinated system

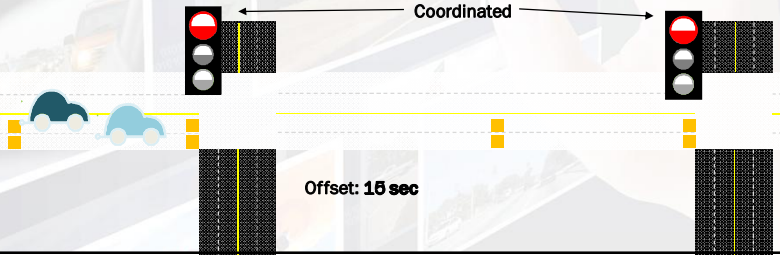
59

FDOT HCS 2010

Signalized Intersections

Terminology

- **Coordinated system:** A system of interconnected traffic signals that are timed to maximize flow along a major street
- **Offset:** The time delay (in seconds) between the start of a cycle at a "master" intersection in a coordinated system and another intersection—typically set so that the light turns green when you arrive at the next traffic signal



60

FDOT HCS 2010

Signalized Intersections

Terminology

- **Recall:** Whether or not the controller will automatically place a call for a specified phase each time the controller is servicing a conflicting phase
  - **Off:** A phase will not automatically place a call; also called None
  - **Minimum recall:** A phase will automatically place a call and only allocate the minimum green time to the phase unless subsequent calls are placed
  - **Maximum recall:** A phase will place a call each time and the maximum green time or split will be allocated to the phase. All phases should be considered as maximum recall for pre-timed traffic signals
  - **Pedestrian recall:** The controller will place a continuous call for pedestrian service on the phase and then service the phase for at least an amount of time equal to its walk and pedestrian clear intervals (more if vehicle detections are received). Pedestrian recall is used for phases that have a high probability of pedestrian demand every cycle and no pedestrian detection.

61

FDOT HCS 2010

Signalized Intersections

Terminology

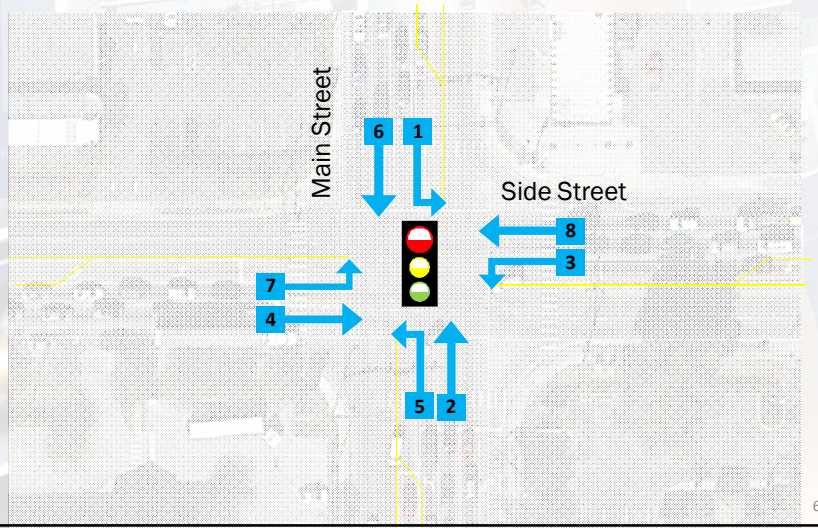
- **Pedestrian timings:** Whether or not the controller will automatically place a call for a specified phase each time the controller is servicing a conflicting phase
  - **Walk interval:** The walk interval is intended to give pedestrians adequate time to perceive the WALK indication and depart the curb before the pedestrian change interval begins
  - **Pedestrian clearance:** A flashing DON'T WALK or countdown timer indication is displayed during this interval

62

FDOT HCS 2010

Signalized Intersections

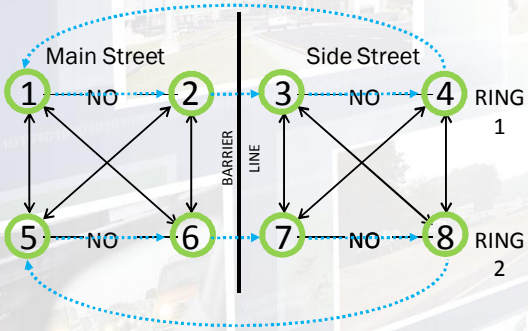
National Electrical Manufacturers Association (NEMA) Phasing

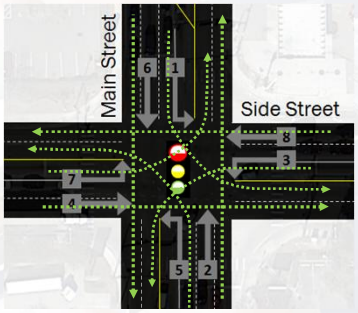


63

FDOT HCS 2010

Signalized Intersections





64

FDOT HCS 2010

Signalized Intersections

Left-Turn Phasing

- **Protected turn:** A green arrow
- **Permissive turn:** A green ball (or flashing yellow arrow) where left turns have to yield to oncoming traffic
- **Protected + Permissive turn:** Starts as green arrow, changes to green ball (or vice versa)

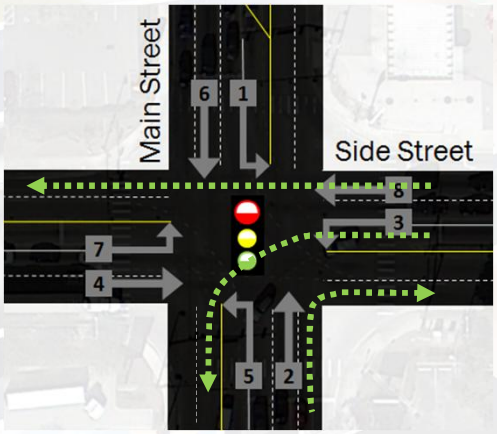
65

FDOT HCS 2010

Signalized Intersections

Overlap Phasing

- Right-turn movements operating in exclusive lanes assigned to more than one phase that is not conflicting



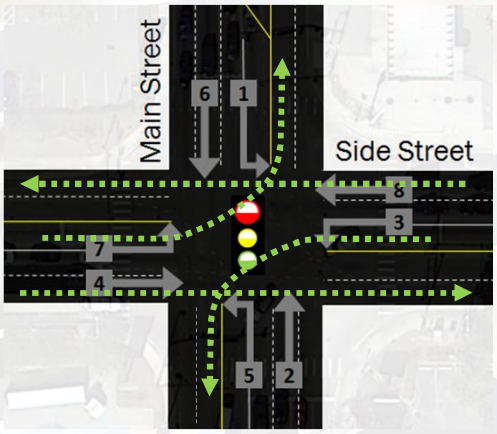
66

FDOT HCS 2010

Signalized Intersections

Split Phasing

- Having two opposing approaches time consecutively rather than concurrently



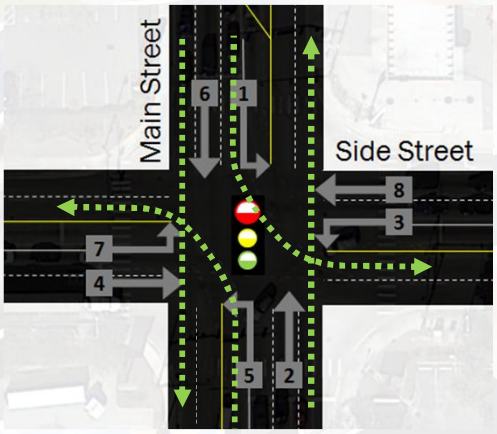
67

FDOT HCS 2010

Signalized Intersections

Lead: Phasing in which left turn phase precedes opposing through phase

Lag: Phasing in which left turn phase follows opposing through phase



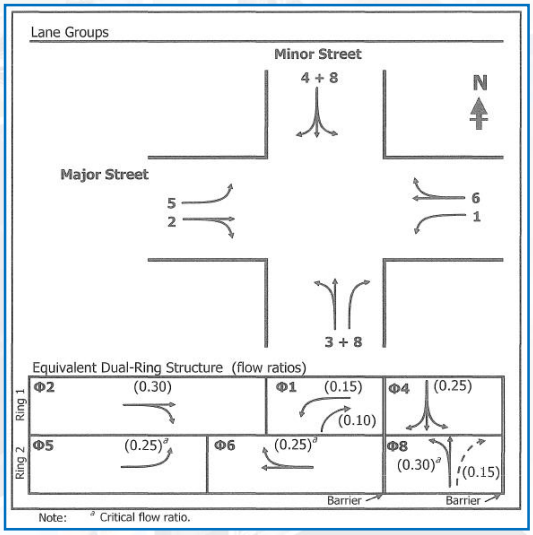
68

FDOT HCS 2010

Signalized Intersections

Critical Paths

- *HCM 2010* Exhibit 18-15



69

FDOT HCS 2010

Signalized Intersections

Arrival Type

- Describes the quality of signal progression
- Values range from 1 to 6
  - Value of 1 represents poor progression
  - Value of 3 represents random arrivals
  - Value of 6 represents exceptional progression
- Typically, arrival type 3 used for uncoordinated movements and arrival type 4 used for most coordinated movements

70

FDOT HCS 2010

Signalized Intersections

- *HCM 2010* Exhibit 18-8

Platoon Ratio	Arrival Type	Progression Quality
0.33	1	Very poor
0.67	2	Unfavorable
1.00	3	Random arrivals
1.33	4	Favorable
1.67	5	Highly favorable
2.00	6	Exceptionally favorable

- *HCM 2010* Exhibit 18-29

Arrival Type	Progression Quality	Signal Spacing (ft)	Conditions Under Which Arrival Type Is Likely to Occur
1	Very poor	≤1,600	Coordinated operation on a two-way street where the subject direction does not receive good progression
2	Unfavorable	>1,600–3,200	A less extreme version of Arrival Type 1
3	Random arrivals	>3,200	Isolated signals or widely spaced coordinated signals
4	Favorable	>1,600–3,200	Coordinated operation on a two-way street where the subject direction receives good progression
5	Highly favorable	≤1,600	Coordinated operation on a two-way street where the subject direction receives good progression
6	Exceptional	≤800	Coordinated operation on a one-way street in dense networks and central business districts

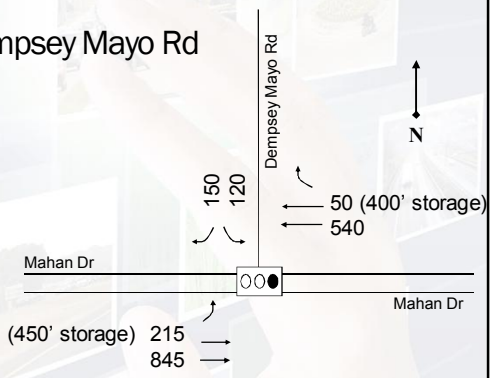
71

FDOT HCS 2010

Signalized Intersections

Example #4: Mahan Dr at Dempsey Mayo Rd (Tallahassee, FL)

- Forward direction – eastbound
- PHF – 0.95 for all movements
- 6% HV on major approaches
- 3% HV on minor approach
- Level terrain
- Arrival type 4 on mainline, 3 on side street
- 45 MPH speed limit on all approaches
- Cycle length – 80 seconds (actuated-coordinated)



Phase Approach	2 EBT	4 SBT	5 EBL	6 WBT
Phase Split	64.0	16.0	18.0	46.0
Yellow	4.4	4.0	3.0	4.3
Red	1.6	1.0	3.5	1.7
Min. Green	15.0	5.0	5.0	15.0
Recall	Min	Off	Off	Min

72

FDOT HCS 2010

Signalized Intersections

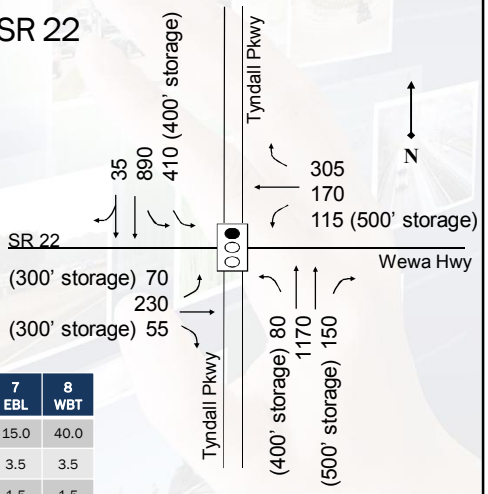
73

FDOT HCS 2010

Signalized Intersections

<u>Workshop #7:</u> Tyndall Pkwy at SR 22 (Callaway, FL)

- Forward direction – northbound
- PHF – 0.90 for all movements
- Saturation – 1950 pc/h/ln
- 6% heavy vehicles for all movements
- Level terrain
- Arrival type 4 on mainline, 3 on side street
- 35 MPH speed limit on all approaches
- Cycle length – 160 seconds (coordinated)
- Protected RT at phases: 1, 3, 5
- E/W LT phases are protected + permitted
- Field-measured phase times are used



Phase Approach	1 SBL	2 NBT	3 WBL	4 EBT	5 NBL	6 SBT	7 EBL	8 WBT
Phase Split	30.0	75.0	15.0	40.0	30.0	75.0	15.0	40.0
Yellow	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Red	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Min. Green	8	15	8	15	8	15	8	15
Recall	Off	Max	Off	Off	Off	Max	Off	Off

74

FDOT HCS 2010

Signalized Intersections

75

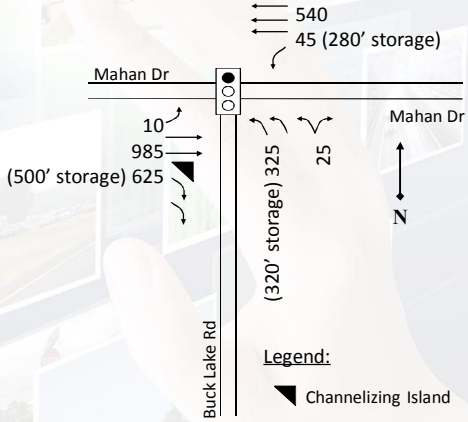
FDOT HCS 2010

Signalized Intersections

<u>Workshop #8:</u> Mahan Dr at Buck Lake Rd (Tallahassee, FL)

- Forward direction – eastbound
- PHF – 0.92 for all approaches
- 8% heavy vehicles on all movements
- Level terrain
- Arrival type 3
- 45 MPH speed limit on all approaches
- Cycle length – 160 seconds
- Field-measured phase times are used

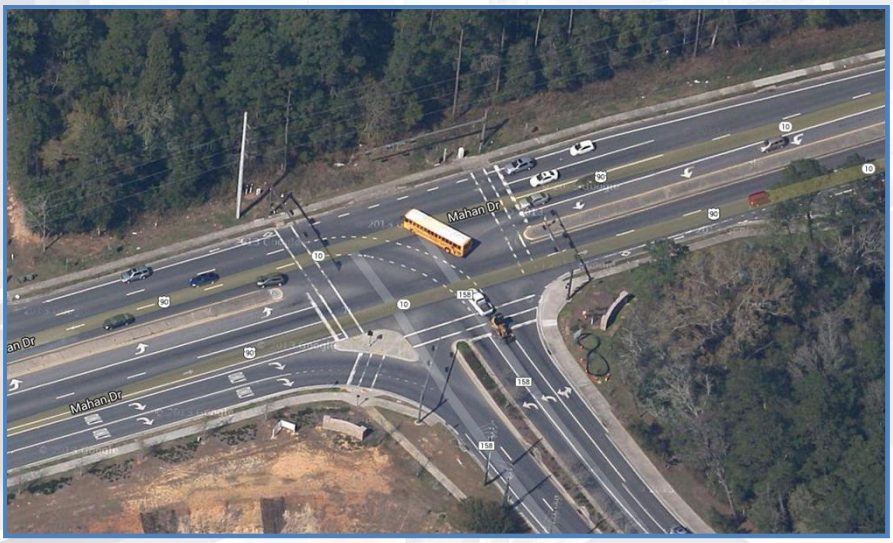
Phase Approach	1 WBL	2 EBT	3 NBL	6 WBT
Split	18.0	100.0	42.0	118.0
Yellow	3.0	4.1	3.0	4.1
Red	3.3	1.9	4.0	1.9
Min. Green	4.0	18.0	7.0	18.0
Recall	Off	Max	Off	Off



76

FDOT HCS 2010

Signalized Intersections



77

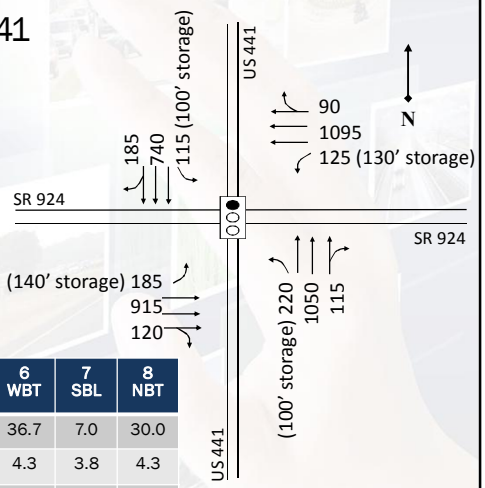
FDOT HCS 2010

Signalized Intersections

<u>Workshop #9:</u> SR 924 at US 441

(Miami, FL)

- Forward direction – eastbound
- PHF – 0.96 for all approaches
- 3% heavy vehicles on all movements
- Level terrain
- Arrival type 3
- 40 MPH speed limit on all approaches
- Cycle length – 100 seconds (pre-timed)
- Uncoordinated intersection
- Protected + permissive for all lefts



Phase Approach	1 WBL	2 EBT	3 NBL	4 SBT	5 EBL	6 WBT	7 SBL	8 NBT
Max. Green	7.0	36.7	7.0	30.0	7.0	36.7	7.0	30.0
Yellow	4.2	4.3	3.8	4.3	4.2	4.3	3.8	4.3
Red	0.0	1.3	0.0	1.4	0.0	1.3	0.0	1.4
Min. Green	5.0	7.0	5.0	7.0	5.0	7.0	5.0	7.0

78

FDOT HCS 2010

Signalized Intersections

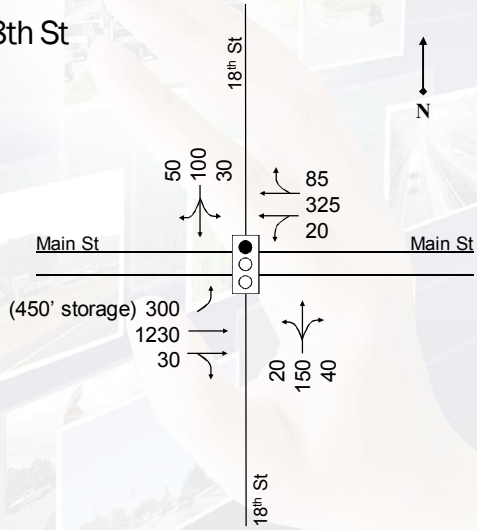
79

FDOT HCS 2010

Signalized Intersections

Workshop #10: Main St at 18th St

- Forward direction – eastbound
- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- Level terrain
- Arrival type 3
- 25 MPH speed limit for all approaches
- Cycle – 120 sec (pre-timed)
- 7 sec walk-time, 11-sec ped clearance
- 40 peds/hr crossing all approaches
- Split phasing on 18th St (NB is lag phase)
- Uncoordinated intersection
- Field-measured phase times are used



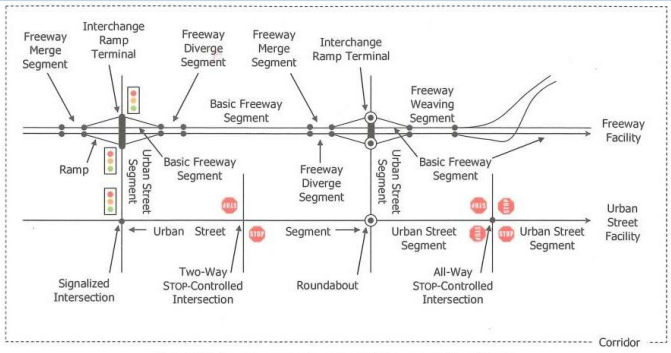
Phase Approach	2 EBT	5 EBL	6 WBT	8 NBT/SBT
Max. Green	54.5	18.5	30.5	24.5
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4

80

FDOT HCS 2010

Day 2 – Interrupted Flow

- Signalized Intersections
- Urban Streets
  - Segments ◀
  - Facilities



(a) Points, Segments, Facilities, and Corridors

81

FDOT HCS 2010

Urban Streets - Segments

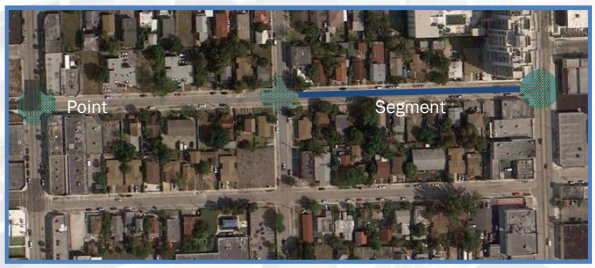
- Chapter 17 – *HCM 2010*
- New methodology for *HCM 2010* (based on NCHRP 3-79)
- Multimodal
  - Automobile, pedestrian, bicycle, and transit
- One-way and two-way arterials/collectors
- Intersections on segment end points
  - Signalized and unsignalized
- Multiple Level of Service criteria
  - Automobiles (travel speed and volume/capacity)
  - Pedestrians (LOS score and space value)
  - Bicycle/Transit (LOS score)

82

FDOT HCS 2010

Urban Streets - Segments

- Vocabulary
  - **Point** – A boundary between links, usually a signalized intersection
  - **Segment** – A portion of roadway extending from one point to another



83

FDOT HCS 2010

Urban Streets - Segments

- *HCM 2010* Exhibit 17-2 (LOS for Automobiles)

Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Volume-to-Capacity Ratio[a] ≤1.0	> 1.0
>85	A	F
>67–85	B	F
>50–67	C	F
>40–50	D	F
>30–40	E	F
≤30	F	F

Note: [a]Volume-to-capacity ratio of through movement at downstream boundary intersection.

- *HCM 2010* Exhibit 17-3 (LOS for Pedestrians)

Pedestrian LOS Score	LOS by Average Pedestrian Space (ft^2/p) >60	>40–60	>24–40	>15–24	>8.0–15[a]	≤ 8.0[a]
≤2.00	A	B	C	D	E	F
>2.00–2.75	B	B	C	D	E	F
>2.75–3.50	C	C	C	D	E	F
>3.50–4.25	D	D	D	D	E	F
>4.25–5.00	E	E	E	E	E	F
>5.00	F	F	F	F	F	F

Note: [a]In cross-flow situations, the LOS E/F threshold is 13 ft^2/p.

- *HCM 2010* Exhibit 17-4 (LOS Bicycle and Transit)

LOS	LOS Score
A	≤2.00
B	>2.00–2.75
C	>2.75–3.50
D	>3.50–4.25
E	>4.25–5.00
F	>5.00

84

FDOT HCS 2010

Urban Streets - Segments

Required Data

- Mid-segment and access point flow rates
- Lane configurations
- Number of access points
- Segment length
- Boundary intersection information
  - Signalized intersection information
  - Unsignalized intersection information
- Mid-segment intersection information
  - Unsignalized intersection information

85

FDOT HCS 2010

Urban Streets - Segments

Required Data

- Unsignalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factors
  - Special factors (channelization, median storage, grades, and upstream signals)

86

FDOT HCS 2010

Urban Streets - Segments

Required Data

- Signalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factor or 15-minute traffic volumes
  - Traffic signal phasing
  - Traffic signal timing parameters

87

FDOT HCS 2010

Urban Streets - Segments

Required Data (non-automobile)

- Pedestrian
  - Pedestrian flow rate
  - Sidewalk information
  - Distance to nearest signal-controlled crossing
- Bicycle
  - On-street parking occupied
  - Lane configurations
  - Pavement condition rating
- Transit
  - Dwell time, transit frequency
  - Area type (CBD)
  - Transit stop information

88

FDOT HCS 2010

Urban Streets - Segments

Limitations

- Automobile
  - On-street parking activity
  - Capacity constraints between intersections
  - Queuing at the downstream boundary intersection
  - Shared-use lanes (Automobile/Bicycle)
- Non-automobile
  - Segments bound by All-Way Stop/Roundabouts
  - Mid-segment unsignalized crosswalks
  - Points of high volume pedestrian access to a sidewalk
  - Points where a high volume of vehicles cross a sidewalk

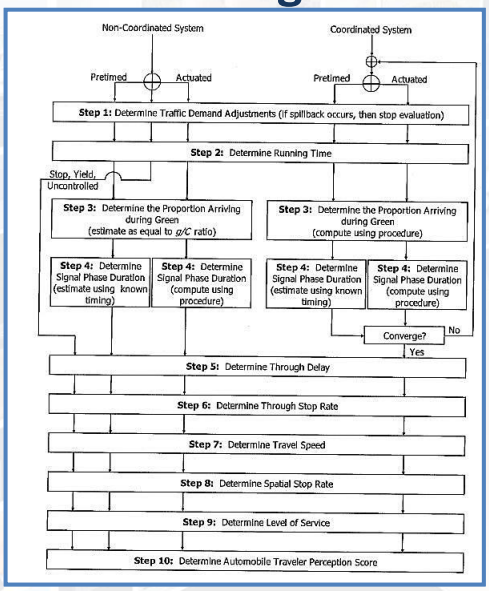
89

FDOT HCS 2010

Urban Streets - Segments

Methodology

- Automobile Mode (Exhibit 17-8)



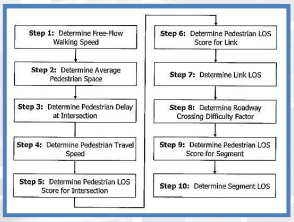
90

FDOT HCS 2010

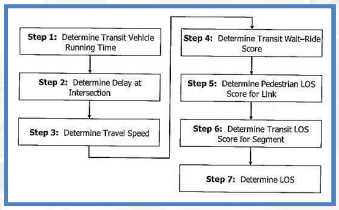
Urban Streets - Segments

Methodology

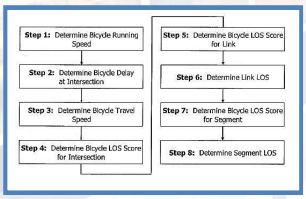
- Pedestrian Mode (Exhibit 17-15)



- Transit Mode (Exhibit 17-22)



- Bicycle Mode (Exhibit 17-20)



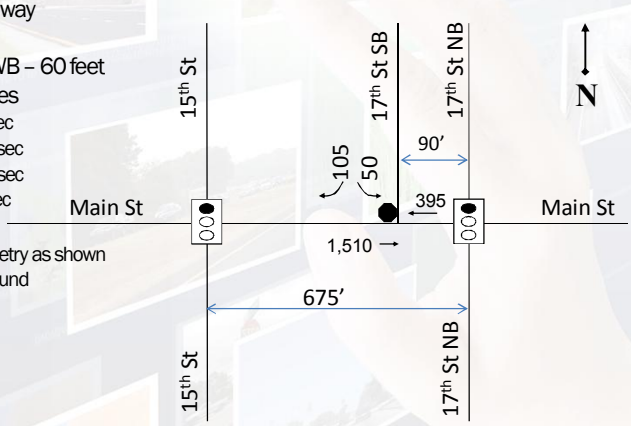
91

FDOT HCS 2010

Urban Streets - Segments

Example #5: Main St between 15th St and 17th St NB

- Forward direction – eastbound
- 4-lane undivided roadway
- 25 MPH speed limit
- Upstream width EB/WB – 60 feet
- Segment default values
  - Cycle length: 120 sec
  - Minimum green: 4 sec
  - Yellow change: 3.5 sec
  - Red clearance: 2 sec
- Access Point
  - Volumes and geometry as shown
  - 17th Street southbound
  - PHF = 0.90



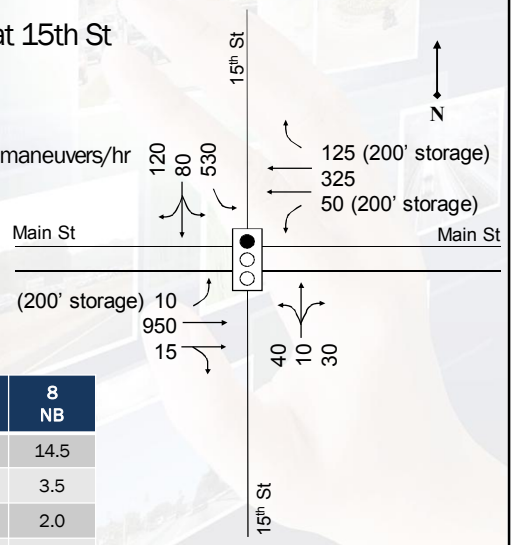
92

FDOT HCS 2010

Urban Streets - Segments

Example #5 (cont): Main St at 15th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 20 peds/hr crossing all approaches
- Arrival type 3
- Cycle length – 90 sec (pre-timed)
- Split phasing (NB lag)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance



Phase Approach	2 EB	4 SB	6 WB	8 NB
Max. Green	29.5	29.5	29.5	14.5
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4

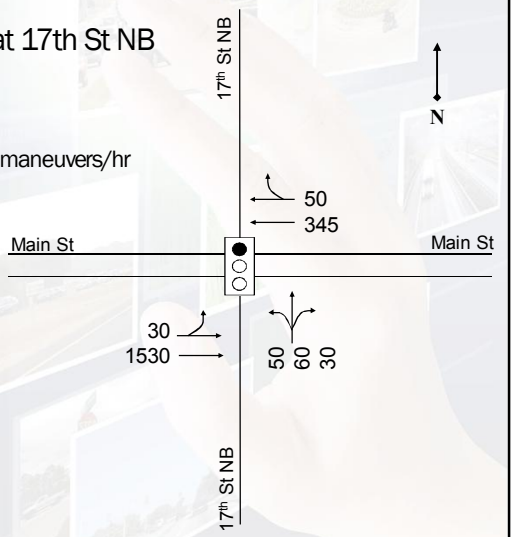
93

FDOT HCS 2010

Urban Streets - Segments

Example #5 (cont): Main St at 17th St NB

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 20 peds/hr crossing all approaches
- Arrival type 3
- Cycle length – 90 sec (pre-timed)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance



Phase Approach	2 EB	4 NB	6 WB
Max. Green	62.5	16.5	62.5
Yellow	3.5	3.5	3.5
Red	2.0	2.0	2.0
Min. Green	4	4	4

94

FDOT HCS 2010

Urban Streets - Segments

Workshop #11: SR 22 between Transmitter Rd and Bob Little Rd (Springfield, FL)

- Forward direction – eastbound
- 2-lane undivided mainline roadway
- 45 MPH speed limit
- Upstream width EB/WB – 40 feet
- Segment default values:
  - Cycle length: 60 sec
  - Minimum green: 2 sec
  - Yellow change: 3 sec
  - Red clearance: 1 sec
- Access Points
  - Volumes and geometry as shown
  - Assume turn lanes with 200' storage from SR 22
  - PHF = 0.90

95

FDOT HCS 2010

Urban Streets - Segments

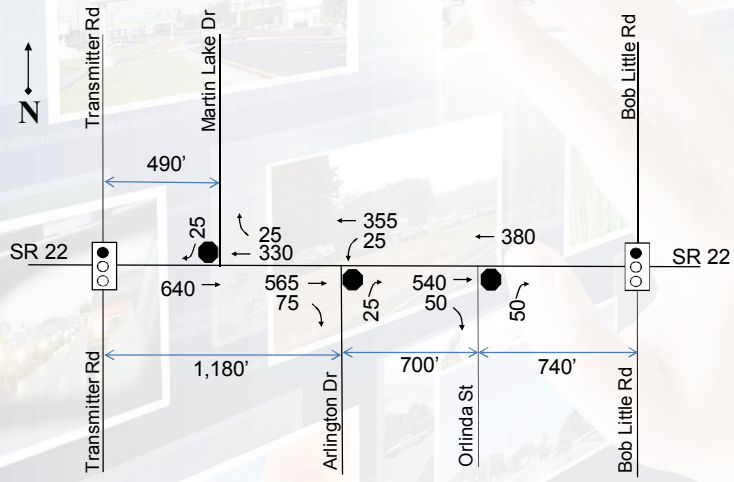
Workshop #11: SR 22 between Transmitter Rd & Bob Little Rd (Springfield, FL)

96

FDOT HCS 2010

Urban Streets - Segments

Workshop #11 (cont): SR 22 between Transmitter Rd and Bob Little Rd



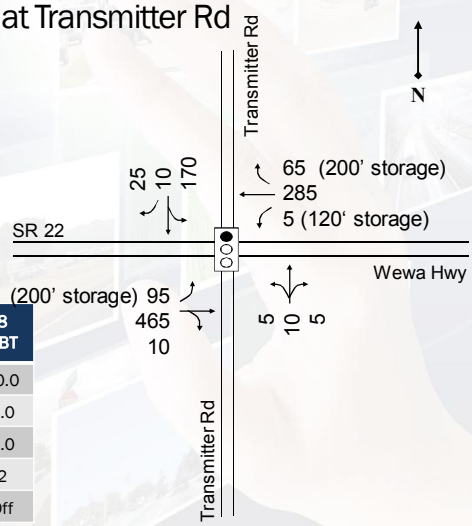
97

FDOT HCS 2010

Urban Streets - Segments

Workshop #11 (cont): SR 22 at Transmitter Rd

- 0.92 – PHF for all approaches
- 6% heavy vehicles on all movements
- Cycle length – 60 sec (actuated)
- Offset – 15 sec
- RT overlap & lag on Phase 7
- Field-measured phase times are used



Phase Approach	2 EBT	4 SBT	6 WBT	7 SBL	8 NBT
Split	40.0	20.0	40.0	10.0	10.0
Yellow	3.0	3.0	3.0	3.0	3.0
Red	1.0	1.0	1.0	1.0	1.0
Min. Green	2	2	2	2	2
Recall	C-Min	Off	C-Min	Off	Off

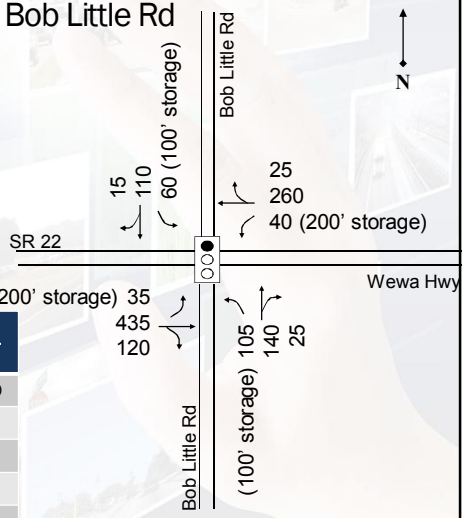
98

FDOT HCS 2010

Urban Streets - Segments

Workshop #11 (cont): SR 22 at Bob Little Rd

- 0.92 – PHF for all approaches
- 6% heavy vehicles on all movements
- Cycle length – 60 sec (actuated)
- Offset – 35 sec
- Lag phase: Phase 3
- Field-measured phase times are used



Phase Approach	2 EBT	3 NBL	4 SBT	6 WBT	8 NBT
Split	35.0	15.0	10.0	35.0	25.0
Yellow	3.0	3.0	3.0	3.0	3.0
Red	1.0	1.0	1.0	1.0	1.0
Min. Green	2	2	2	2	2
Recall	C-Min	Off	Off	C-Min	Off

99

FDOT HCS 2010

Day 2 – Interrupted Flow

- Signalized Intersections
- Urban Streets
  - Segments
  - Facilities ◀

100

FDOT HCS 2010

Urban Streets - Facilities

- Chapter 16 – *HCM 2010*
- New methodology for *HCM 2010*
- Multimodal
  - Automobile, pedestrian, bicycle, and transit
- One-way and two-way arterials/collectors
- Multiple level of service criteria
  - Travel speed (all modes)
  - Stop rate (automobile)
  - Perception score (pedestrian/bicycle/transit)
  - Pedestrian (space)

101

FDOT HCS 2010

Urban Streets - Facilities

- Exhibit 16-4 *HCM 2010* (LOS for Automobiles)

Travel Speed as a Percentage of Base Free-Flow Speed (%)	LOS by Critical Volume-to-Capacity Ratio[a]	
	≤ 1.0	> 1.0
>85	A	F
>67–85	B	F
>50–67	C	F
>40–50	D	F
>30–40	E	F
≤30	F	F

Note: [a] The critical volume-to-capacity ratio is based on consideration of the through movement volume-to-capacity ratio at each boundary intersection in the subject direction of travel. The critical volume-to-capacity ratio is the largest ratio of those considered.

- Exhibit 16-5 *HCM 2010* (LOS for Pedestrians)

Pedestrian LOS Score	LOS by Average Pedestrian Space (ft^2/p)					
	>60	>40–60	>24–40	>15–24	>8.0–15[a]	≤ 8.0[a]
≤2.00	A	B	C	D	E	F
>2.00–2.75	B	B	C	D	E	F
>2.75–3.50	C	C	C	D	E	F
>3.50–4.25	D	D	D	D	E	F
>4.25–5.00	E	E	E	E	E	F
>5.00	F	F	F	F	F	F

Note: [a] In cross-flow situations, the LOS E–F threshold is 13 ft^2/p.

- Exhibit 16-6 *HCM 2010* (LOS for Bicycle and Transit)

LOS	LOS Score
A	≤2.00
B	>2.00–2.75
C	>2.75–3.50
D	>3.50–4.25
E	>4.25–5.00
F	>5.00

102

FDOT HCS 2010

Urban Streets - Facilities

- Exhibit 16-7 *HCM 2010* (Input Data Requirements)

Data Category	Location	Input Data Element	Basis
Geometric Design	Segment	Segment length	Segment
Other	Segment	Analysis period duration	Facility
Performance Measures	Boundary intersection	Volume-to-capacity ratio	Through-movement group
	Segment	Base free-flow speed Travel speed	Segment Segment

Notes: Through-movement group = one value for the segment through movement at the downstream boundary intersection (inclusive of any turn movements in a shared lane).
Segment = one value or condition for each segment and direction of travel on the facility.
Facility = one value or condition for the facility.

103

FDOT HCS 2010

Urban Streets - Facilities

Required Data

- Mid-segment and access point flow rates
- Lane configurations
- Number of access points
- Segment length
- Boundary intersection information
  - Signalized intersection information
  - Unsignalized intersection information
- Mid-segment intersection information
  - Unsignalized intersection information

104

FDOT HCS 2010

Urban Streets - Facilities

Required Data

- Unsignalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factors
  - Special factors (channelization, median storage, grades, upstream signals)

105

FDOT HCS 2010

Urban Streets - Facilities

Required Data

- Signalized boundary intersection
  - Lane configurations
  - Percentage of heavy vehicles
  - Peak hour turning movement volumes
  - Peak hour factor or 15-minute traffic volumes
  - Traffic signal phasing
  - Traffic signal timing parameters

106

FDOT HCS 2010

Urban Streets - Facilities

Required Data (non-automobile)

- Pedestrian
  - Pedestrian flow rate
  - Sidewalk information
  - Distance to nearest signal-controlled crossing
  - Legality of mid-segment pedestrian crossing
- Bicycle
  - On-street parking occupied
  - Lane configurations
  - Pavement condition rating
- Transit
  - Dwell time, transit frequency
  - Area type (CBD)
  - Transit stop information

107

FDOT HCS 2010

Urban Streets - Facilities

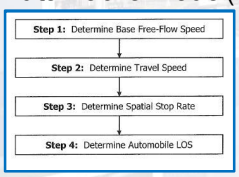
- Limitations consistent with:
  - Unsignalized intersections
  - Signalized intersections
  - Interchange ramp terminals
  - Urban street segments
- However:
  - If spillback affects performance, the analyst should consider using an alternative analysis tool that is able to model the effect of spillback conditions

108

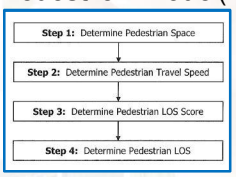
FDOT HCS 2010

Urban Streets - Facilities

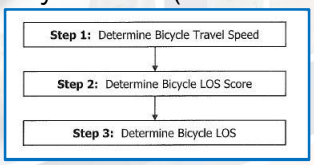
- Methodology
- Automobile Mode (Exhibit 16-9)



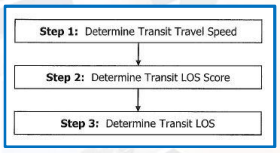
- Pedestrian Mode (Exhibit 16-10)*



- Bicycle Mode (Exhibit 16-12)*



- Transit Mode (Exhibit 16-13) *



*Specific to one side of street

109

FDOT HCS 2010

Urban Streets - Facilities

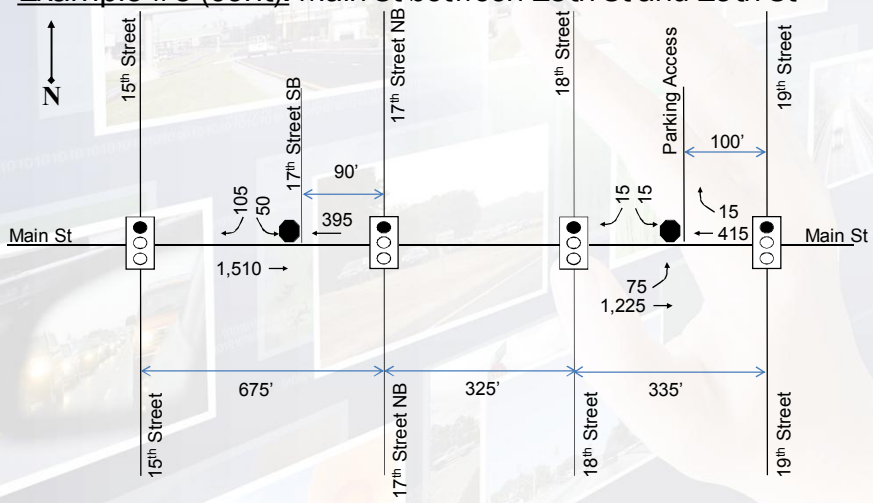
Example #6: Main St between 15th St and 19th St

- Forward direction – eastbound
- 4-lane undivided roadway
- 25 MPH speed limit
- Upstream width EB/WB – 60 feet
- Segment default values
  - Cycle length: 90 sec
  - Minimum green: 4 sec
  - Yellow change: 3.5 sec
  - Red clearance: 2 sec
- Access Points
  - 17th St SB (585' east of 15th St)
  - Parking Access (235' east of 18th St)
  - PHF = 0.90
- Field-measured phase times

110

Urban Streets - Facilities

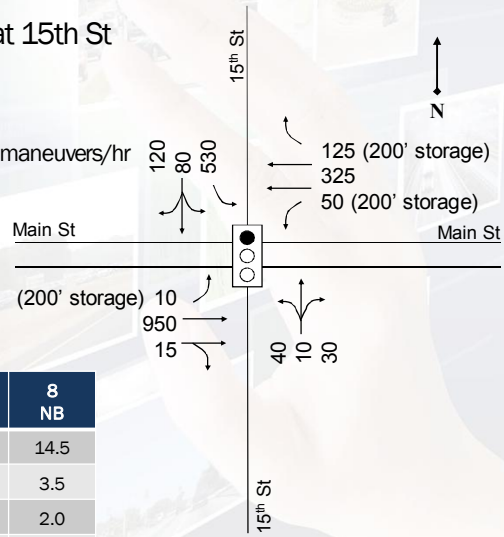
Example #6 (cont): Main St between 15th St and 19th St



Urban Streets - Facilities

Example #6 (cont): Main St at 15th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 20 peds/hr crossing all approaches
- Arrival type 3
- Cycle length – 90 sec (pre-timed)
- Split phasing (NB lag)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance



Phase Approach	2 EB	4 SB	6 WB	8 NB
Max. Green	29.5	29.5	29.5	14.5
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4

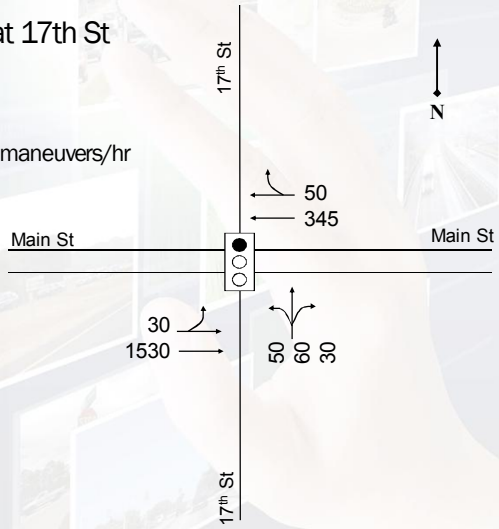
FDOT HCS 2010

Urban Streets - Facilities

Example #6 (cont): Main St at 17th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 20 peds/hr crossing all approaches
- Arrival type 3
- Cycle length – 90 sec (pre-timed)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance

Phase Approach	2 EB	4 NB	6 WB
Max. Green	62.5	16.5	62.5
Yellow	3.5	3.5	3.5
Red	2.0	2.0	2.0
Min. Green	4	4	4



113

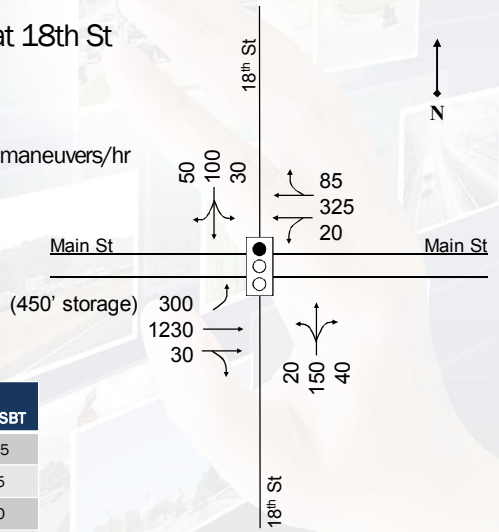
FDOT HCS 2010

Urban Streets - Facilities

Example #6 (cont): Main St at 18th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB - 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 40 peds/hr crossing all approaches
- Arrival type 3
- Cycle length – 120 sec (pre-timed)
- Split phasing (NB lag)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance

Phase Approach	2 EBT	5 EBL	6 WBT	8 NBT/SBT
Max. Green	54.5	18.5	30.5	24.5
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4



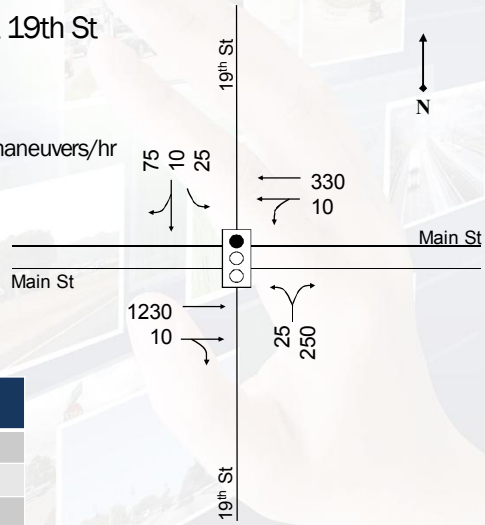
114

FDOT HCS 2010

Urban Streets - Facilities

Example #6 (cont): Main St at 19th St

- PHF – 0.90 for all movements
- 2% heavy vehicles for all movements
- EB and WB – 5 buses/hr
- On-street parking on WB approach – 10 maneuvers/hr
- 10 peds/hr crossing all approaches
- Arrival type 3
- Cycle – 90 sec (pre-timed)
- Split phasing (SB lag)
- Uncoordinated intersection
- Field-measured phase times
- 7 sec walk-time, 11-sec ped clearance



Phase Approach	2 EB	4 SB	6 WB	8 NB
Max. Green	32	18	32	23
Yellow	3.5	3.5	3.5	3.5
Red	2.0	2.0	2.0	2.0
Min. Green	4	4	4	4

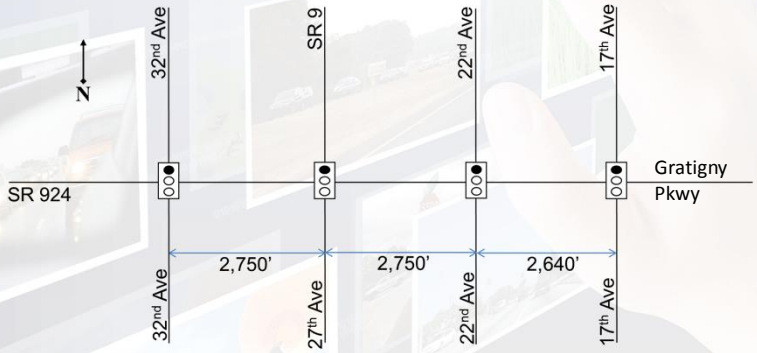
115

FDOT HCS 2010

Urban Streets - Facilities

Workshop #12: SR 924 (Gratigny Pkwy) between 32nd Ave and 17th Ave (Miami, FL)

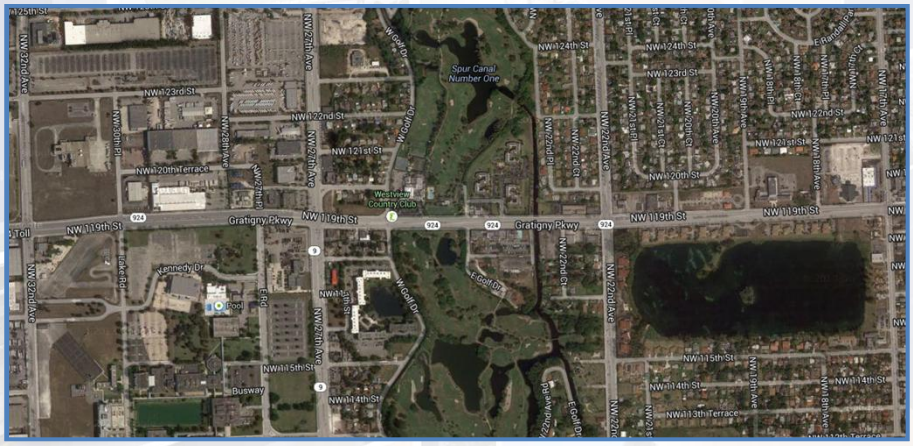
- 8-lane divided roadway with 30' median
- Upstream width EB/WB – 100 feet
- Cycle length = 100 sec for all intersections



116

FDOT HCS 2010

Urban Streets - Facilities

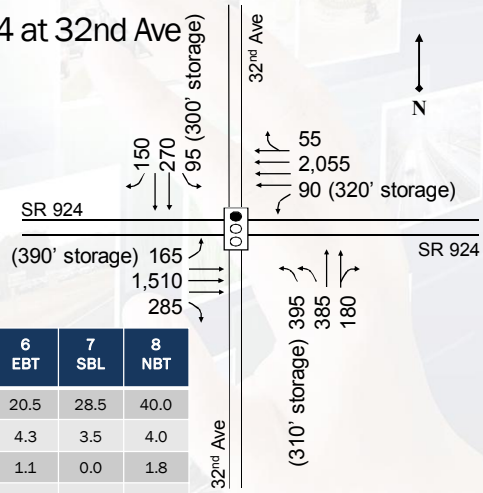


FDOT HCS 2010

Urban Streets - Facilities

Workshop #12 (cont): SR 924 at 32nd Ave

- 0.92 – PHF for all approaches
- 5% HV on mainline approaches
- 14% HV on minor approaches
- 40 MPH speed limit on all approaches
- Cycle length – 100 sec (actuated)
- Offset – 28 sec
- EB, WB, & SB LT phases protected + permissive
  - NB LT phase protected only



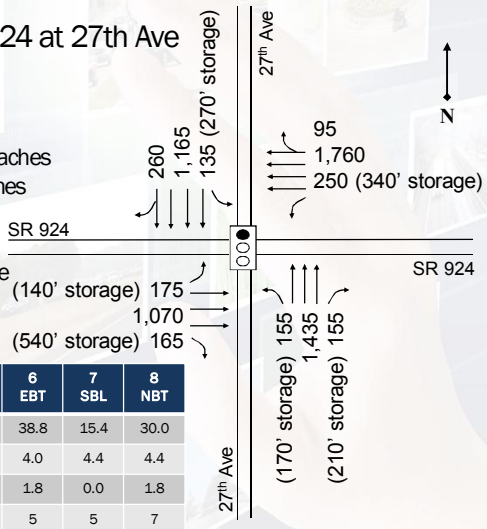
Phase Approach	1 EBL	2 WBT	3 NBL	4 SBT	5 WBL	6 EBT	7 SBL	8 NBT
Split	11.0	20.5	28.5	40.0	11.0	20.5	28.5	40.0
Yellow	5.0	4.3	3.5	4.0	5.0	4.3	3.5	4.0
Red	0.0	1.1	0.0	1.8	0.0	1.1	0.0	1.8
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off

FDOT HCS 2010

Urban Streets - Facilities

Workshop #12 (cont): SR 924 at 27th Ave

- 0.96 – PHF for all approaches
- 5% HV on mainline approaches
- 7% HV on minor approaches
- 40 MPH speed limit on mainline approaches
- 45 MPH speed limit on minor approaches
- Cycle length – 100 sec (actuated)
- Offset – 50 sec
- All LT phases are protected + permissive



Phase Approach	1 EBL	2 WBT	3 NBL	4 SBT	5 WBL	6 EBT	7 SBL	8 NBT
Split	15.8	38.8	15.4	30.0	15.8	38.8	15.4	30.0
Yellow	4.8	4.0	4.4	4.4	4.8	4.0	4.4	4.4
Red	0.0	1.8	0.0	1.8	0.0	1.8	0.0	1.8
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off

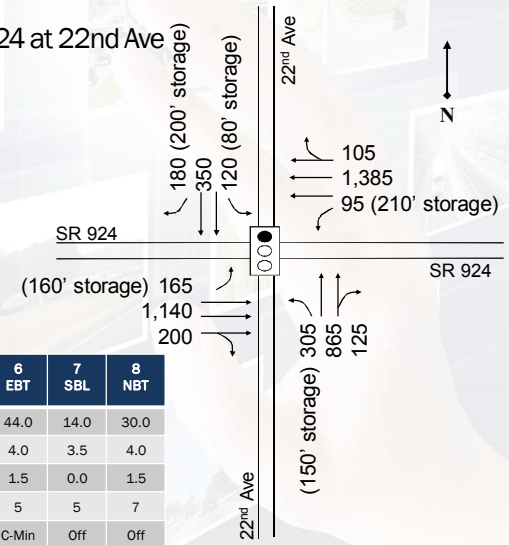
119

FDOT HCS 2010

Urban Streets - Facilities

Workshop #12 (cont): SR 924 at 22nd Ave

- 0.93 – PHF for all approaches
- 3% HV on mainline approaches
- 2% HV on minor approaches
- 40 MPH speed limit on all approaches
- Cycle length – 100 sec (actuated)
- Offset – 99 sec
- N/S LT phases protected + permissive
  - E/W LT phases protected only



Phase Approach	1 EBL	2 WBT	3 NBL	4 SBT	5 WBL	6 EBT	7 SBL	8 NBT
Split	12.0	44.0	14.0	30.0	12.0	44.0	14.0	30.0
Yellow	3.5	4.0	3.5	4.0	3.5	4.0	3.5	4.0
Red	0.0	1.5	0.0	1.5	0.0	1.5	0.0	1.5
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off

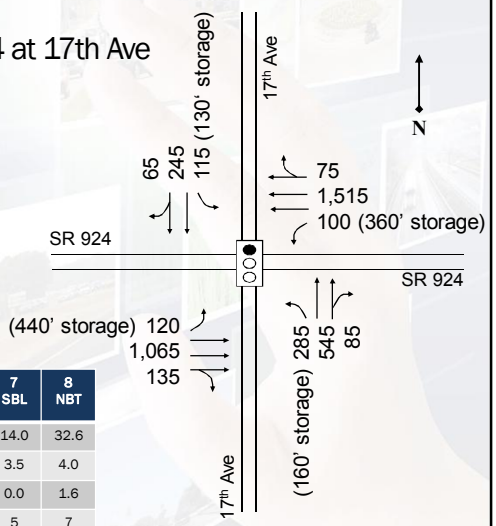
120

FDOT HCS 2010

Urban Streets - Facilities

Workshop #12 (cont): SR 924 at 17th Ave

- 0.88 – PHF for all approaches
- 3% heavy vehicles on all movements
- 40 MPH speed limit on all approaches
- Cycle length – 100 sec (actuated)
- Offset – 68 sec
- All LT phases protected + permissive



Phase Approach	1 WBL	2 EBT	3 NBL	4 SBT	5 EBL	6 WBT	7 SBL	8 NBT
Split	11.0	42.4	14.0	32.6	11.0	42.4	14.0	32.6
Yellow	3.5	4.0	3.5	4.0	3.5	4.0	3.5	4.0
Red	0.0	1.1	0.0	1.6	0.0	1.1	0.0	1.6
Min. Green	5	5	5	7	5	5	5	7
Recall	Off	C-Min	Off	Off	Off	C-Min	Off	Off

121

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges ◀
- Freeways
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

122

FDOT HCS 2010

Housekeeping

- Breaks
  - 10:00 – 10:15 am
  - Lunch 11:30 – 1:00 pm
  - 2:30 – 2:45 pm

123

FDOT HCS 2010

Interchanges

- Located at the bottom of "Detailed Input Data" in Streets
- User must designate two signals that will comprise the interchange
- User can choose between 8 configurations:
  - Diamond
  - Parclo A-2Q
  - Parclo A-4Q
  - Parclo B-2Q
  - Parclo B-4Q
  - Parclo AB-2Q
  - Parclo AB-4Q
  - SPUI

124

FDOT HCS 2010

Interchanges

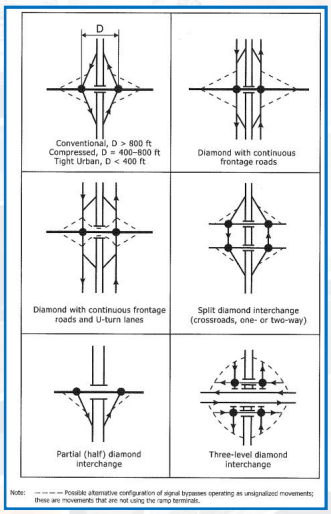
- "Parclo" is short for Partial Cloverleaf configuration
- Letters A, B, or AB refer to relative quadrant locations of ramps
- Numbers 2 or 4 refer to number of Quadrants
- "SPUI" is an acronym for Single-Point Urban Interchange; operates with only one intersection

125

FDOT HCS 2010

Interchanges

- *HCM 2010* Exhibit 22-1



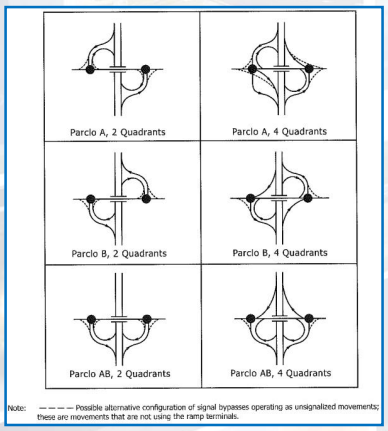
126

FDOT HCS 2010

Interchanges

Configuration types

- *HCM 2010* Exhibit 22-2

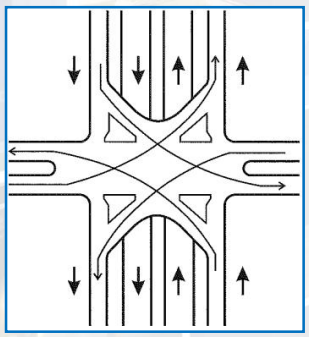


127

FDOT HCS 2010

Interchanges

- *HCM 2010*
  Exhibit 22-3



Single-Point Urban Interchange

128

FDOT HCS 2010

Interchanges

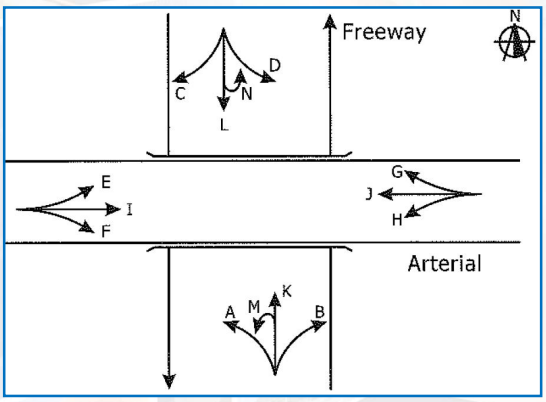
Single-Point Urban Interchange

129

FDOT HCS 2010

Interchanges

- Every possible Origin-Destination (O-D) movement within a configuration is assigned a letter A – N
- *HCM 2010* Exhibit 22-5

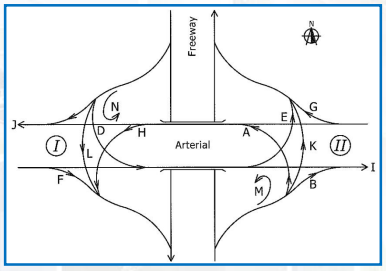


130

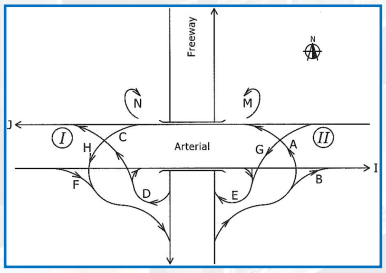
FDOT HCS 2010

Interchanges

- *HCM 2010* Exhibit 22-6



- *HCM 2010* Exhibit 22-7

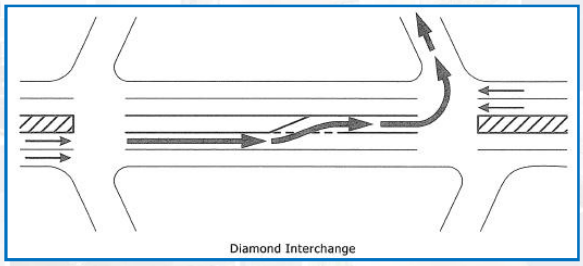


131

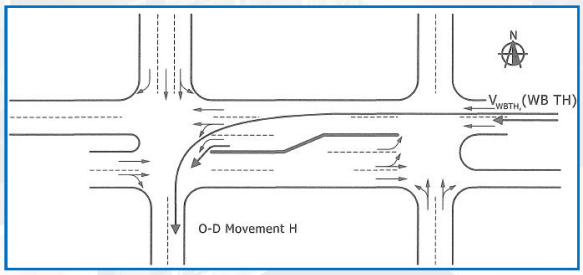
FDOT HCS 2010

Interchanges

- *HCM 2010* Exhibit 22-8



- *HCM 2010* Exhibit 22-10



132

FDOT HCS 2010

Interchanges

- Each movement has a unique Demand (veh/h), Delay (s/veh) and corresponding LOS

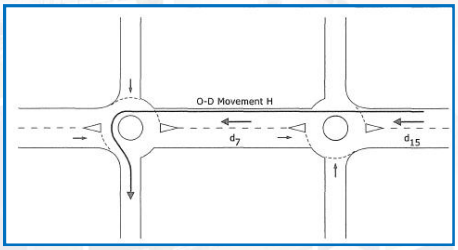
  - *HCM 2010* Exhibit 22-11

Control Delay (s/veh)	O-D LOS $v/c < 1$ and $R_Q < 1$ for Every Lane Group	$v/c > 1$ for Any Lane Group	$R_Q > 1$ for Any Lane Group
≤15	A	F	F
>15–30	B	F	F
>30–55	C	F	F
>55–85	D	F	F
>85–120	E	F	F
>120	F	F	F

FDOT HCS 2010

Interchanges

- *HCM 2010* Exhibit 22-12 - Interchanges with Roundabouts



- *HCM 2010* Exhibit 22-13 – Interchanges with Roundabouts

Control Delay (s/veh)	O-D LOS $v/c < 1$ and $R_Q < 1$ for All Approaches	$v/c > 1$ for Any Approach	$R_Q > 1$ for Any Approach
≤15	A	F	F
>15–25	B	F	F
>25–35	C	F	F
>35–50	D	F	F
>50–75	E	F	F
>75	F	F	F

FDOT HCS 2010

Interchanges

- A new formatted report titled "Interchange Report" provides an overview of how the interchange is performing
- Additional input data is required by the user
  - Segment length, ft
  - U-turn volume, veh/h
  - Turn radius, ft
- Refer to HCM Chapter 22 for more information on how to choose the appropriate configuration

135

FDOT HCS 2010

Interchanges

Required Data

- *HCM 2010* Exhibit 22-15

Type of Condition	Parameter
Geometric conditions	Area type
	Number of lanes (N)
	Average lane width (W, ft)
	Grade (G, %)
	Existence of exclusive left- or right-turn lanes
	Length of storage for each lane group (L_{sg}, ft)
	Distance corresponding to the internal storage between the two intersections in the interchange (D, ft)
	Distances corresponding to the internal storage between interchange intersections and adjacent closely spaced intersections (ft)
	Turning radii for all turning movements (ft)
Traffic conditions	Demand volume by O-D or turning movement (V, veh/h)
	Right-turn-on-red flow rates
	Base saturation flow rate (s_b, pc/hg/ln)
	Peak hour factor (PHF)
	Percent heavy vehicles (HV, %)
	Approach pedestrian flow rates (v_{ped}, ped/h)
	Approach bicycle flow rates (v_b, bicycles/h)
	Local bus stopping rate (N_B, buses/h)
	Parking activity (N_m, maneuvers/h)
	Arrival type (AT)
	Upstream filtering adjustment factor
	Approach speed (S_a, mi/h)
Signalization conditions	Type of signal control
	Phase sequence
	Cycle length (if appropriate) (C, s)
	Green times (if appropriate) (G, s)
	Yellow-plus-all-red change-and-clearance interval (intergreen) (Y, s)
	Offset (if appropriate)
	Maximum, minimum green, passage times, phase recall (for actuated control)
	Pedestrian push button
	Minimum pedestrian green (G_p, s)
	Phase plan

136

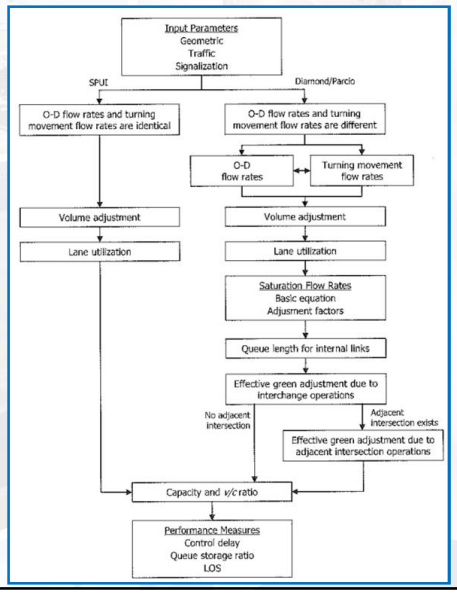
FDOT HCS 2010

Interchanges

Methodology

- *HCM 2010*

  Exhibit 22-14

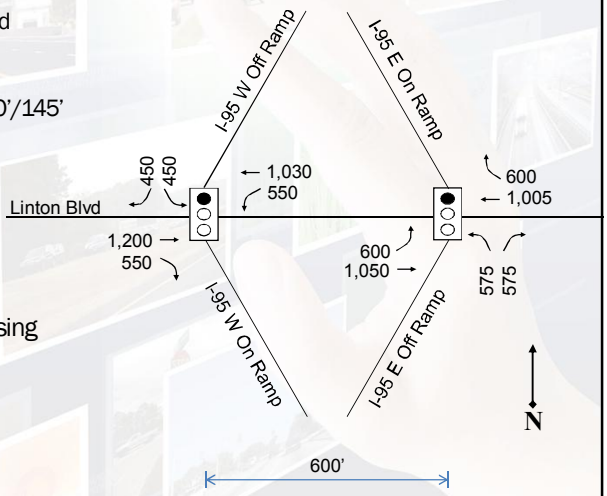


FDOT HCS 2010

Urban Streets - Interchanges

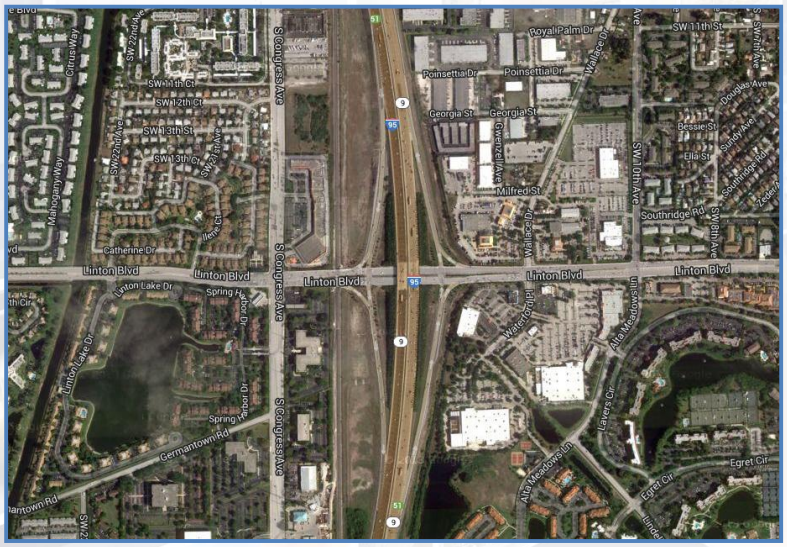
Example #7: Linton Blvd and I-95 Ramp Interchange

- Forward direction – eastbound
- Diamond interchange
- 40 MPH speed limit
- Upstream width EB/WB – 170'/145'
- Segment default values
  - Cycle length: 90 sec
  - Minimum green: 5 sec
  - Yellow change: 4 sec
  - Red clearance: 1 sec
  - PHF = 0.92
- 6% heavy vehicles
- Protected/Permissive Phasing



FDOT HCS 2010

Urban Streets - Interchanges



FDOT HCS 2010

Urban Streets - Interchanges

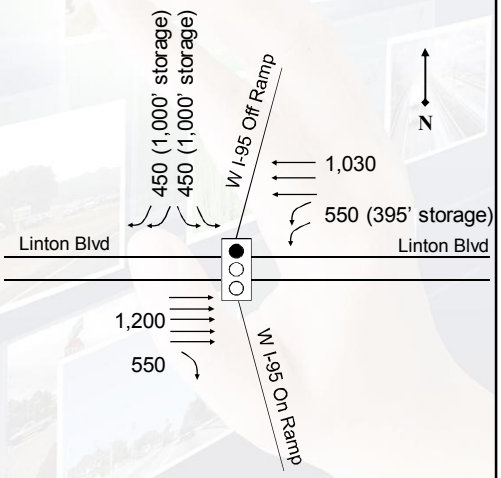
Example #7 (cont): Linton Blvd and W I-95 Ramp

- PHF – 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 SB
- Cycle length – 90 sec. (Actuated)
- Coordinated intersection

Phase Approach	1 WBL	2 EB	4 SB	6 WB
Split	10	55	25	65
Yellow	4.0	4.0	4.0	4.0
Red	1.0	1.0	1.0	1.0
Min. Green	5	5	5	5
Recall Mode	Off	Min	Off	Min

Interchange Inputs

Movement	EBR	WBL	SBL	SBR
Turn Radius	250	125	100	150



FDOT HCS 2010

Urban Streets - Interchanges

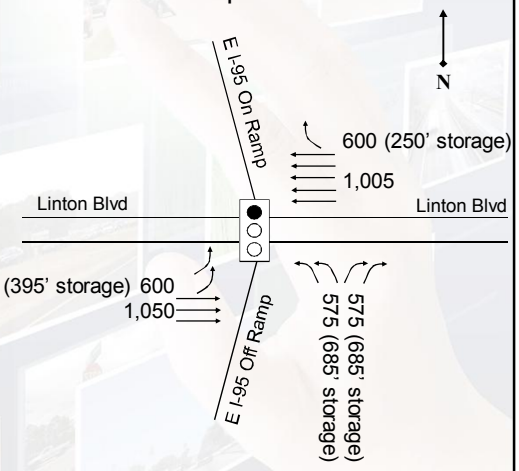
Example #7 (cont): Linton Blvd and E I-95 Ramp

- PHF – 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 NB
- Cycle length – 90 sec. (Actuated)
- Coordinated intersection – 10s offset

Phase Approach	2 EB	5 EBL	6 WB	8 NB
Split	65	10	55	25
Yellow	4.0	4.0	4.0	4.0
Red	1.0	1.0	1.0	1.0
Min. Green	5	5	5	5
Recall Mode	Min	Off	Min	Off

Interchange Inputs

Movement	EBL	WBR	NBL	NBR
Turn Radius	100	175	100	175



141

FDOT HCS 2010

Urban Streets - Interchanges

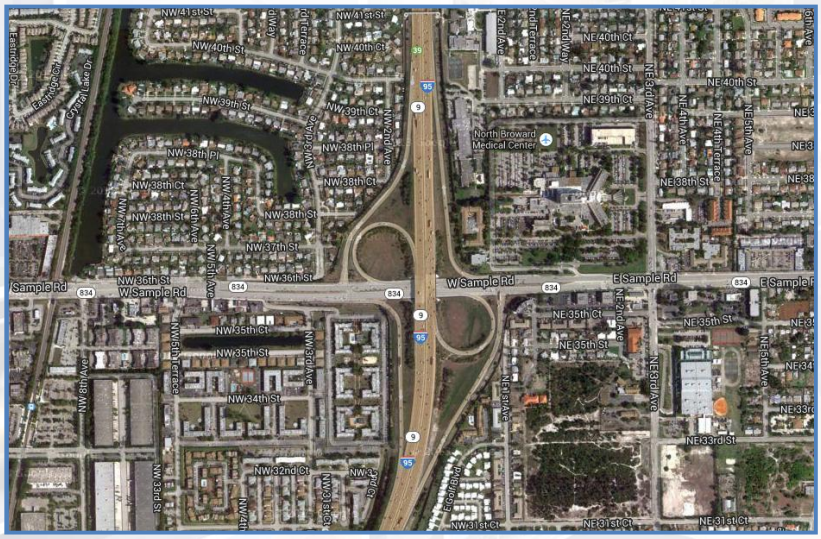
Workshop #13: Sample Rd and I-95 Ramp Interchange

- Forward direction – eastbound
- Parclo A-4 Quadrant interchange
- 45 MPH speed limit
- Upstream width EB/WB – 110'/135'
- Segment default values
  - Cycle length: 90 sec
  - Minimum green: 5 sec
  - Yellow change: 4 sec
  - Red clearance: 1 sec
  - PHF = 0.92
- 6% heavy vehicles

142

FDOT HCS 2010

Urban Streets - Interchanges

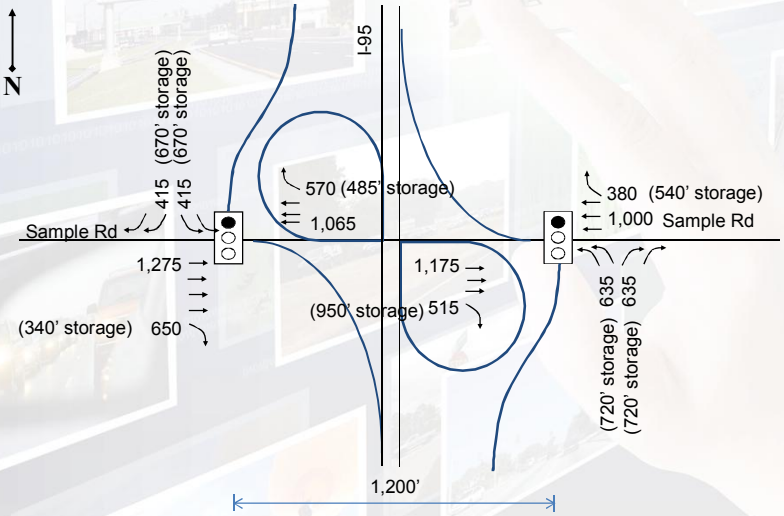


143

FDOT HCS 2010

Urban Streets - Interchanges

Workshop #13 (cont): Sample Rd and I-95 Ramp Interchange



144

FDOT HCS 2010

Urban Streets - Interchanges

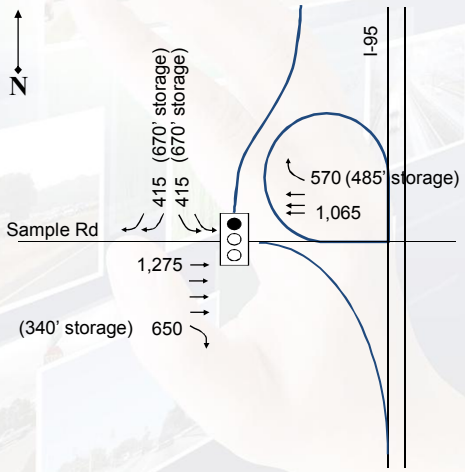
Workshop #13 (cont): Sample Rd and W I-95 Ramp

- PHF – 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 SB
- Cycle length – 90 sec. (Actuated)
- Coordinated intersection

Phase Approach	2 EB	4 SB	6 WB
Split	60	30	60
Yellow	4.0	4.0	4.0
Red	1.0	1.0	1.0
Min. Green	5	5	5
Recall Mode	Min	Off	Min

Interchange Inputs

Movement	EBR	WBR	SBL	SBR
Turn Radius	225	250	300	300



145

FDOT HCS 2010

Urban Streets - Interchanges

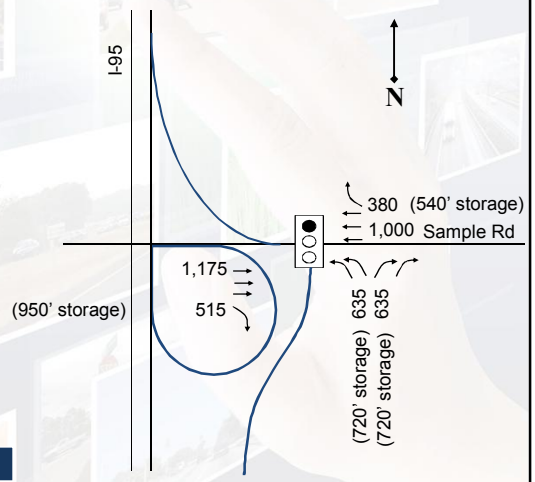
Workshop #13 (cont): Sample Rd and E I-95 Ramp

- PHF – 0.92 for all movements
- 6% heavy vehicles for all movements
- No pedestrians
- Arrival type 4 EB/WB, 3 NB
- Cycle length – 90 sec. (Actuated)
- Coordinated intersection – 18s offset

Phase Approach	2 EB	6 WB	8 NB
Split	55	55	35
Yellow	4.0	4.0	4.0
Red	1.0	1.0	1.0
Min. Green	5	5	5
Recall Mode	Min	Min	Off

Interchange Inputs

Movement	EBR	WBR	NBL	NBR
Turn Radius	250	200	350	350



146

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments ◄
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

147

FDOT HCS 2010

Basic Freeway Segments

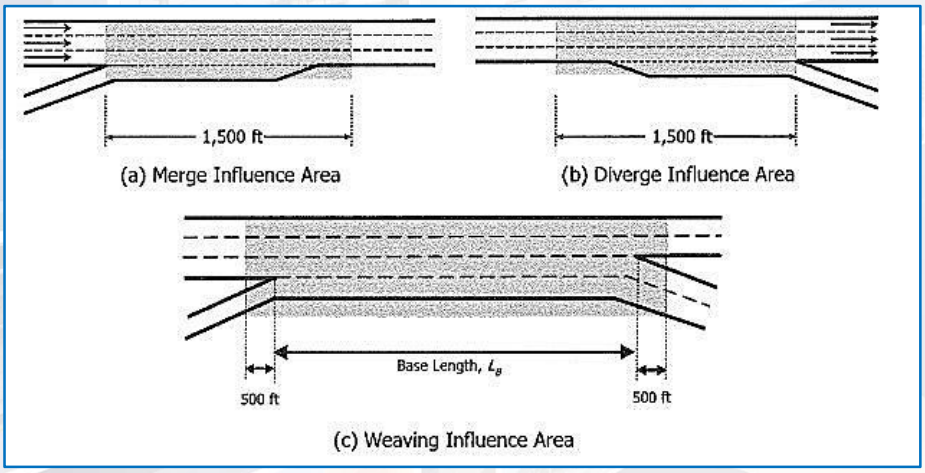
- Chapter 11 – *HCM 2010*
- Freeway segments without influence from
  - Merging (1,500 feet downstream)
  - Diverging (1,500 feet upstream)
  - Weaving (500 feet upstream/downstream)
- Uniform segments under base conditions
  - Good weather/visibility
  - No incidents/work zone activity/pavement deterioration
- Level-of-service criteria
  - Density (passenger cars/mile/lane)
- New in 2010: New speed-flow curve for 75 mph

148

FDOT HCS 2010

Basic Freeway Segments

- *HCM 2010* Exhibit 10-1

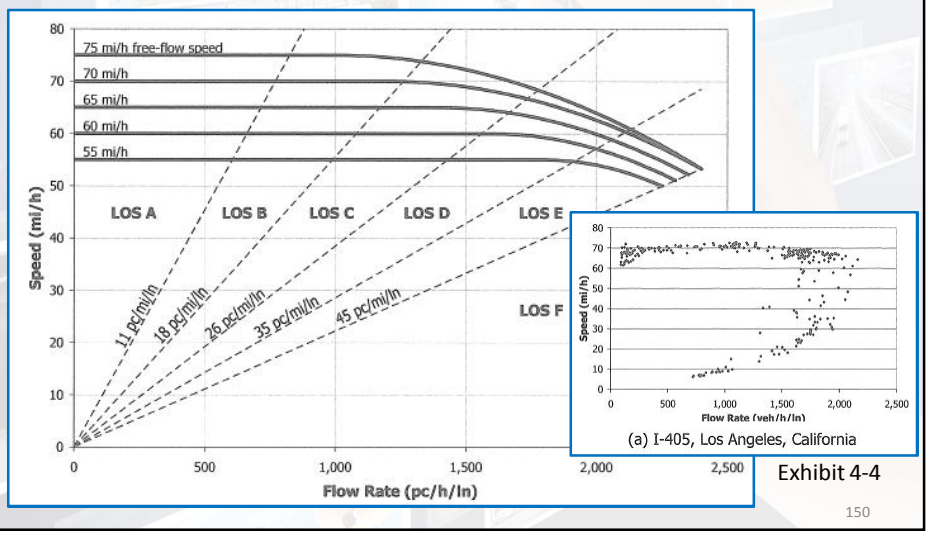


149

FDOT HCS 2010

Basic Freeway Segments

- *HCM 2010* Exhibit 11-6



(a) I-405, Los Angeles, California

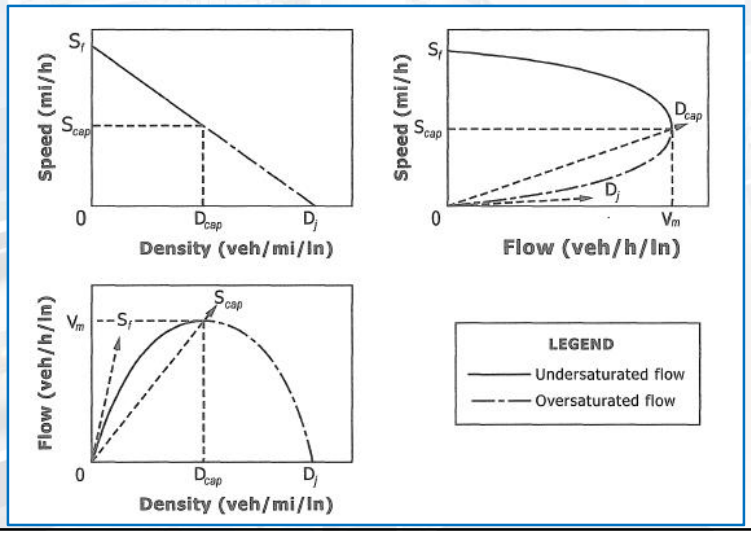
Exhibit 4-4

150

FDOT HCS 2010

Speed, Flow, Density Relationships

- *HCM 2010* Exhibit 4-3

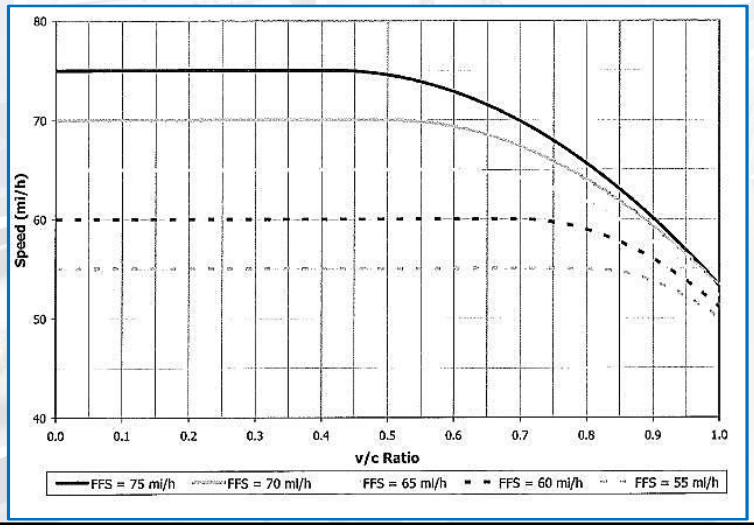


151

FDOT HCS 2010

Basic Freeway Segments

- *HCM 2010* Exhibit 11-14



152

FDOT HCS 2010

Basic Freeway Segments

- *HCM 2010* Exhibit 11-5 (LOS for Automobiles)

LOS	Density (pc/mi/ln)
A	≤11
B	>11–18
C	>18–26
D	>26–35
E	>35–45
F	Demand exceeds capacity >45

153

FDOT HCS 2010

Basic Freeway Segments

Required Data

- Number of lanes, lane widths and lateral clearance
- Free-flow speed (FFS)
- Ramp density (ramps/mile)
  - On and off ramps (one direction) 3 miles upstream and 3 miles downstream of segment midpoint, divided by 6 miles
- Terrain
  - Level, rolling, mountainous, or length/percent grade
- Demand data
  - AADT, K factor and directional distribution (planning level)
  - Peak hour volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

154

FDOT HCS 2010

Basic Freeway Segments

Limitations

- Special lanes and lane control
  - HOV lanes, truck lanes, climbing lanes and lane changing restrictions
- Free-flow speed (FFS) below 55 mph and above 75 mph
- Influence from downstream queues
- Posted speed limit and enforcement
- Impacts of Intelligent Transportation Systems (ITS)
- Operations in construction zones, near toll plazas and extended bridge/tunnel segments
- Oversaturated conditions

155

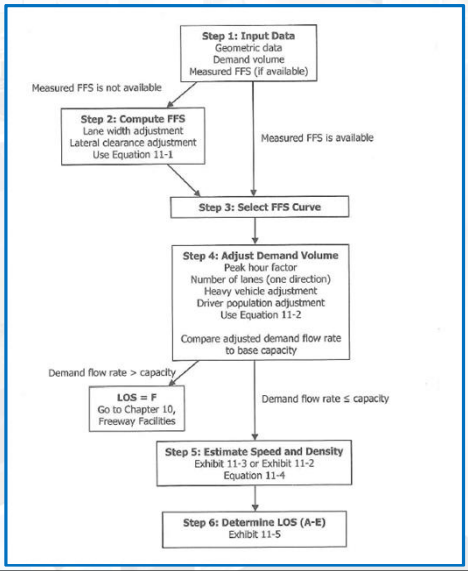
FDOT HCS 2010

Basic Freeway Segments

Methodology

- *HCM 2010*

  Exhibit 11-7



156

FDOT HCS 2010

Basic Freeway Segments

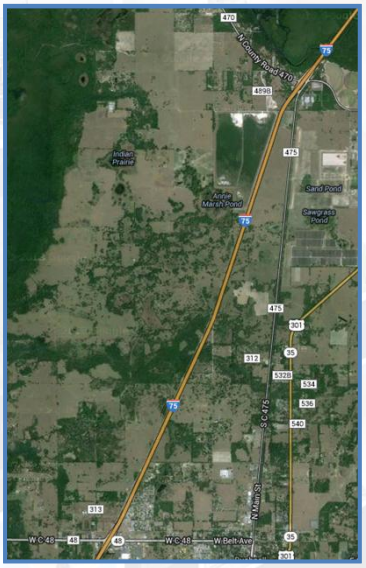
Example #8: I-75 NB from CR 470 to FL-48 (Bushnell, FL)

- Select "Operations" Analysis, utilize Planning Data
  - AADT – 37,700 veh/day
  - K – 10%
  - D – 56%
- PHF – 0.88
- 2-lane freeway
- Level terrain
- 20% trucks and buses
- 75.4 MPH base free-flow speed
  - Lane width – 12.0 ft
  - Right-side lateral clearance – 6.0 ft
  - Total ramp density – 4 ramps/6 mi = 0.66 ramps/mi

157

FDOT HCS 2010

Basic Freeway Segments



158

FDOT HCS 2010

Basic Freeway Segments

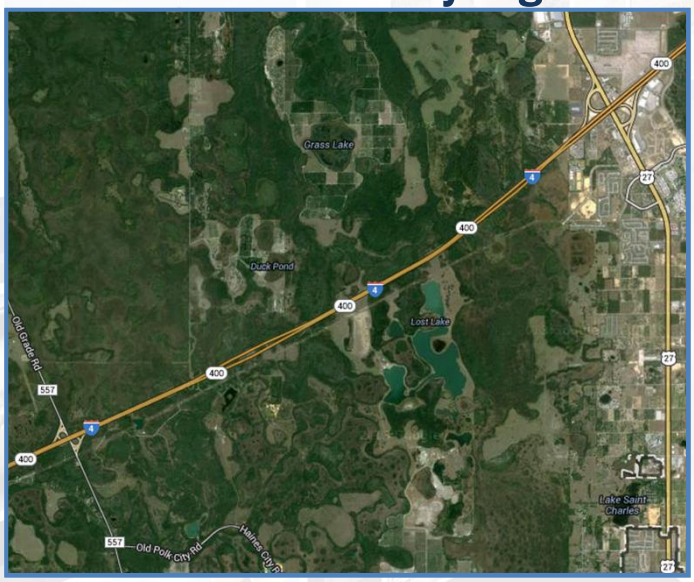
Workshop #14: I-4 EB from CR 557 to US-27 (Haines City, FL)

- Select "Operations" Analysis, utilize Planning Data
  - AADT – 77,500 veh/day
  - K – 9% (FDOT "standard K")
  - D – 52%
- 3-lane freeway
- PHF – 0.92
- Level terrain
- 14% trucks and buses
- 75.4 MPH base free-flow speed
  - Lane width – 11.0 ft
  - Right-side lateral clearance – 3.0 ft
  - Total ramp density – 0 ramps/6 mi = 0.0 ramps/mi

159

FDOT HCS 2010

Basic Freeway Segments



160

FDOT HCS 2010

Basic Freeway Segments

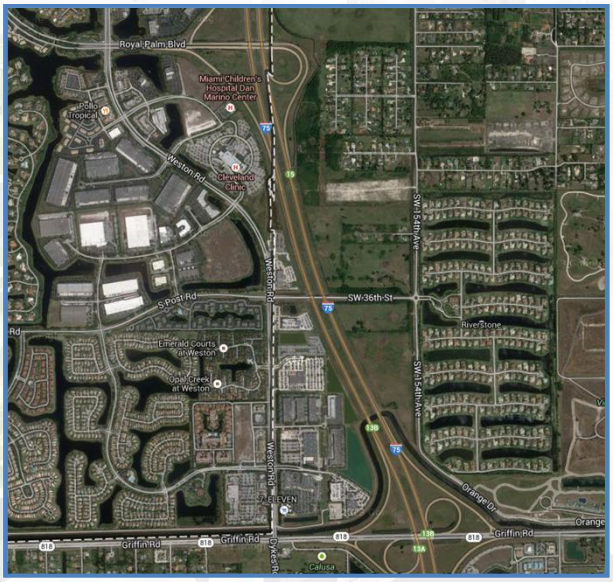
Workshop #15: I-75 NB from Griffin Rd to Royal Palm Blvd (Hollywood, FL)

- Select "Operations" Analysis, use Planning Data
  - AADT – 149,500 veh/day
  - K – 9% (FDOT "standard K")
  - D – 54%
- PHF – 0.94
- 4-lane freeway
- Level terrain
- 6% trucks and buses
- Primarily commuter traffic
- 75.4 MPH base free-flow speed
  - Lane width - 12.0 ft
  - Right-side lateral clearance – 6.0 ft
  - Total ramp density – 6 ramps/6 mi = 1.0 ramp/mi

161

FDOT HCS 2010

Basic Freeway Segments



162

FDOT HCS 2010

Basic Freeway Segments

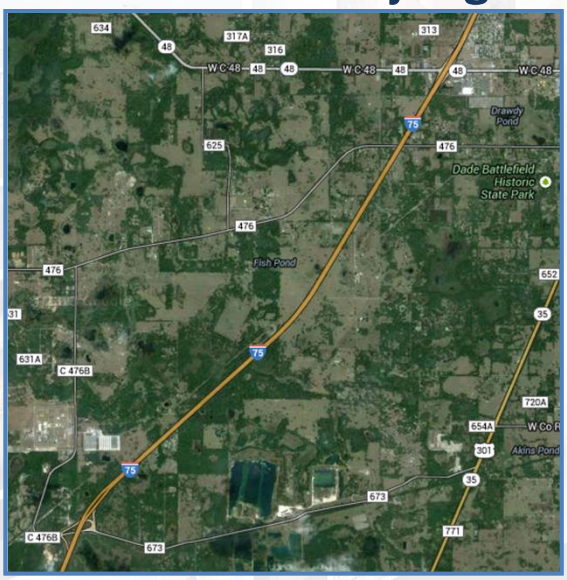
Workshop #16A: I-75 NB from CR 673 to FL-48 (Bushnell, FL)

- Select "Operations" analysis, but don't check "Planning Data"
- Volume – 1,950 veh/hr
- PHF – 0.88
- Level terrain
- 2-lane freeway
- 20% trucks and buses
- 75.4 MPH base free-flow speed
  - Lane width – 11.0 ft
  - Right-side lateral clearance – 6.0 ft
  - Total ramp density – 4 ramps/6 mi = 0.66 ramps/mi

163

FDOT HCS 2010

Basic Freeway Segments



164

FDOT HCS 2010

Basic Freeway Segments

Workshop #16B: I-75 NB from CR 673 to FL-48 (Bushnell, FL)

- Rather than Operations, select Design as the analysis type
  - Check box to enable Planning Data input fields
- Input same basic characteristics as Workshop #15A

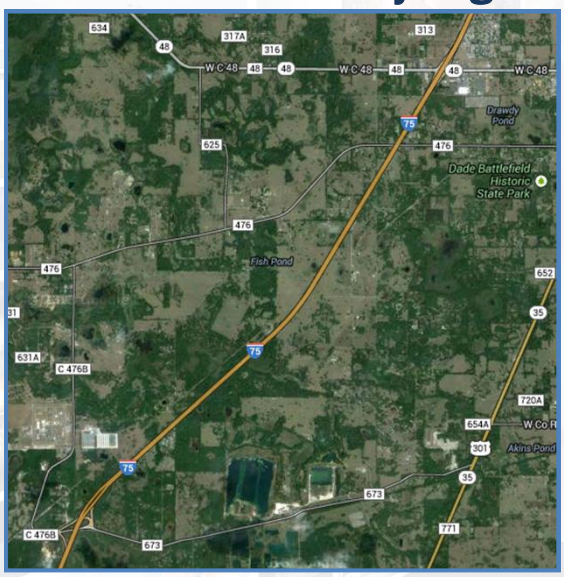
How many lanes are required for LOS C?

- Assume:
  - AADT = 76,000 veh/day
  - K = 10%
  - D = 55%

165

FDOT HCS 2010

Basic Freeway Segments



166

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments ◀
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

167

FDOT HCS 2010

Weaving Segments

- Chapter 12 – *HCM 2010*
- Merge segments closely followed by diverge segments
- Three geometric characteristics affect a weaving segment:
  - Length of weaving segment based on short length
  - Width of weaving segment
  - Configuration
- Level-of-service criteria
  - Density (passenger cars/mile/lane)
- New methodology in *HCM 2010* based on NCHRP 3-75
  - LOS F threshold changes

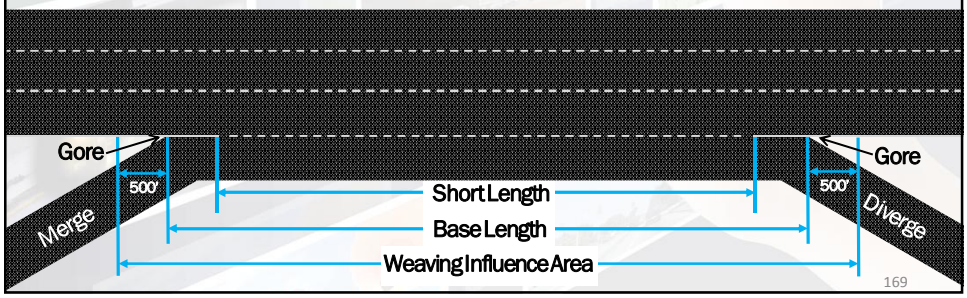
168

FDOT HCS 2010

Weaving Segments

Terminology

- Length of Weaving Segment: Distance between the merge and diverge that form the weaving segment
  - Short Length: Distance between barrier markings
  - Base Length: Gore to gore length



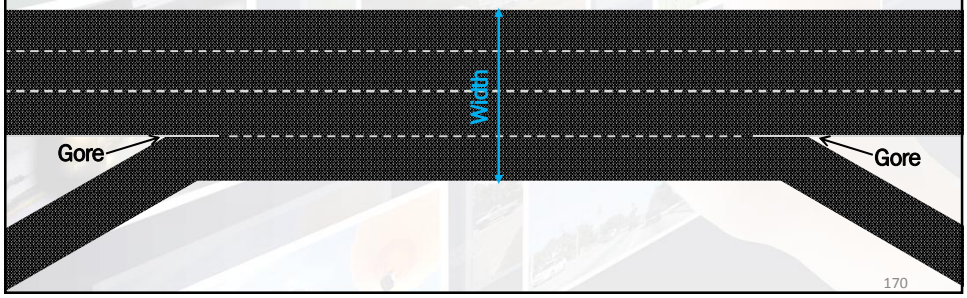
169

FDOT HCS 2010

Weaving Segments

Terminology

- Width of Weaving Segment : Number of continuous lanes within a weaving segment
  - Number of lanes between the entry and exit gore



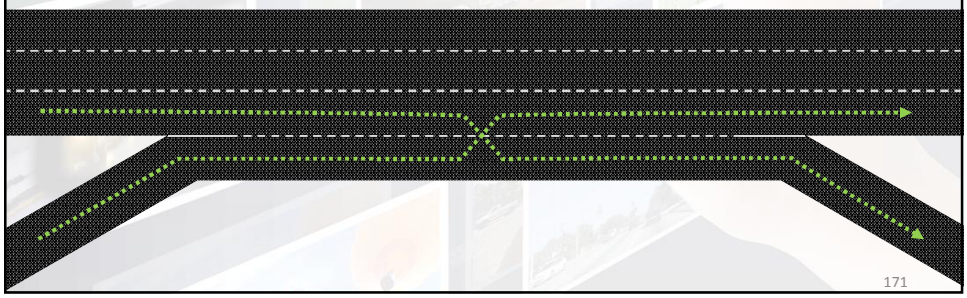
170

FDOT HCS 2010

Weaving Segments

Terminology

- One-Sided Weaving Segment: Weaving maneuvers require no more than two lane changes
- One-sided ramp weave shown



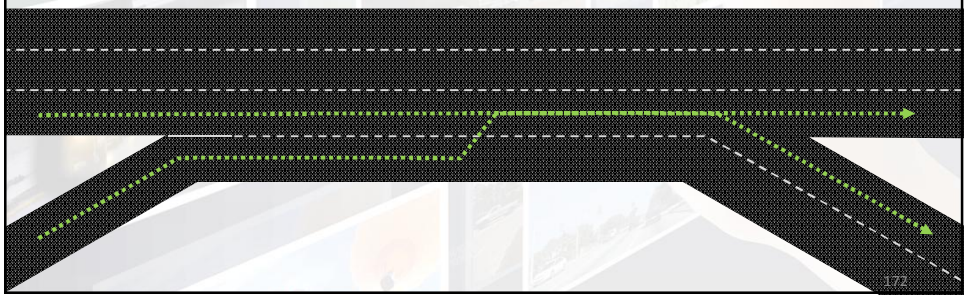
171

FDOT HCS 2010

Weaving Segments

Terminology

- One-Sided Weaving Segment: Weaving maneuvers require no more than two lane changes
- One-sided major weave shown



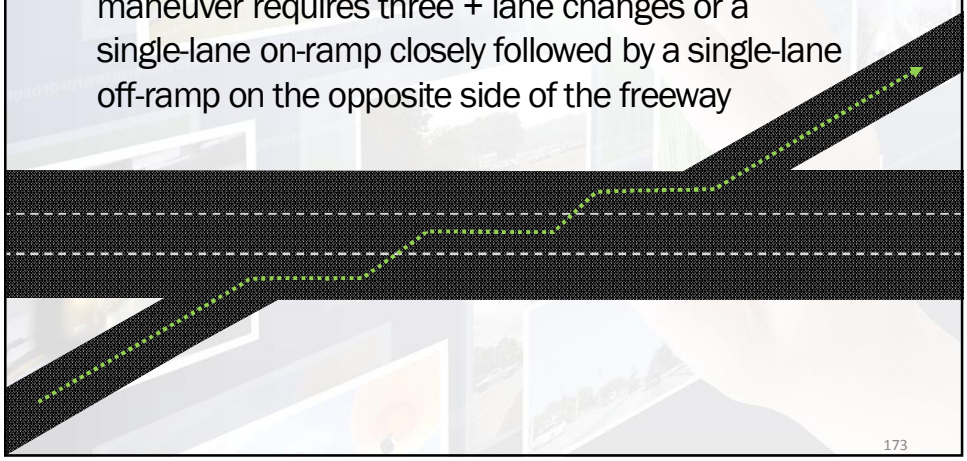
172

FDOT HCS 2010

Weaving Segments

Terminology

- Two-Sided Weaving Segment: At least one weaving maneuver requires three + lane changes or a single-lane on-ramp closely followed by a single-lane off-ramp on the opposite side of the freeway



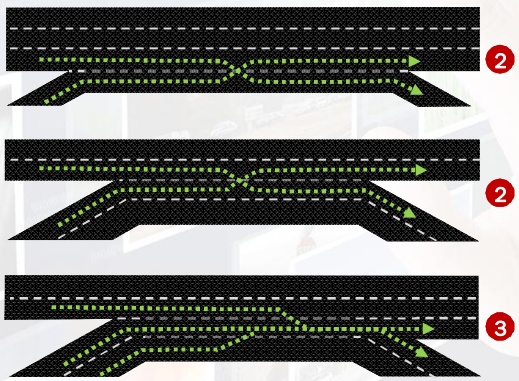
173

FDOT HCS 2010

Weaving Segments

Maneuver Lanes

- Number of lanes from which a weaving maneuver may be completed with one lane change or no lane changes



174

FDOT HCS 2010

Weaving Segments

Minimum Lane Changes

- Minimum number of lane changes that must be made by a single weaving vehicle to successfully execute a:
  - Ramp to Freeway maneuver
  - Freeway to Ramp maneuver
  - Ramp to Ramp maneuver

Assume that every weaving vehicle enters in the lane closest to their desired exit leg and leaves the segment in the lane closest to their entry leg. This is only applicable for one-sided weaving segments.

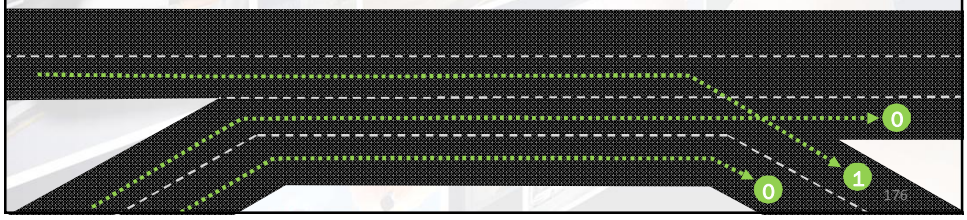
175

FDOT HCS 2010

Weaving Segments

Minimum Lane Changes

- Ramp to Freeway
- Freeway to Ramp
- Ramp to Ramp



176

FDOT HCS 2010

Weaving Segments

- *HCM 2010* Exhibit 12-10 (LOS for Automobiles)

LOS	Density (pc/mi/ln) Freeway Weaving Segments	Weaving Segments on Multilane Highways or C-D Roadways
A	0–10	0–12
B	>10–20	>12–24
C	>20–28	>24–32
D	>28–35	>32–36
E	>35	>36
F	Demand exceeds capacity	

177

FDOT HCS 2010

Weaving Segments

Required Data

- Roadway configuration
  - Number of lanes on entry and exit legs
  - Number of lanes within weaving segment
  - Length of roadway segment
- Demand data
  - Volumes and PHF
    - Freeway to freeway, freeway to ramp, ramp to freeway, and ramp to ramp
  - Percentage of heavy vehicles

178

FDOT HCS 2010

Weaving Segments

Limitations

- Special lanes within weaving segment
  - HOV lanes, truck lanes, climbing lanes
- Ramp metering
- Influence from downstream congestion
- Posted speed limit and enforcement
- Impacts of Intelligent Transportation Systems (ITS)
- Weaving segments on arterials or urban streets
- Oversaturated conditions
- Multiple weaving segments

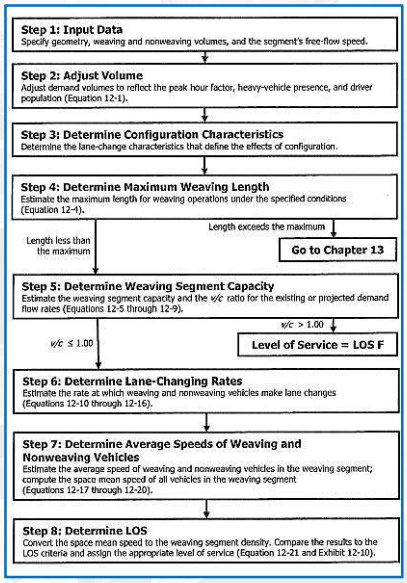
179

FDOT HCS 2010

Weaving Segments

Methodology

- *HCM 2010* Exhibit 12-6



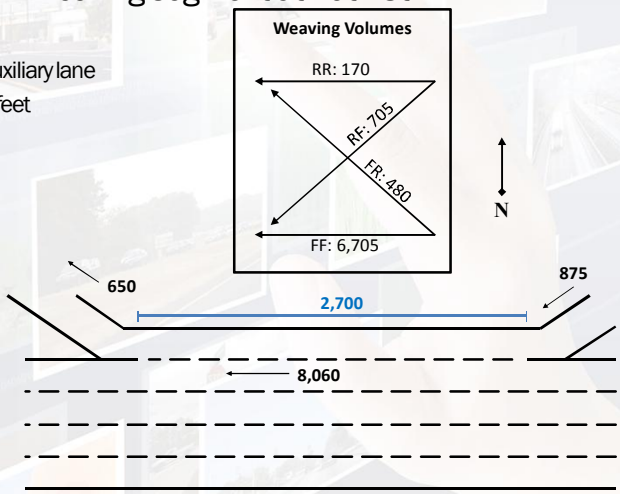
180

FDOT HCS 2010

Weaving Segments

Example #9: I-95 NB weaving segment at 10th St (Deerfield Beach, FL)

- 4-lane mainline, 1-lane auxiliary lane
- Segment length – 2,700 feet
- 70 mph FFS
- 55 mph ramp FFS
- 15 mph minimum speed
- PHF – 0.92
- 7% trucks and buses
- 1.3 interchanges/mile



I-95 Weaving Segment

181

FDOT HCS 2010

Weaving Segments

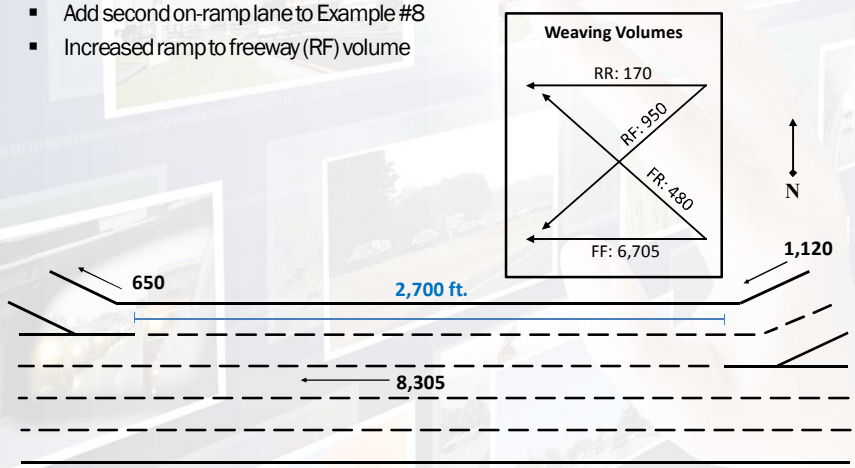
182

FDOT HCS 2010

Weaving Segments

Workshop #17: Sample Weaving Segment

- Add second on-ramp lane to Example #8
- Increased ramp to freeway (RF) volume



183

FDOT HCS 2010

Weaving Segments

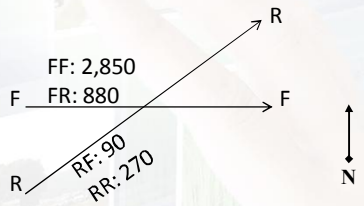
184

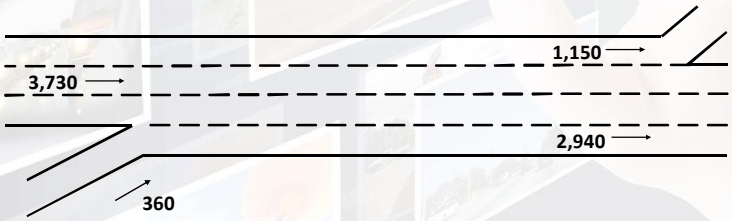
FDOT HCS 2010

Weaving Segments

Workshop #18: Sample Weaving Segment

- 3-lane mainline, 1-lane ramps
- Segment length – 2,000 feet
- 70 mph free-flow speed
- 15 mph minimum speed
- PHF – 0.90
- 5% trucks and buses
- 1.0 interchange/mile





185

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments
  - Merge and diverge segments ◀
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments

186

FDOT HCS 2010

Merge/Diverge Segments

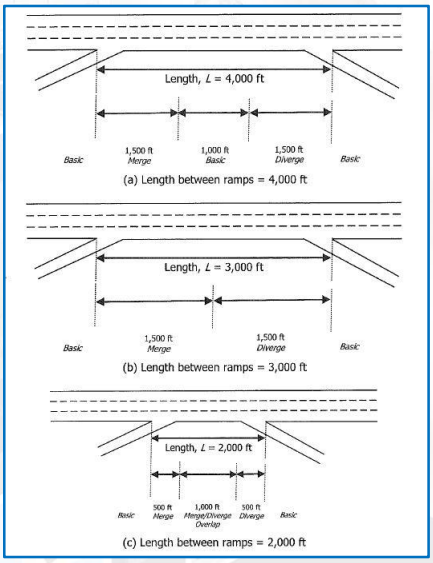
- Chapter 13 – *HCM 2010*
- At ramp junctions on freeways without control
- Influence area
  - Merging (1,500 feet downstream of merge point)
  - Diverging (1,500 feet upstream of diverge point)
- Segments under base conditions
  - Good weather/visibility
  - No incidents/work zone activity/pavement deterioration
  - 12 foot lanes and adequate lateral clearances
- Level-of-service criteria
  - Density (passenger cars/mile/lane)

187

FDOT HCS 2010

Merge/Diverge Segments

- *HCM 2010*
  Exhibit 10-12

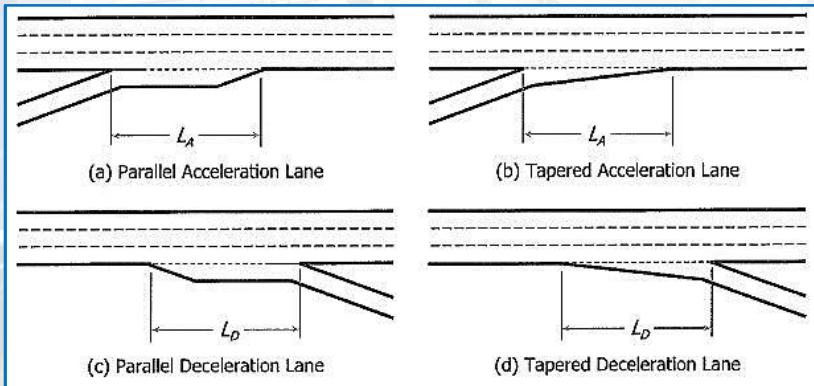


188

FDOT HCS 2010

Merge/Diverge Segments

- *HCM 2010* Exhibit 13-3



189

FDOT HCS 2010

Merge/Diverge Segments

- *HCM 2010* Exhibit 13-2 (LOS for Automobiles)

LOS	Density (pc/mi/ln)	Comments
A	≤10	Unrestricted operations
B	>10–20	Merging and diverging maneuvers noticeable to drivers
C	>20–28	Influence area speeds begin to decline
D	>28–35	Influence area turbulence becomes intrusive
E	>35	Turbulence felt by virtually all drivers
F	Demand exceeds capacity	Ramp and freeway queues form

190

FDOT HCS 2010

Merge/Diverge Segments

Required Data

- Freeway information
  - Number of lanes
  - Free-flow speed ranging from 55 mph to 75 mph
  - Terrain: level, rolling, mountainous, or length/percent grade
- Ramp information
  - Type of ramp and side of junction (right- or left-hand)
  - Number of lanes, length of acceleration/deceleration lane(s)
  - Free-flow speed ranging from 20 mph to 50 mph
  - Terrain: level, rolling, mountainous, or length/percent grade

191

FDOT HCS 2010

Merge/Diverge Segments

Required Data (cont)

- Demand data
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

192

FDOT HCS 2010

Merge/Diverge Segments

Limitations

- Special lanes including HOV lanes
- Ramp metering
- Posted speed limit and enforcement
- Impacts of Intelligent Transportation Systems (ITS)

193

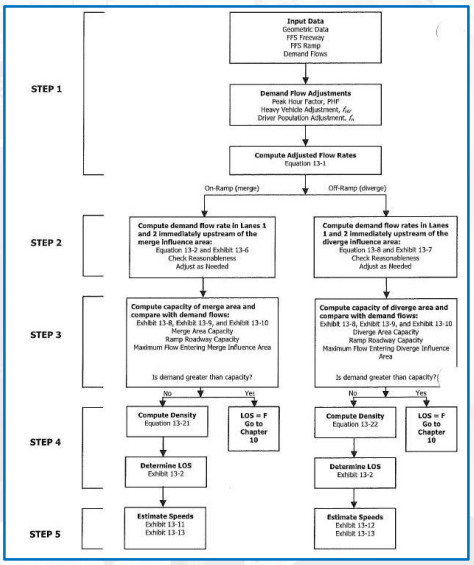
FDOT HCS 2010

Merge/Diverge Segments

Methodology

- *HCM 2010*

  Exhibit 13-4



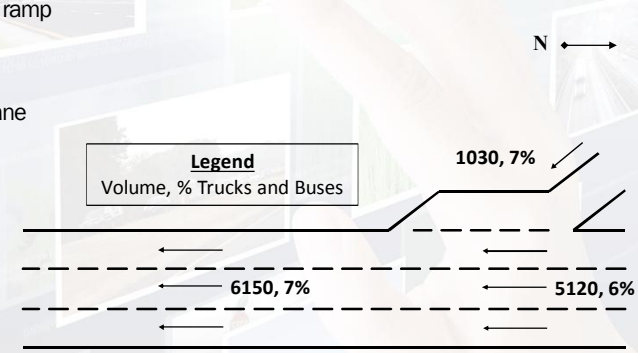
194

FDOT HCS 2010

Merge/Diverge Segments

Example #10: I-75 SB/Griffin Road merge (Hollywood, FL)

- 3-lane mainline, 1-lane ramp
- 70 mph mainline FFS
- 40 mph ramp FFS
- 1130 ft. acceleration lane
- PHF – 0.94
- 1% grade for 0.5 miles

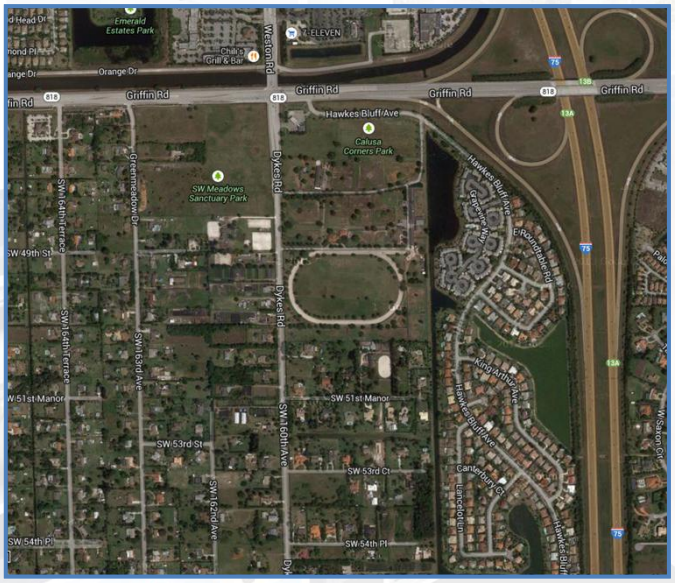


I-75 / Griffin Road Merge

195

FDOT HCS 2010

Merge/Diverge Segments



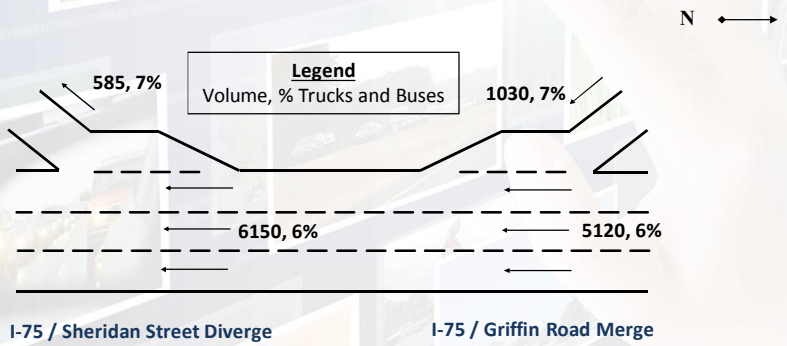
196

FDOT HCS 2010

Merge/Diverge Segments

Workshop #19: I-75 SB merge
(Hollywood, FL)

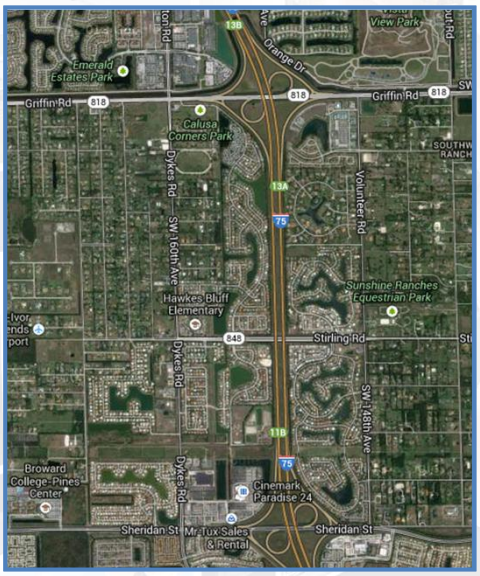
- Now, take into account the downstream off-ramp (6,800 ft. away)



197

FDOT HCS 2010

Merge/Diverge Segments



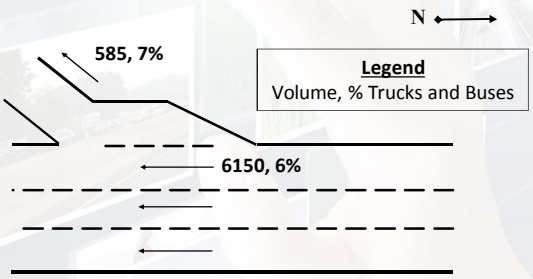
198

FDOT HCS 2010

Merge/Diverge Segments

Workshop #20: I-75 SB /Sheridan Street diverge (Hollywood, FL)

- 3-lane mainline, 1-lane ramp
- 70 mph mainline FFS
- 40 mph ramp FFS
- 480 ft. deceleration lane
- PHF – 0.94
- Level terrain

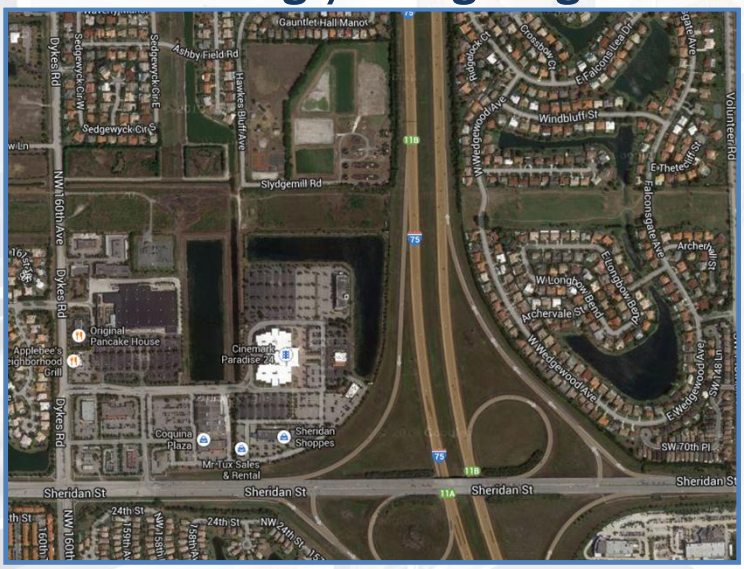


I-75 / Sheridan Street Diverge

199

FDOT HCS 2010

Merge/Diverge Segments



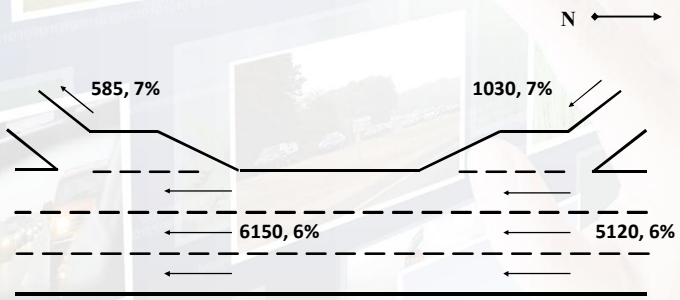
200

FDOT HCS 2010

Merge/Diverge Segments

Workshop #21: I-75 SB/Sheridan Street diverge (Hollywood, FL)

- Now, take into account the upstream on-ramp (2,000 ft. away)



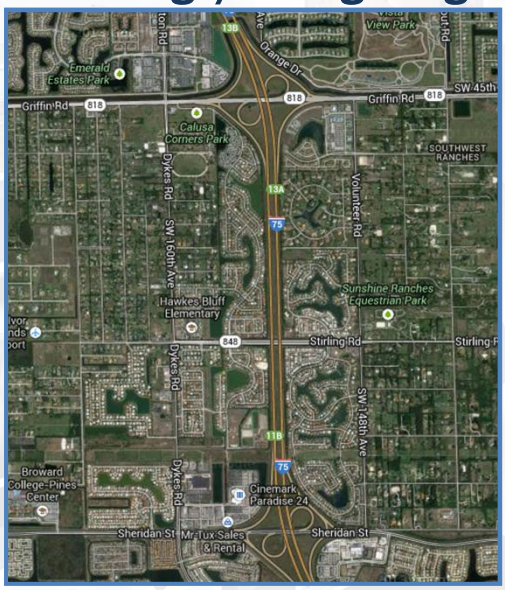
I-75 / Sheridan Street diverge

I-75 / Griffin Road merge

201

FDOT HCS 2010

Merge/Diverge Segments



202

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- **Freeways**
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - **Freeway facilities** ◀
- Multi-lane highway segments
- Two-lane highway segments

203

FDOT HCS 2010

Freeway Facilities

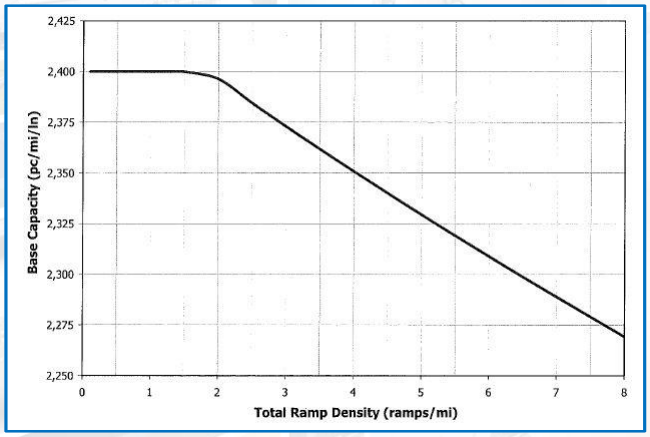
- Chapter 10 – *HCM 2010*
- Extended lengths of freeways
  - Including continuously connected basic freeway, weaving, merge, and diverge segments
- Multiple and continuous 15-min time periods
- Accounts for the spreading of impacts of breakdowns
- Freeway facility capacity is based on the capacity of the critical segment
  - Critical segment – the segment that will breakdown first
- Level-of-service criteria
  - Density (passenger cars/mile/lane)

204

FDOT HCS 2010

Freeway Facilities

- *HCM 2010* Exhibit 10-6



205

FDOT HCS 2010

Freeway Facilities

- *HCM 2010* Exhibit 10-7 (LOS for Automobiles)

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

206

FDOT HCS 2010

Freeway Facilities

Required Data

- Freeway information
  - Number of lanes, free flow speed (FFS) - 55 mph to 75 mph
  - Terrain: level, rolling, mountainous, or length/percent grade
- Ramp information
  - Type of ramp and side of junction (right- or left-hand)
  - Number of lanes, length of acceleration/deceleration lane(s)
  - Free-flow speed ranging from 20 mph to 50 mph
  - Terrain: level, rolling, mountainous, or length/percent grade

207

FDOT HCS 2010

Freeway Facilities

Required Data

- Demand Data
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

208

FDOT HCS 2010

Freeway Facilities

Limitations

- Multiple overlapping breakdowns or bottlenecks
- The effects of traffic management strategies
- System-wide oversaturation flow conditions
- Conditions where demand-to-capacity ratios > 1.00
- HOV Lanes
  - HOV operating characteristics and their effect on rest of freeway
  - The interaction between HOV lanes and mixed-flow lanes
- The effects of off-ramp capacity issues
- The effects of toll plaza operations

209

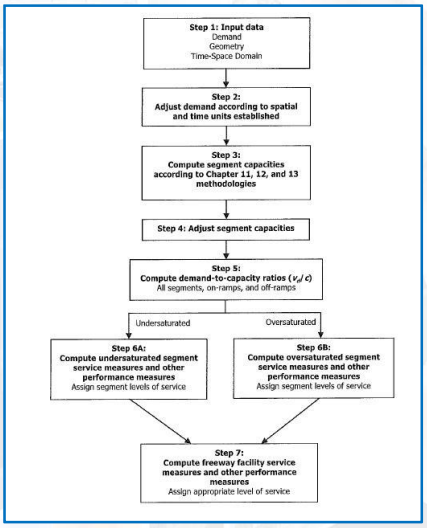
FDOT HCS 2010

Freeway Facilities

Methodology

- *HCM 2010*

  Exhibit 10-10



210

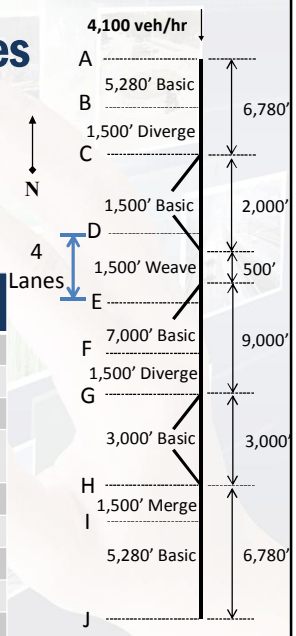
FDOT HCS 2010

Freeway Facilities

Example #11: I-95 SB (Jacksonville, FL)

- 3-lane freeway
- Level terrain
- 70 mph freeway FFS
- 40 mph ramp FFS
- 10% trucks

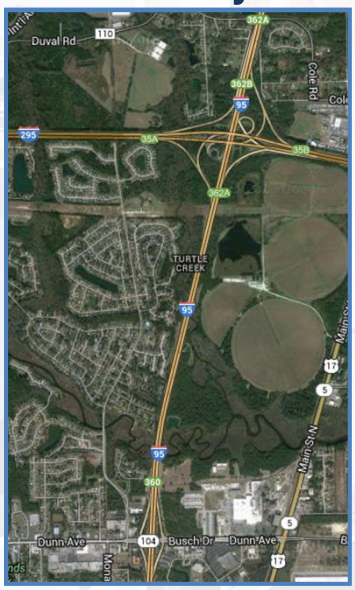
Segment	Name	Type	Length (ft.)	Mainline Volume	Ramp Volume	Acc / Dec Length (ft.)
1	A-B	Basic	5,280	4,100	-	-
2	B-C	Off-Ramp	1,500	4,100	1,700	850
3	C-D	Basic	1,500	2,400	-	-
4	D-E	Weaving	1,500	2,600	On: 200 Off: 400	-
5	E-F	Basic	7,000	2,200	-	-
6	F-G	Off-Ramp	1,500	2,200	500	600
7	G-H	Basic	3,000	1,700	-	-
8	H-I	On-Ramp	1,500	2,600	900	600
9	I-J	Basic	5,280	2,600	-	-



211

FDOT HCS 2010

Freeway Facilities



212

FDOT HCS 2010

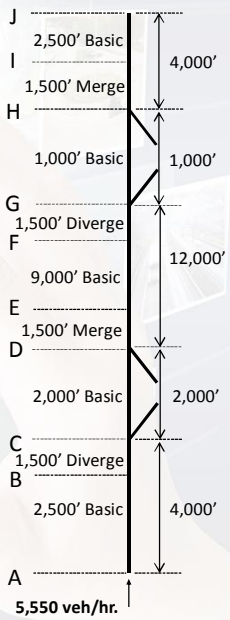
Freeway Facilities

Workshop #22: NB I-275 (Tampa, FL)

- 3-lane freeway
- Level terrain
- 75 mph freeway FFS
- 40 mph ramp FFS
- 8% trucks on mainline
- 3% trucks on ramps

N

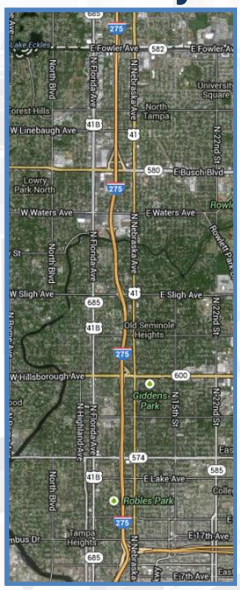
Segment	Name	Type	Length (ft.)	Mainline Volume	Ramp Volume	Acc / Dec Length (ft.)
1	A-B	Basic	2,500	5,550	-	-
2	B-C	Off-Ramp	1,500	5,550	550	450
3	C-D	Basic	2,000	5,000	-	-
4	D-E	On-Ramp	1,500	6,000	1,000	700
5	E-F	Basic	9,000	6,000	-	-
6	F-G	Off-Ramp	1,500	6,000	250	450
7	G-H	Basic	1,000	5,750	-	-
8	H-I	On-Ramp	1,500	6,750	1,000	900
9	I-J	Basic	2,500	6,750	-	



213

FDOT HCS 2010

Freeway Facilities



214

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- **Multi-lane highway segments** ◀
- Two-lane highway segments

215

FDOT HCS 2010

Multi-Lane Highways

- Chapter 14 – *HCM 2010*
- For situations where signalized intersections are 2 miles or more apart
  - Use urban streets module where signals are more closely spaced
- Four- to six-lane facilities
  - Divided and undivided including two-way left-turn lane (TWLTL)
- Level-of-service criteria
  - Density (automobiles)
  - Bicycle LOS Score (bicycles)

216

FDOT HCS 2010

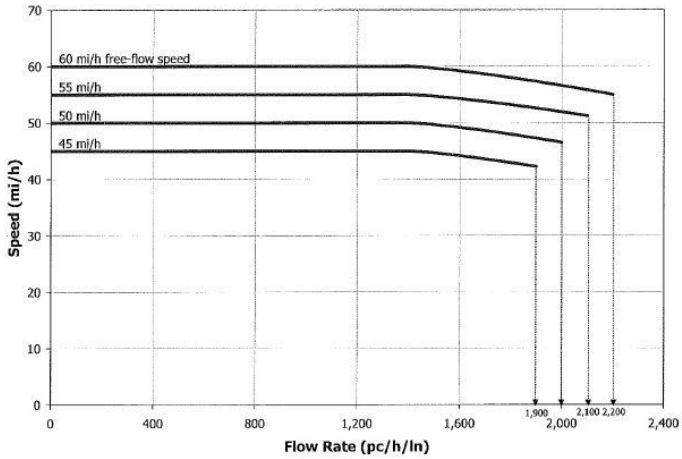
Multi-Lane Highways

217

FDOT HCS 2010

Multi-Lane Highways

- *HCM 2010* Exhibit 14-2



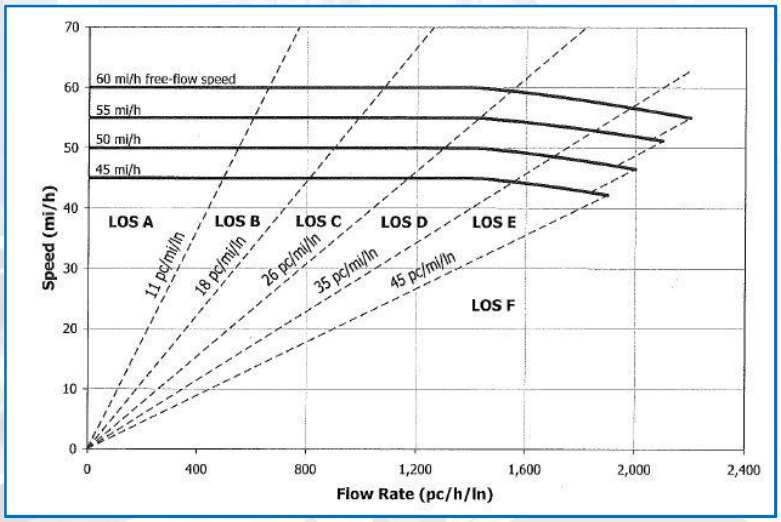
Note: Maximum densities for LOS E occur at a *v/c* ratio of 1.00. These are 40, 41, 43, and 45 pc/mi/ln for FFSs of 60, 55, 50, and 45 mi/h, respectively.

218

FDOT HCS 2010

Multi-Lane Highways

- *HCM 2010* Exhibit 14-5



219

FDOT HCS 2010

Multi-Lane Highways

- *HCM 2010* Exhibit 14-4 (LOS for Automobiles)

LOS	FFS (mi/h)	Density (pc/mi/ln)
A	All	>0–11
B	All	>11–18
C	All	>18–26
D	All	>26–35
E	60	>35–40
	55	>35–41
	50	>35–43
	45	>35–45
F	Demand Exceeds Capacity	
	60	>40
	55	>41
	50	>43
	45	>45

- *HCM 2010* Exhibit 14-6 (LOS for Bicycles)

LOS	Bicycle LOS Score
A	≤1.5
B	>1.5–2.5
C	>2.5–3.5
D	>3.5–4.5
E	>4.5–5.5
F	>5.5

220

FDOT HCS 2010

Multi-Lane Highways

Required Data

- Number of lanes, lane widths, and lateral clearance
- Median type: divided, TWLTL, or undivided
- Free-flow speed (FFS) between 45 and 60 mph
- Access-point density (accesses/mile) between 0 and 40
- Terrain type
  - Level, rolling, mountainous, or length/percent grade
- Demand data
  - AADT, K factor and directional distribution (planning level)
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Driver population factor

221

FDOT HCS 2010

Multi-Lane Highways

Limitations

- Free-flow speed less than 45 mph and more than 60 mph
- The effect of lane drops/additions
- Downstream queuing effects
- Differences between median treatments
  - Barriers, raised curb and TWLTL
- The presence of on-street parking
- Significant transit and pedestrian activity
- The impacts of weather and incidents

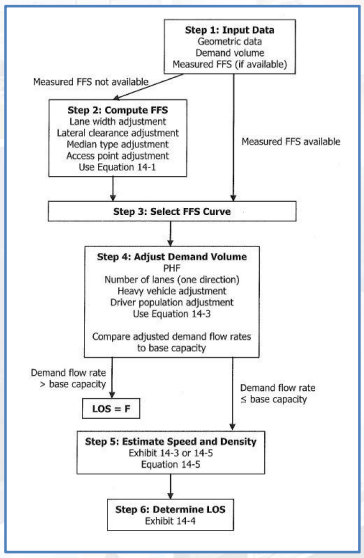
222

FDOT HCS 2010

Multi-Lane Highways

Methodology

- *HCM 2010* Exhibit 14-7



223

FDOT HCS 2010

Multi-Lane Highways

Example #12: US-19/27 from Avalon Rd to CR 14 (Lamont, FL)

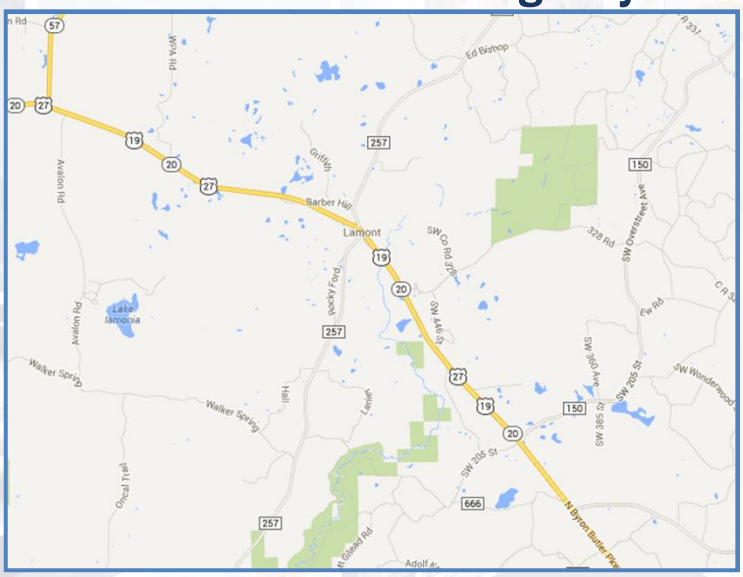
- 4-lane divided highway
- 65 mph base FFS
- 12 ft. lane width
- 6 ft. lateral clearance on both edges
- Level terrain

Direction	Southbound	Northbound
Access Points per Mile	2	3
Hourly Volume	260	220
PHF	0.88	0.88
Trucks and Buses	12%	16%

224

FDOT HCS 2010

Multi-Lane Highways



225

FDOT HCS 2010

Multi-Lane Highways

Workshop #23: SR 289 (Pensacola, FL)

- 4-lane undivided highway
- 50 MPH speed limit posted
  - 55 base free-flow speed
- 12 ft. lane width
- No lateral clearance on right edge
- Level terrain
- No on-street parking available
- Pavement rating: 5

Direction	Southbound	Northbound
Access Points per Mile	30	35
Hourly Volume	765	975
PHF	0.92	0.85
Trucks and Buses	5%	2%

226

FDOT HCS 2010

Multi-Lane Highways

FDOT HCS 2010

Multi-Lane Highways

Workshop #24: US-301 (Wildwood, FL)

- 4-lane highway with TWLTL
- 40 MPH speed limit posted
  - 45 MPH base free-flow speed
- 12 ft. lane width
- 8 ft. lateral clearance on right edge
- Level terrain
- No on-street parking available
- Pavement rating: 4

Direction	Southbound	Northbound
Access Points per Mile	18	23
Hourly Volume	690	890
PHF	0.94	0.90
Trucks and Buses	11%	13%

FDOT HCS 2010

Multi-Lane Highways

229

FDOT HCS 2010

Multi-Lane Highways

Workshop #25: SR 40 (Ormond Beach, FL)

- 4-lane divided highway
- 45 MPH posted speed limit
  - 50 MPH base free-flow speed
- 11 ft. lane width
- 6 ft. lateral clearance on left edge
- No clearance on right edge
- Level terrain
- Driver population factor: 0.90
- No on-street parking available
- Pavement rating: 3

Direction	Eastbound	Westbound
Access Points per Mile	11	15
Hourly Volume	1,840	1,130
PHF	0.84	0.78
Trucks and Buses	9%	20%

230

FDOT HCS 2010

Multi-Lane Highways

231

FDOT HCS 2010

Multi-Lane Highways

Workshop #26: US 27 (Haines City, FL)

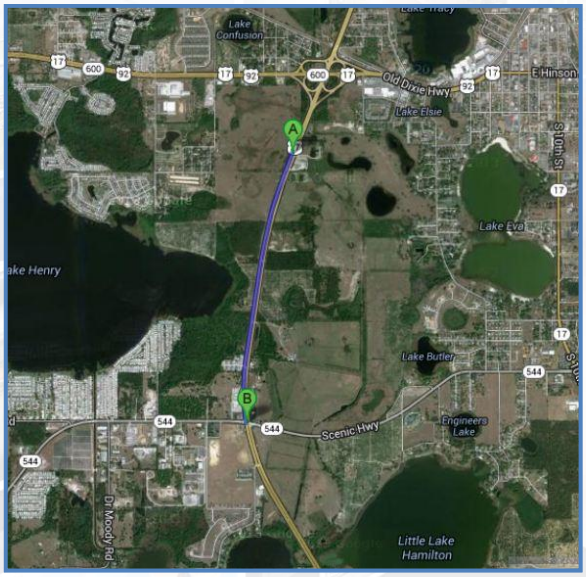
- 6-Lane divided highway
- 50 mph posted speed limit
  - 55 mph base free-flow speed
- 12 ft. lane width
- 6 ft. lateral clearance to the left and right
- Level terrain
- No on-street parking available
- Pavement rating: 4

Direction	Eastbound	Westbound
Access Points per Mile	8	8
Hourly Volume	1,845	1,845
PHF	0.92	0.92
Trucks and Buses	9%	9%

232

FDOT HCS 2010

Multi-Lane Highways



233

FDOT HCS 2010

Day 3 – Uninterrupted Flow (Mostly)

- Interchanges
- Freeways
  - Basic segments
  - Weaving segments
  - Merge and diverge segments
  - Freeway facilities
- Multi-lane highway segments
- Two-lane highway segments ◄

234

FDOT HCS 2010

Two-Lane Highways

- Chapter 15 – *HCM 2010*
- Roadway segments generally 2-3 miles from the nearest signalized intersection with a single lane in each direction
- Serve a wide range of functions
- Classification System
  - Class I
  - Class II
  - Class III

235

FDOT HCS 2010

Two-Lane Highways

Class I Highway – Primary connectors, long-distance trips, and high travel speeds

236

FDOT HCS 2010

Two-Lane Highways

Class II Highway – Scenic routes, areas with rugged terrain and/or low expected speeds

237

FDOT HCS 2010

Two-Lane Highways

Class III Highway – Moderately developed areas such as towns with more access points

238

FDOT HCS 2010

Two-Lane Highways

- Passing occurs in the opposing travel lane
- LOS criteria for automobiles
  - Average Travel Speed (ATS)
  - Percent Time-Spent-Following (PTSF)
  - Percent of Free-Flow Speed (PFFS)
- LOS criteria for bicycles
  - LOS Score

239

FDOT HCS 2010

Two-Lane Highways

- *HCM 2010* Exhibit 15-3 (LOS for Automobiles)

LOS	Class I Highways ATS (mi/h)	Class I Highways PTSF (%)	Class II Highways PTSF (%)	Class III Highways PFFS (%)
A	>55	≤35	≤40	>91.7
B	>50–55	>35–50	>40–55	>83.3–91.7
C	>45–50	>50–65	>55–70	>75.0–83.3
D	>40–45	>65–80	>70–85	>66.7–75.0
E	≤40	>80	>85	≤66.7

- *HCM 2010* Exhibit 15-4 (LOS for Bicycles)

LOS	BLOS Score
A	≤1.5
B	>1.5–2.5
C	>2.5–3.5
D	>3.5–4.5
E	>4.5–5.5
F	>5.5

240

FDOT HCS 2010

Two-Lane Highways

Required Data

- Highway class – I, II, or III
- Lane widths, shoulder width and terrain
- Speed limit and base design speed
- Access point density (one side)
- Percent no-passing and/or passing lane length
- Demand data
  - Volumes and PHF
  - Percentage of heavy vehicles
  - Directional split

241

FDOT HCS 2010

Two-Lane Highways

Limitations

- Segments with signalized intersections
  - Streets module should be used to analyze isolated intersections
- Urban/suburban areas with multiple signalized intersections less than 2 miles apart
  - These situations should be analyzed using the Streets module
- Bicycle methodology adapted from urban & suburban data
  - Heavy vehicle percentages greater than 2%
  - Driver behavior factors may vary
  - Drivers slowing down for cyclists or drivers providing additional horizontal clearance while passing cyclists

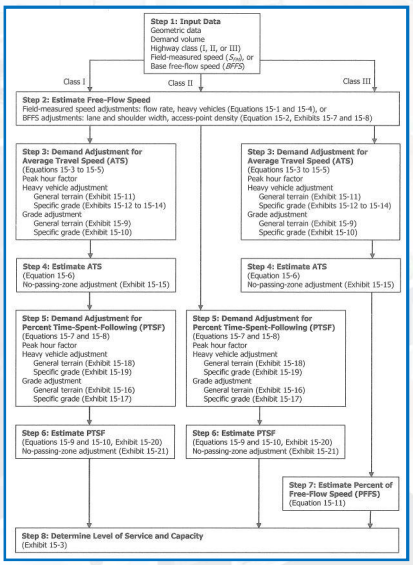
242

FDOT HCS 2010

Two-Lane Highways

Methodology

- *HCM2010* Exhibit 15-6



243

FDOT HCS 2010

Two-Lane Highways

Example #13A: SR 490 (Lecanto, FL)

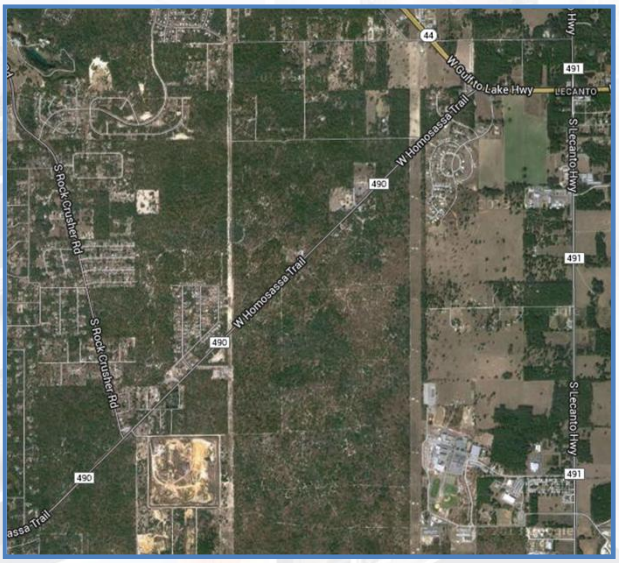
- Level terrain
- 2 ft. shoulder width
- 12 ft. lane width
- 6.0-mile corridor length
- Class I highway segment
- 90% no passing zones
- 10 access points per mile
- 55 mph base FFS (50 mph posted)
- Pavement rating: 3

Analysis Direction Volume	444 vph
Opposing Direction Volume	296 vph
PHF	0.85
Trucks and Buses	6%

244

FDOT HCS 2010

Two-Lane Highways



245

FDOT HCS 2010

Two-Lane Highways

Example #13B: SR 490 (Lecanto, FL)

- Level terrain
- 2 ft. shoulder width
- 12 ft. lane width
- 6.0-mile corridor length
- Class I highway segment
- 90% no passing zones
- 10 access points per mile
- 55 mph base FFS (50 mph posted)
- Pavement rating: 3

Analysis Direction Volume	444 vph
Opposing Direction Volume	296 vph
PHF	0.85
Trucks and Buses	6%
Passing Lane	
Length Upstream of Passing Lane	1.5 mi
Length of Passing Lane Including Tapers	1.0 mi

246

FDOT HCS 2010

Two-Lane Highways

Workshop #27: SR 789 (Sarasota, FL)

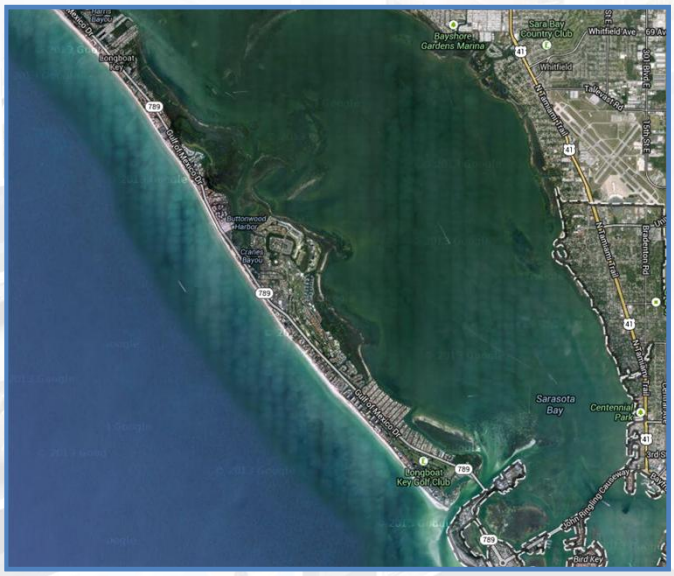
- Level terrain
- 4 ft. shoulder width
- 11 ft. lane width
- 17.7-mile corridor length
- Class III two-lane highway segment
- 70% no passing zones
- 25 access points per mile
- 55 mph base FFS (50 MPH posted)
- Pavement rating: 4

Analysis Direction Volume	684 vph
Opposing Direction Volume	456 vph
PHF	0.90
Trucks and Buses	4%

247

FDOT HCS 2010

Two-Lane Highways



248

FDOT HCS 2010

Two-Lane Highways

Workshop #28A: SR 20 (Crawfordville, FL)

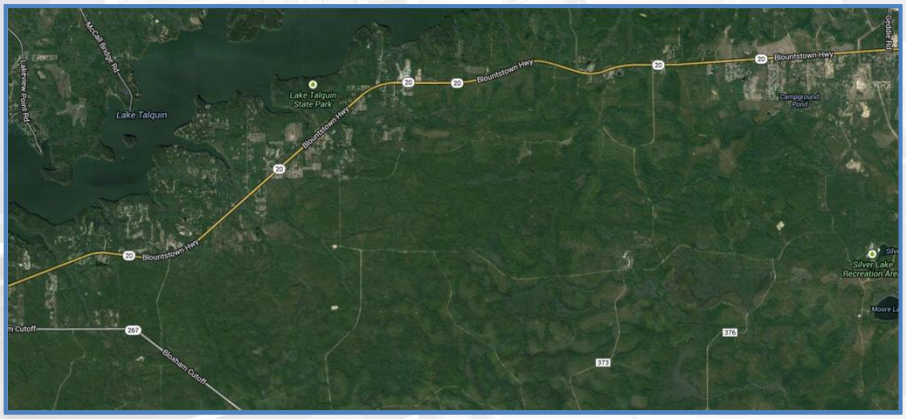
- Level terrain
- 6 ft. shoulder width
- 12 ft. lane width
- 14.5-mile corridor length
- Class II two-lane highway segment
- 62% no passing zones
- 13 access points per mile
- 60 MPH base FFS (55 MPH posted)
- Pavement rating: 4

Analysis Direction Volume	353 vph
Opposing Direction Volume	182 vph
PHF	0.88
Trucks and Buses	7%

249

FDOT HCS 2010

Two-Lane Highways



250

FDOT HCS 2010

Two-Lane Highways

Workshop #28B: SR 20 (Crawfordville, FL)

- Level terrain
- 6 ft. shoulder width
- 12 ft. lane width
- 14.5-mile corridor length
- Class II two-lane highway segment
- 62% no passing zones
- 13 access points per mile
- 60 MPH base FFS (55 MPH posted)
- Pavement rating: 4

Analysis Direction Volume	353 vph
Opposing Direction Volume	182 vph
PHF	0.88
Trucks and Buses	7%
Passing Lane	
Length Upstream of Passing Lane	10
Length of Passing Lane Including Tapers	2.5

251

FDOT HCS 2010

Two-Lane Highways

Workshop #29: SR A1A (St. Augustine, FL)

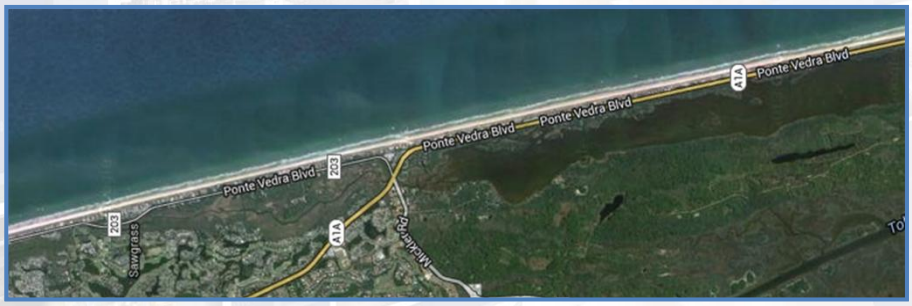
- Level terrain
- 2 ft. shoulder width
- 11 ft. lane width
- 15-mile corridor length
- Class III two-lane highway segment
- 80% no passing zones
- 25 access points per mile
- 55 MPH base FFS (50 MPH posted)
- Pavement rating: 3

Analysis Direction Volume	420 vph
Opposing Direction Volume	180 vph
PHF	0.90
Trucks and Buses	2%

252

FDOT HCS 2010

Two-Lane Highways



253

FDOT HCS 2010

Two-Lane Highways

Workshop #30: 8th Avenue (Gainesville, FL)

- Rolling terrain
- 2 ft. shoulder width
- 11 ft. lane width
- 2.5-mile corridor length
- Class II two-lane highway segment
- 60% no passing zones
- 10 access points per mile
- 50 MPH base FFS (45 MPH posted)
- 15% occupied on-highway parking
- Pavement rating: 4

Analysis Direction Volume	630 vph
Opposing Direction Volume	270 vph
PHF	0.85
Trucks and Buses	3%

254

FDOT HCS 2010

Two-Lane Highways

255

FDOT HCS 2010

Wrap-Up

HCS 2010 versus *HCS+*

- New or Significantly Upgraded Modules
  - Roundabouts
  - Interchange Ramp Terminals
  - Urban Streets
- Increased focus on pedestrians and bicycles
- Viewable simulation using *TRAFVU*

256

FDOT HCS 2010

Wrap-Up

Contact Information

- Tim White
  - tim.white@kimley-horn.com
  - (804) 672-4705
- Brian Smalkoski
  - brian.smalkoski@kimley-horn.com
  - (651) 643-0472

257