



STATE OF FLORIDA
DEPARTMENT OF TRANSPORTATION

HCS 2010

Introductions

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

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 **HCS 2010**

Housekeeping

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

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 **HCS 2010**

Day 1 – Interrupted Flow

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



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Day 2 – Interrupted Flow

- Signalized Intersections
- Urban Streets
 - Segments
 - Facilities



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Day 3 – Uninterrupted Flow (Mostly)

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






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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*

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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

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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

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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**

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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

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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

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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

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Study Period vs Analysis Period

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

The diagram illustrates three approaches to evaluating flow rate over a 1.0-hour study period. The y-axis is labeled 'Flow Rate (veh/h)' and the x-axis is labeled 'Time'. A legend indicates that hatched bars represent analysis periods.

- Approach A:** Study Period = 1.0 h. Single analysis period $T = 0.25$ h. The analysis period is the peak 15-minute interval.
- Approach B:** Study Period = 1.0 h. Single analysis period $T = 1.0$ h. The analysis period covers the entire study period.
- Approach C:** Study Period = 1.0 h. Multiple analysis periods $T = 0.25$ h. The analysis periods are the four 15-minute intervals.

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Day 1 – Interrupted Flow

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

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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

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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.

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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

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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

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TWSC

Methodology

- HCM 2010*
- Exhibit 19-4

```

graph TD
    S1[Step 1: Determine and Label Movement Priorities] --> S2[Step 2: Convert Movement Demand Volumes to Flow Rates]
    S2 --> S3[Step 3: Determine Conflicting Flow Rates]
    S3 --> S4[Step 4: Determine Critical Headways and Follow-Up Headways]
    S4 --> D1{Coordinated Upstream Signals Present?}
    D1 -- No --> S5a[Step 5a: Compute Potential Capacities]
    D1 -- Yes --> S5b[Step 5b: Compute Potential Capacities Adjusting for Effects of Upstream Signals]
    I1[Chapter 17 Inputs (P0,1)] --> S5b
    S5a --> S6[Step 6: Compute Rank 1 Movement Capacities]
    S5b --> S6
    S6 --> S7[Step 7: Compute Rank 2 Movement Capacities]
    S7 --> S8[Step 8: Compute Rank 3 Movement Capacities]
    S8 --> S9[Step 9: Compute Rank 4 Movement Capacities]
    S5b --> S10[Step 10: Final Capacity Adjustments]
    S10 --> S11[Step 11: Compute Movement Control Delay]
    S11 --> S12[Step 12: Compute Approach and Intersection Control Delay]
    S12 --> S13[Step 13: Compute 95th Percentile Queue Lengths]
  
```

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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

SR 22

N. Fox Ave

N. Fox Ave

Wewa Hwy

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HCS 2010

TWSC

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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

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HCS 2010

TWSC

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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

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HCS 2010

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

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Day 1 – Interrupted Flow

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

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All-Way Stop Control (AWSC)

- Chapter 20 – *HCM 2010*
- Every vehicle required to stop
- Isolated intersections
- Level of Service criteria
 - Minor-street movements
 - Major-street left turns
- New in 2010: a queue estimation model has been added

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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.

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AWSC

Required Data

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

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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

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HCS 2010

AWSC

Methodology

- *HCM 2010*
- Exhibit 20-9

```

    graph TD
      S1[Step 1: Convert movement demand volumes to flow rates] --> S2[Step 2: Determine lane flow rates]
      S2 --> S3[Step 3: Determine geometry group for each approach]
      S3 --> S4[Step 4: Determine saturation headway adjustments]
      S4 --> S5[Step 5: Determine initial departure headway]
      S5 --> S6[Step 6: Calculate initial degree of utilization]
      S6 --> S7[Step 7: Compute probability states]
      S7 --> S8[Step 8: Compute probability adjustment factors]
      S8 --> S9[Step 9: Compute saturation headways]
      S9 --> S10[Step 10: Compute departure headways]
      S10 --> S11[Step 11: Check for convergence]
      S11 -- No --> S8
      S11 -- Yes --> S12[Step 12: Compute capacity]
      S11 -- Yes --> S13[Step 13: Compute service times]
      S12 --> S16[Step 16: Compute queue lengths]
      S13 --> S14[Step 14: Compute control delay for each lane]
      S14 --> S15[Step 15: Compute control delay and determine LOS for each approach and the intersection]
      S15 --> S16
  
```

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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

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AWSC

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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

Maple St Cedar Drive Maple St

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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

Maple St Cedar Dr Maple St

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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

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Day 1 – Interrupted Flow

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

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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

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Roundabouts

- *HCM 2010* Exhibit 21-9

```

graph TD
    S1[Step 1: Convert movement demand volumes to flow rates] --> S2[Step 2: Adjust flow rates for heavy vehicles]
    S2 --> S3[Step 3: Determine circulating and exiting flow rates]
    S3 --> S4[Step 4: Determine entry flow rates by lane]
    S4 --> S5[Step 5: Determine the capacity of each entry lane and bypass lane as appropriate in passenger car equivalents]
    S5 --> S6[Step 6: Determine pedestrian impedance to vehicles]
    S6 --> S7[Step 7: Convert lane flow rates and capacities into vehicles per hour]
    S7 --> S8[Step 8: Compute the volume-to-capacity ratio for each lane]
    S8 --> S9[Step 9: Compute the average control delay for each lane]
    S9 --> S10[Step 10: Determine LOS for each lane on each approach]
    S10 --> S11[Step 11: Compute the average control delay and determine LOS for each approach and the roundabout as a whole]
    S11 --> S12[Step 12: Compute 95th percentile queues for each lane]
  
```

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Roundabouts

Required Data

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

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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

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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

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Roundabouts

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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

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Roundabouts

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Day 2 – Interrupted Flow

- Signalized Intersections ◀
- Urban Streets
 - Segments
 - Facilities

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Housekeeping

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

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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

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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 |

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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

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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)

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Signalized Intersections

Methodology

- HCM 2010 Exhibit 18-11

```

    graph TD
      subgraph "Pre-timed"
        S1[Step 1. Determine Movement Groups and Lane Groups]
        S2[Step 2. Determine Movement Group Flow Rate]
        S3[Step 3. Determine Lane Group Flow Rate]
        S4[Step 4. Determine Adjusted Saturation Flow Rate]
        S5[Step 5. Determine Proportion Arriving During Green]
      end
      subgraph "Actuated"
        S6[Step 6. Determine Signal Phase Duration]
        S7[Step 7. Determine Capacity and Volume-to-Capacity Ratio]
        S8[Step 8. Determine Delay]
        S9[Step 9. Determine LOS]
        S10[Step 10. Determine Queue Storage Ratio]
      end
      S1 --> S2
      S2 --> S3
      S3 --> S4
      S4 --> S5
      S5 --> S6
      S6 --> Con{Converge?}
      Con -- No --> S3
      Con -- Yes --> S7
      S7 --> S8
      S8 --> S9
      S9 --> S10
  
```

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Signalized Intersections

Actuation

- Vehicle detection for an approach

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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

90 second Cycle

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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.
- **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

Vehicle Clearance Time

Platoon

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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

The diagram illustrates a signalized intersection. A car is shown in the left lane, with a callout box labeled 'Car Call' and 'Extension' pointing to the signal. The signal is shown with a red light and a green light, indicating that the green phase is extended. A second car is shown in the right lane, with a callout box labeled 'Gap out' pointing to the signal, indicating that the signal serves the next phase early because no call was placed on the current phase. The slide number '57' is in the bottom right corner.

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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

The diagram illustrates a coordinated traffic signal system. Two traffic signals are shown at different intersections along a major street. A double-headed arrow labeled 'Coordinated' connects the two signals. Below the signals, a callout box labeled 'Offset: 15 sec' indicates the time delay between the start of a cycle at the two intersections. The slide number '58' is in the bottom right corner.

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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

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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

Walk Interval: 3 sec
Pedestrian Clearance: 10 sec

DONT WALK

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Signalized Intersections

National Electrical Manufacturers Association (NEMA) Phasing

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Signalized Intersections

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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)



The image shows a traffic light with a green arrow pointing left and a sign that reads "LEFT TURN YIELD ON FLASHING YELLOW". Below it is a diagram of a traffic light pole with a green arrow and a green ball.

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Signalized Intersections

Overlap Phasing

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



The diagram shows an intersection with a Main Street and a Side Street. It illustrates the phasing of traffic lights, with arrows indicating the direction of traffic and numbers 1 through 8 representing different phases. A traffic light is shown with a red light and a green arrow pointing right, indicating a right-turn movement.

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Signalized Intersections

Split Phasing

- Having two opposing approaches time consecutively rather than concurrently

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Signalized Intersections

Lead

- Phasing in which the left turn phase precedes the opposing through phase

Lag

- Phasing in which the left turn phase follows the opposing through phase

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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

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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 |

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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 |

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Signalized Intersections

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HCS 2010

Signalized Intersections

Workshop #7: 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 |

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HCS 2010

Signalized Intersections

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HCS 2010

Signalized Intersections

Workshop #8: 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 |

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HCS 2010

Signalized Intersections

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HCS 2010

Signalized Intersections

Workshop #9: 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
- 35 MPH speed limit on all approaches
- Cycle length – 100 seconds (pre-timed)
- Uncoordinated intersection

| 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 |

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HCS 2010

Signalized Intersections

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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)
- 5 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 |

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Day 2 – Interrupted Flow

- Signalized Intersections
- Urban Streets
 - Segments
 - Facilities

(a) Points, Segments, Facilities, and Corridors

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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)

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Urban Streets - Segments

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



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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: ^aVolume-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: ^aIn cross-flow situations, the LOS E/F threshold is 13 ft²/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 |

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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

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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)

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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

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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

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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

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Urban Streets - Segments

Methodology

- Automobile Mode (Exhibit 17-8)

The flowchart for Automobile Mode methodology is divided into two main paths: Non-Coordinated System and Coordinated System. Both paths start with a decision point for 'Pretimed' or 'Actuated' control. The Non-Coordinated path includes steps for determining traffic demand adjustments, running time, proportion arriving during green, signal phase duration, through delay, stop rate, travel speed, spatial stop rate, level of service, and traveler perception score. The Coordinated path includes similar steps but with a 'Converge?' decision point before determining through delay.

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Urban Streets - Segments

Methodology

- Pedestrian Mode (Exhibit 17-15)
- Bicycle Mode (Exhibit 17-20)
- Transit Mode (Exhibit 17-22)

The Pedestrian Mode methodology flowchart consists of 10 steps: 1. Determine Free-Flow Walking Speed; 2. Determine Average Pedestrian Space; 3. Determine Pedestrian Delay at Intersection; 4. Determine Pedestrian Travel Speed; 5. Determine Pedestrian LOS Score for Intersection; 6. Determine Pedestrian LOS Score for Link; 7. Determine Link LOS; 8. Determine Roadway Crossing Difficulty Factor; 9. Determine Pedestrian LOS Score for Segment; 10. Determine Segment LOS.

The Bicycle Mode methodology flowchart consists of 8 steps: 1. Determine Bicycle Running Speed; 2. Determine Bicycle Delay at Intersection; 3. Determine Bicycle Travel Speed; 4. Determine Bicycle LOS Score for Intersection; 5. Determine Bicycle LOS Score for Link; 6. Determine Link LOS; 7. Determine Bicycle LOS Score for Segment; 8. Determine Segment LOS.

The Transit Mode methodology flowchart consists of 7 steps: 1. Determine Transit Vehicle Running Time; 2. Determine Delay at Intersection; 3. Determine Travel Speed; 4. Determine Transit Wait-Ride Score; 5. Determine Pedestrian LOS Score for Link; 6. Determine Transit LOS Score for Segment; 7. Determine LOS.

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Urban Streets - Segments

Example #5: Main St between 15th St and 18th St

- 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

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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
- Cycle length - 90 sec (pre-timed)
- 5 buses/hr on EB/WB
- 10 parking maneuvers/hr on WB
- 20 peds/hr crossing all approaches
- Arrival type 3
- Split phasing on 15th St (NB is lag phase)
- 5 sec walk-time, 11 sec ped clearance
- Uncoordinated intersection

| Phase Approach | 2 EBT | 4 SBT | 6 WBT | 8 NBT |
|----------------|-------|-------|-------|-------|
| Max. Green | 29.5 | 34.5 | 29.5 | 9.5 |
| Yellow | 3.5 | 3.5 | 3.5 | 3.5 |
| Red | 2.0 | 2.0 | 2.0 | 2.0 |
| Min. Green | 4 | 4 | 4 | 4 |

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Urban Streets - Segments

Example #5 (cont): Main St at 18th St

- PHF - 0.90 for all movements
- 2% heavy vehicles for all movements
- Cycle length - 120 sec (pre-timed)
- 5 buses/hr on EB/WB
- 10 parking maneuvers/hr on WB
- 40 peds/hr crossing all approaches
- Arrival type 3
- Split phasing on 18th St (NB is lag phase)
- 5 sec walk-time, 11 sec ped clearance
- 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 |

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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

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Urban Streets - Segments

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

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Urban Streets - Segments

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

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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 |

Diagram details: SR 22 (horizontal) has a left turn (25, 10, 170) and a right turn (95, 465, 10) at Transmitter Rd (vertical). Transmitter Rd has a left turn (65, 285, 5) and a right turn (5, 10, 5) at Wewa Hwy (horizontal). Storage lengths are indicated as (200' storage) for the left turn on SR 22 and (120' storage) for the right turn on Wewa Hwy. A north arrow points up.

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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 |

Diagram details: SR 22 (horizontal) has a left turn (15, 110, 60) and a right turn (35, 435, 120) at Bob Little Rd (vertical). Bob Little Rd has a left turn (25, 260, 40) and a right turn (105, 140, 25) at Wewa Hwy (horizontal). Storage lengths are indicated as (100' storage) for the left turn on SR 22 and (200' storage) for the right turn on Wewa Hwy. A north arrow points up.

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Day 2 – Interrupted Flow

- Signalized Intersections
- **Urban Streets**
 - Segments
 - **Facilities** ◀

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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)

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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 ft²/p.

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

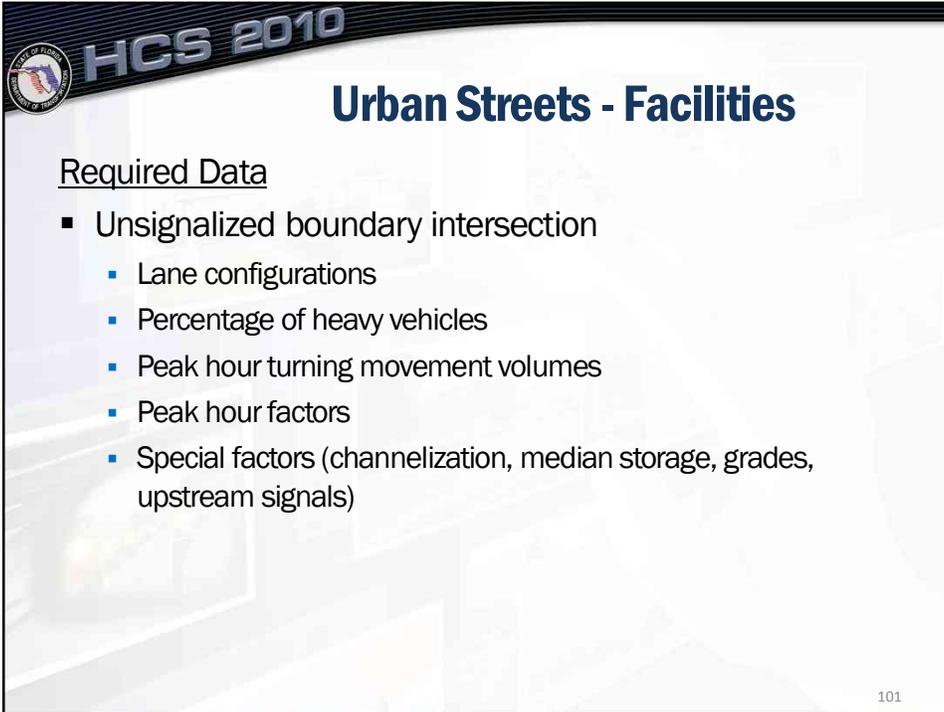
| LOS | LOS Score |
|-----|------------|
| A | ≤2.00 |
| B | >2.00-2.75 |
| C | >2.75-3.50 |
| D | >3.50-4.25 |
| E | >4.25-5.00 |
| F | >5.00 |

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



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)

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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

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 **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

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 **HCS 2010**

 **Urban Streets - Facilities**

- **Limitations consistent with:**
 - Unsignalized intersections
 - Signalized intersections
 - Interchange ramp terminals
 - Urban street segments

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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)

Step 1: Determine Base Free-Flow Speed

Step 2: Determine Travel Speed

Step 3: Determine Spatial Stop Rate

Step 4: Determine Automobile LOS

Step 1: Determine Pedestrian Space

Step 2: Determine Pedestrian Travel Speed

Step 3: Determine Pedestrian LOS Score

Step 4: Determine Pedestrian LOS

Step 1: Determine Bicycle Travel Speed

Step 2: Determine Bicycle LOS Score

Step 3: Determine Bicycle LOS

Step 1: Determine Transit Travel Speed

Step 2: Determine Transit LOS Score

Step 3: Determine Transit LOS

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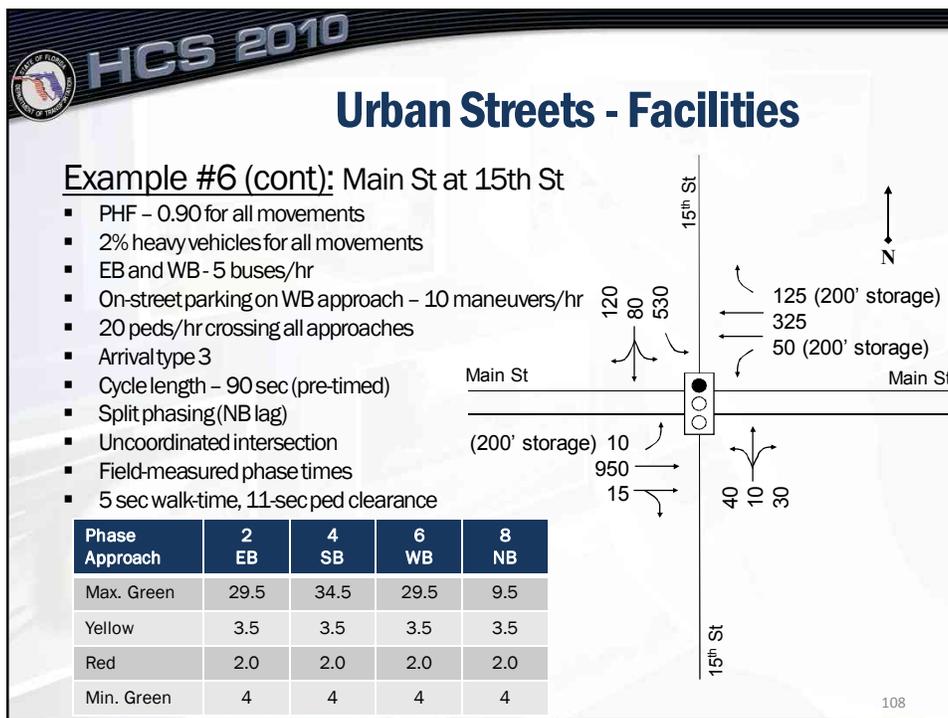
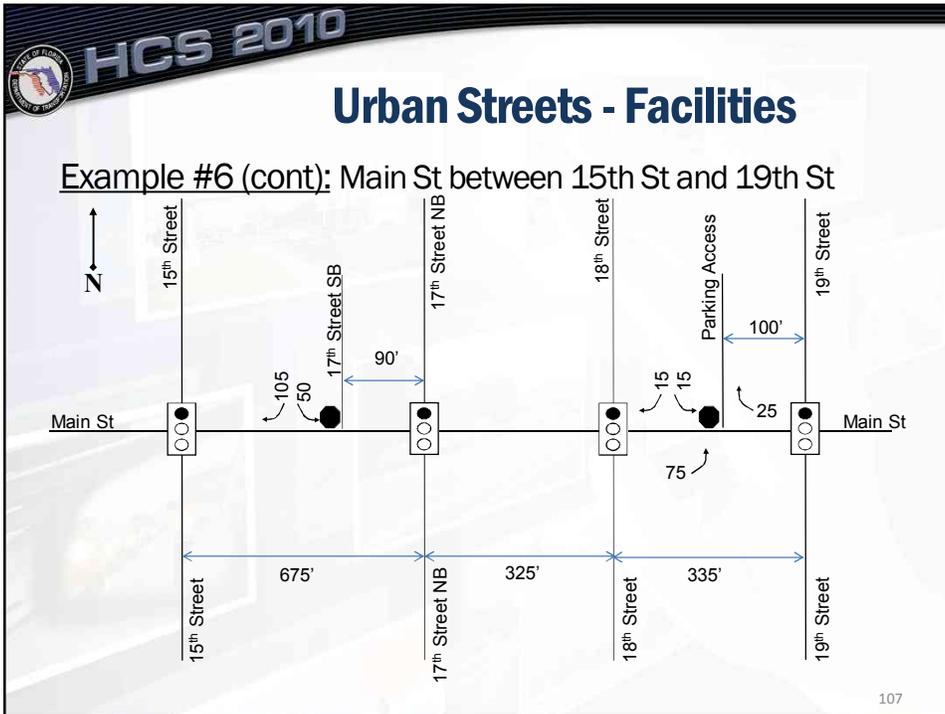
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Urban Streets - Facilities

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

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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
- 5 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 |

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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
- 5 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 |

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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
- 5 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 |

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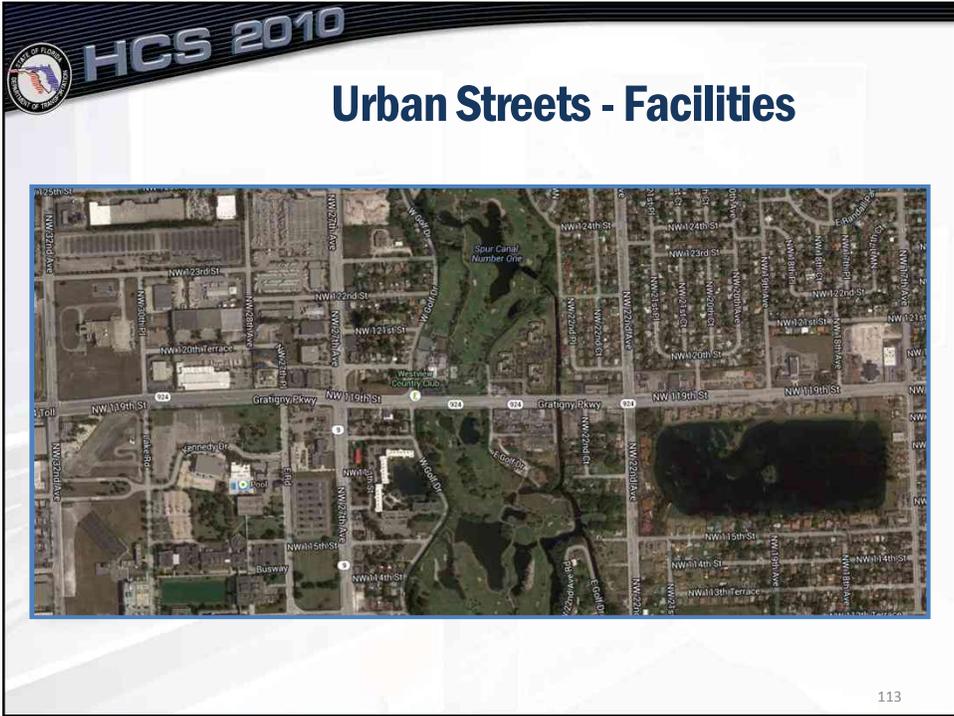
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Urban Streets - Facilities

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

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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
 - NBLT 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 |

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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 |

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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 |

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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 |

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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

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 **HCS 2010**

Housekeeping

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

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 **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

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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

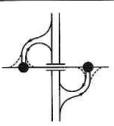
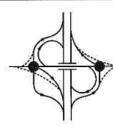
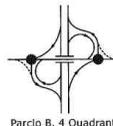
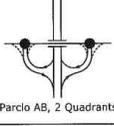
121

HCS 2010

Interchanges

Configuration types

- *HCM 2010*
Exhibit 22-2

| | |
|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|
|  |  |
|  |  |
|  |  |

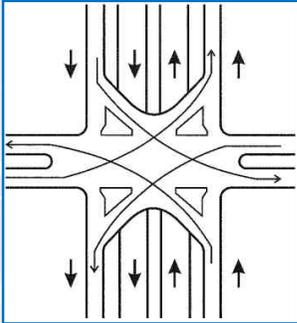
Note: - - - Possible alternative configuration of signal bypasses operating as unsignalized movements; these are movements that are not using the ramp terminals.

122

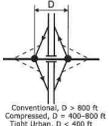
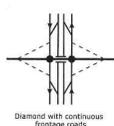
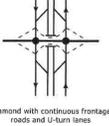
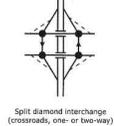
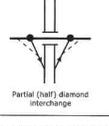
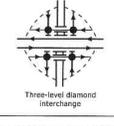
HCS 2010

Interchanges

- HCM 2010 Exhibit 22-3
- HCM 2010 Exhibit 22-1



Single-Point Urban Interchange

| | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------|
|  Conventional, $D > 800$ ft Compressed, $D = 400-800$ ft Tight Urban, $D < 400$ ft |  Diamond with continuous frontage roads |
|  Diamond with continuous frontage roads and U-turn lanes |  Split diamond interchange (crossroads, one- or two-way) |
|  Partial (half) diamond interchange |  Three-level diamond interchange |

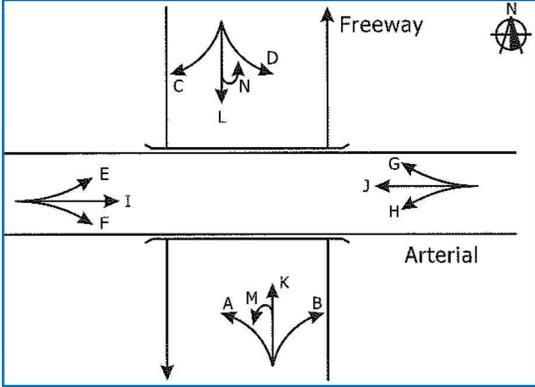
Note: ———— Possible alternative configuration of signal bases operating as unsignalized movements; # indicates movements that are not using the ramp terminals.

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HCS 2010

Interchanges

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



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HCS 2010

Interchanges

- HCM 2010 Exhibit 22-6

- HCM 2010 Exhibit 22-7

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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 |

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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

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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_s , 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_0 , pc/hg/ln) Peak hour factor (PHF) Percent heavy vehicles (HV , %) Approach pedestrian flow rates (V_{ped} , ped/h) Approach bicycle flow rates (s_b , bicycles/h) Local bus stopping rate (N_b , buses/h) Parking activity (N_p , 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 |

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HCS 2010

Interchanges

Methodology

- HCM 2010 Exhibit 22-14

```

graph TD
    A[Input Parameters: Geometric, Traffic, Signalization] --> B[SPUT]
    A --> C[Diamond/Pacific]
    B --> D["O-D flow rates and turning movement flow rates are identical"]
    C --> E["O-D flow rates and turning movement flow rates are different"]
    D --> F[Volume adjustment]
    E --> G["O-D flow rates"]
    E --> H["Turning movement flow rates"]
    G --> I[Volume adjustment]
    H --> I
    F --> J[Lane utilization]
    I --> J
    J --> K[Capacity and v/c ratio]
    C --> L[Saturation Flow Rates, Basic equation, Adjustment factors]
    J --> L
    L --> M[Queue length for internal links]
    M --> N[Effective green adjustment due to interchange operations]
    N --> O[No adjacent intersection]
    N --> P[Adjacent intersection exists]
    O --> K
    P --> Q[Effective green adjustment due to adjacent intersection operations]
    Q --> K
    K --> R["Performance Measures: Control delay, Queue storage ratio, LOS"]
  
```

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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

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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

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HCS 2010

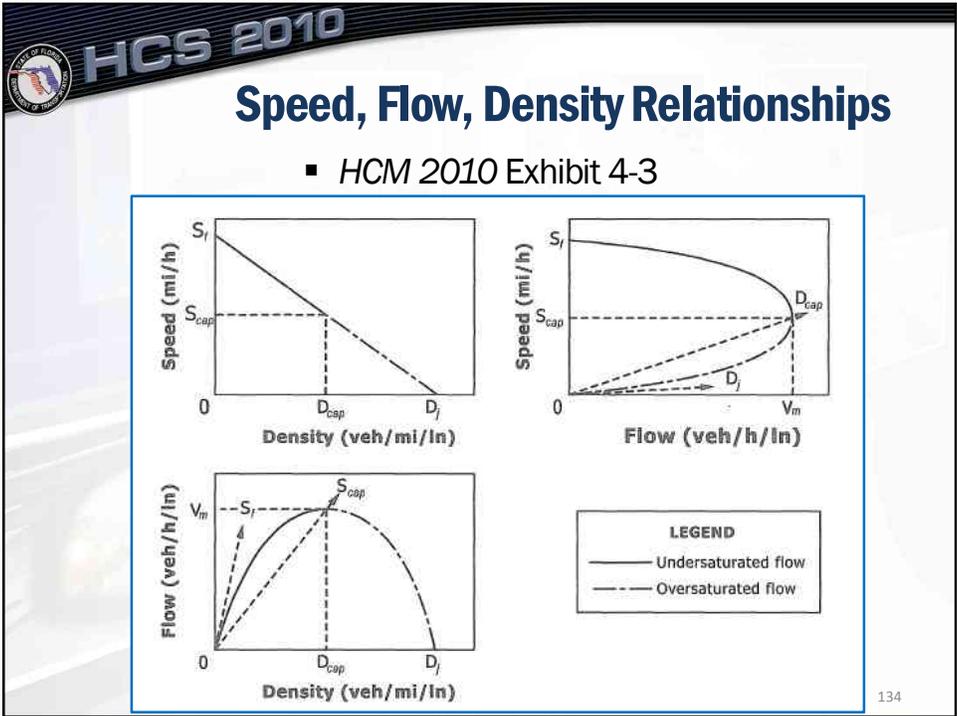
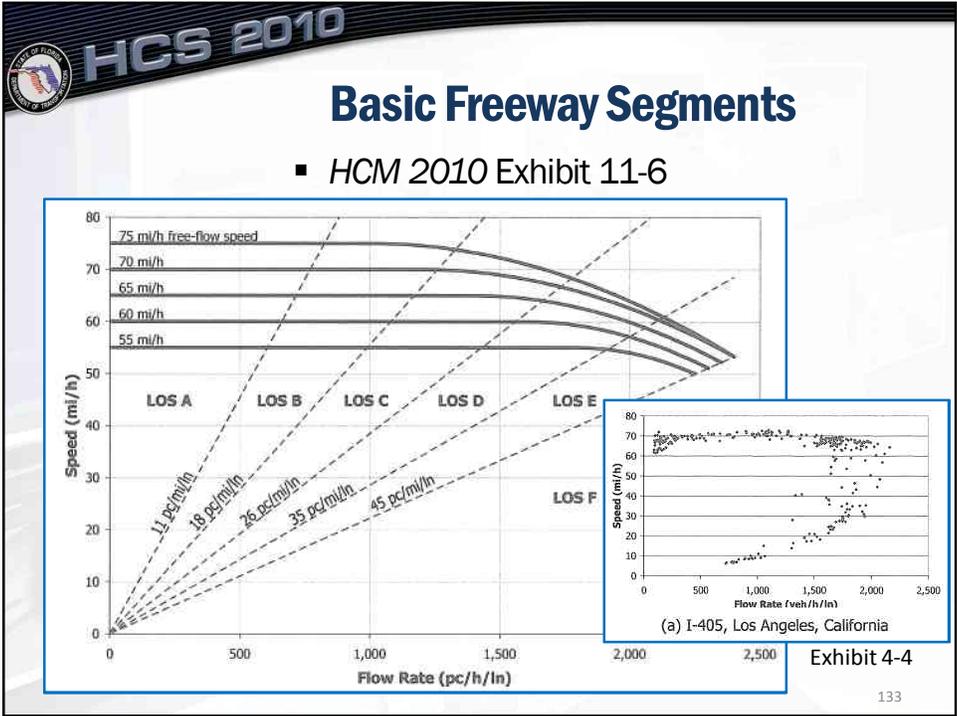
Basic Freeway Segments

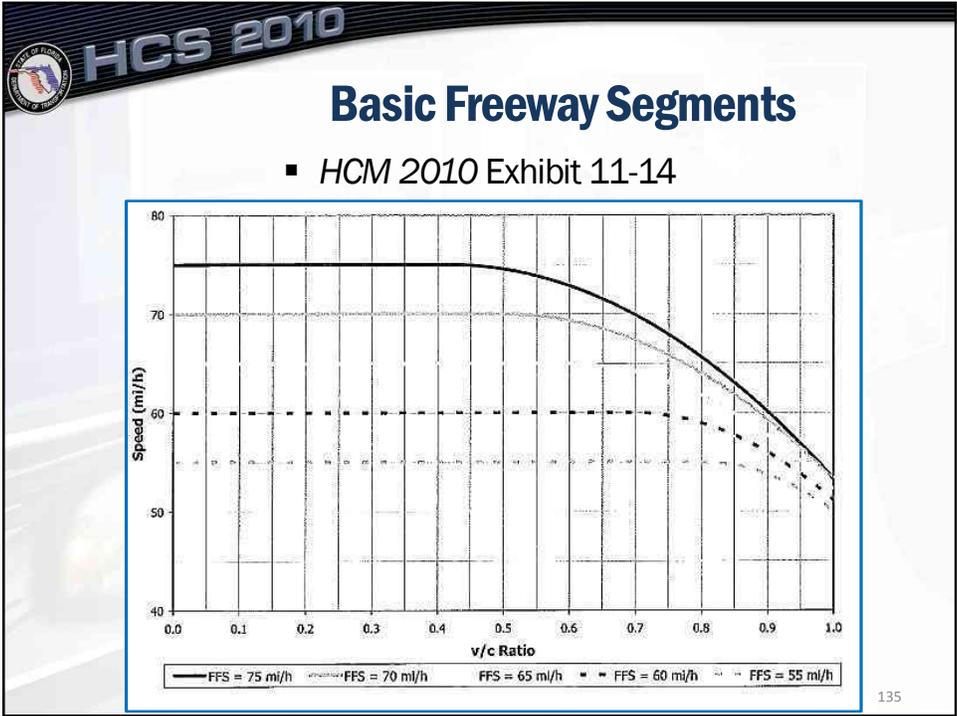
- HCM 2010 Exhibit 10-1

The diagram illustrates three types of freeway influence areas:

- (a) Merge Influence Area: A 1,500 ft segment downstream of a merge point.
- (b) Diverge Influence Area: A 1,500 ft segment upstream of a diverge point.
- (c) Weaving Influence Area: A segment of length L_g (Base Length) centered on a weaving section, with 500 ft offsets on both sides.

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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 |

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 **Basic Freeway Segments**

Required Data

- Number of lanes, lane widths and lateral clearance
- Free-flow speed (FFS)
- Ramp density (ramps/mile)
- 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

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 **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

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HCS 2010

Basic Freeway Segments

Methodology

- HCM 2010 Exhibit 11-7

```

graph TD
    S1[Step 1: Input Data  
Geometric data  
Demand volume  
Measured FFS (if available)] -- "Measured FFS is not available" --> S2[Step 2: Compute FFS  
Lane width adjustment  
Lateral clearance adjustment  
Use Equation 11-1]
    S1 -- "Measured FFS is available" --> S3[Step 3: Select FFS Curve]
    S2 --> S3
    S3 --> S4[Step 4: Adjust Demand Volume  
Peak hour factor  
Number of lanes (one direction)  
Heavy vehicle adjustment  
Driver population adjustment  
Use Equation 11-2]
    S4 -- "Demand flow rate > capacity" --> LOSF[LOS = F  
Go to Chapter 10,  
Freeway Facilities]
    S4 -- "Demand flow rate ≤ capacity" --> S5[Step 5: Estimate Speed and Density  
Exhibit 11-3 or Exhibit 11-2  
Equation 11-4]
    S5 --> S6[Step 6: Determine LOS (A-E)  
Exhibit 11-5]
  
```

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HCS 2010

Basic Freeway Segments

Example #7: 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

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HCS 2010

Basic Freeway Segments

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HCS 2010

Basic Freeway Segments

Workshop #13: 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

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HCS 2010

Basic Freeway Segments

Workshop #14: 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

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HCS 2010

Basic Freeway Segments

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HCS 2010

Basic Freeway Segments

Workshop #15A: 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

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HCS 2010

Basic Freeway Segments

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HCS 2010

Basic Freeway Segments

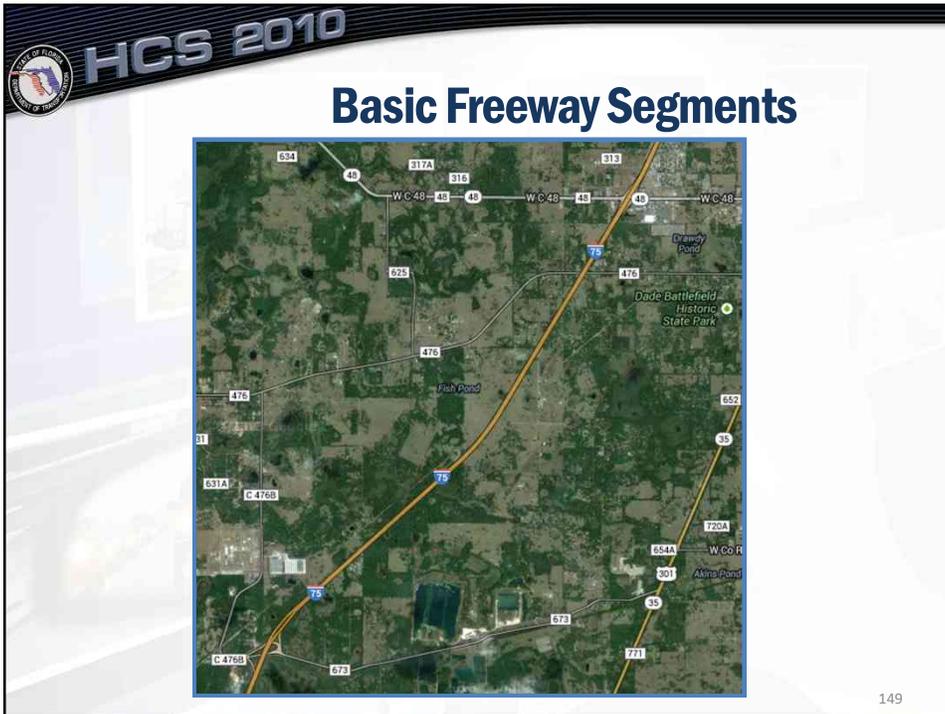
**Workshop #15B: I-75 NB from CR 673 to FL-48
(Bushnell, FL)**

- 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%

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- 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
- 150

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

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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

The diagram illustrates a weaving segment on a highway. It shows a central section between a 'Merge' on the left and a 'Diverge' on the right. Two 'Gore' sections are shown at the ends of the weaving segment. Three horizontal dimensions are indicated with blue arrows: 'Short Length' (distance between barrier markings), 'Base Length' (gore to gore length), and 'Weaving Influence Area' (the total length of the weaving segment). Two vertical dimensions of '500'' are shown, indicating the width of the weaving segment at the merge and diverge points.

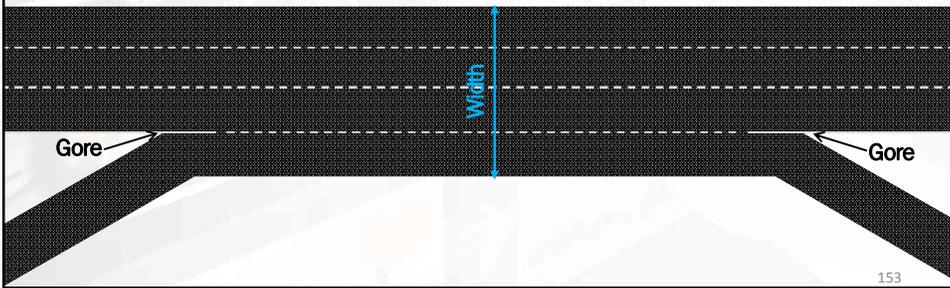
152

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



The diagram illustrates a weaving segment on a highway. It shows a top-down view of a road with two main lanes in each direction, separated by a dashed centerline. On the left side, a ramp merges into the main traffic flow. On the right side, a ramp exits the main traffic flow. The area between the entry and exit ramps is labeled as the 'Width' of the weaving segment. The triangular areas where the ramps meet the main road are labeled as 'Gore'.

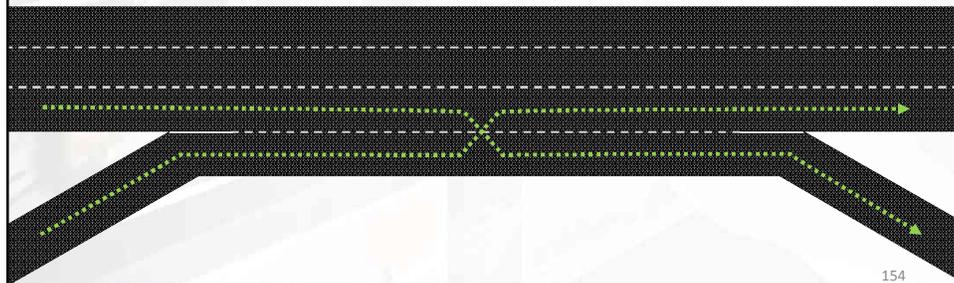
153

HCS 2010

Weaving Segments

Terminology

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



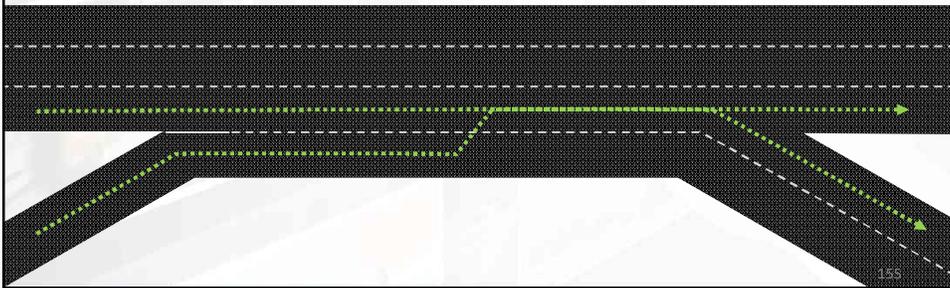
The diagram illustrates a one-sided ramp weave. It shows a top-down view of a road with two main lanes in each direction, separated by a dashed centerline. On the left side, a ramp merges into the main traffic flow. On the right side, a ramp exits the main traffic flow. A green dotted line with arrows indicates the path of a vehicle entering from the ramp, weaving through the main traffic lanes, and exiting onto the ramp. This path involves two lane changes.

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 **Weaving Segments**

Terminology

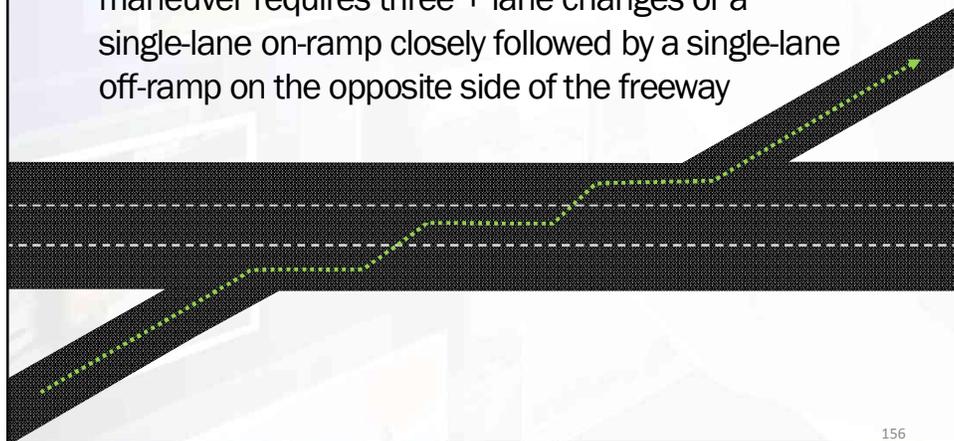
- One-Sided Weaving Segment: Weaving maneuvers require no more than two lane changes
- One-sided major weave shown



 **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



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

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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.

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Weaving Segments

Minimum Lane Changes

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

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 | |

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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

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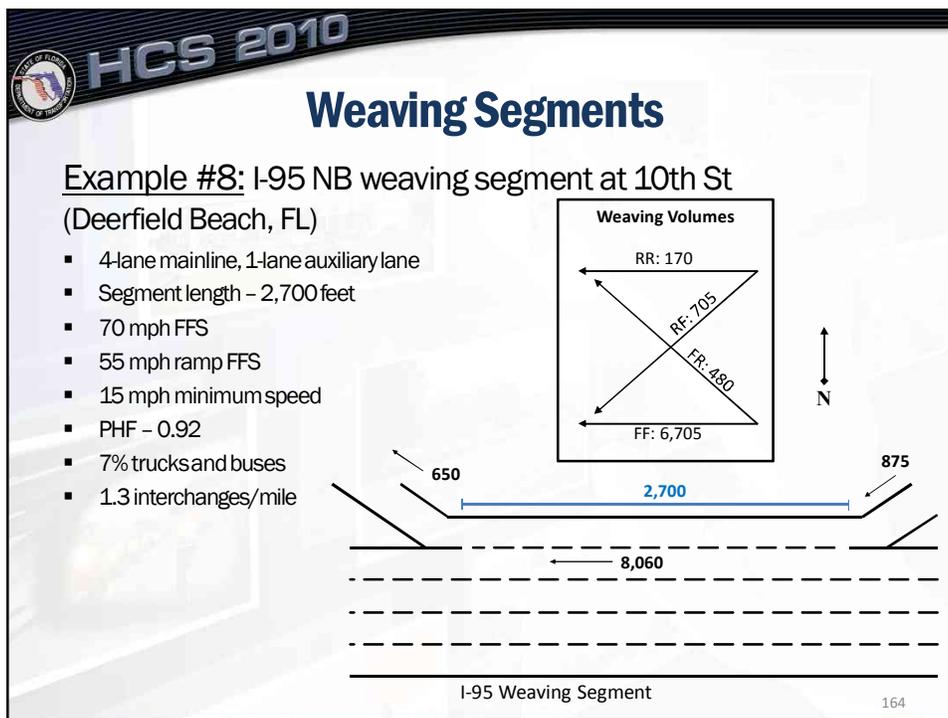
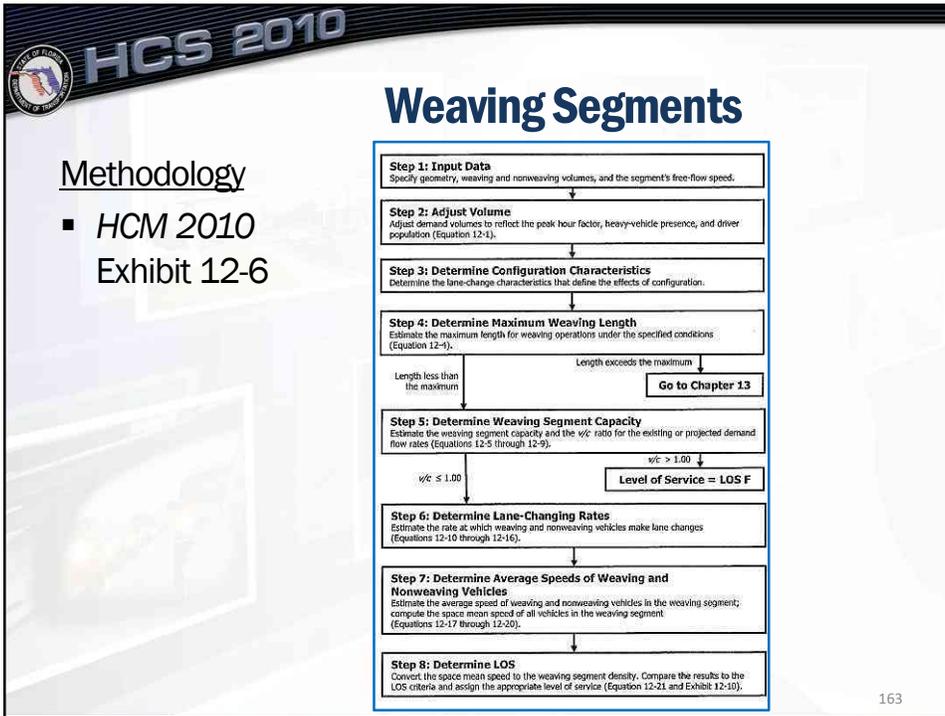


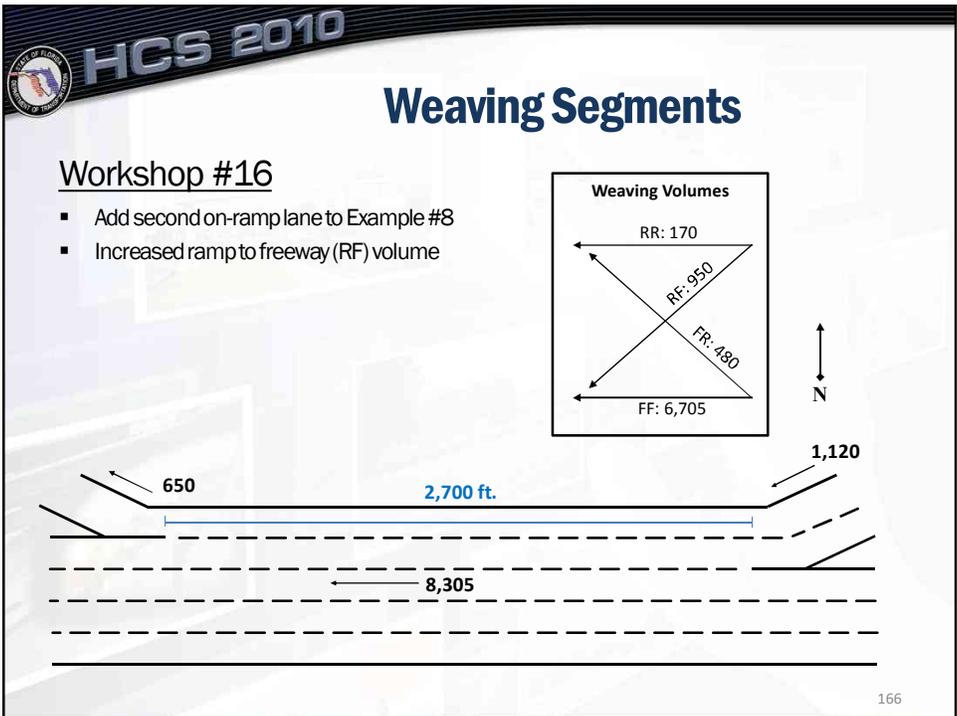
Weaving Segments

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

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HCS 2010

Weaving Segments

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HCS 2010

Weaving Segments

Workshop #17: 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

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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

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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)

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HCS 2010

Merge/Diverge Segments

- HCM 2010**
Exhibit 10-12

(a) Length between ramps = 4,000 ft

(b) Length between ramps = 3,000 ft

(c) Length between ramps = 2,000 ft

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HCS 2010

Merge/Diverge Segments

- HCM 2010 Exhibit 13-3**

(a) Parallel Acceleration Lane

(b) Tapered Acceleration Lane

(c) Parallel Deceleration Lane

(d) Tapered Deceleration Lane

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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 |

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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

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 **HCS 2010**

Merge/Diverge Segments

Required Data (cont)

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

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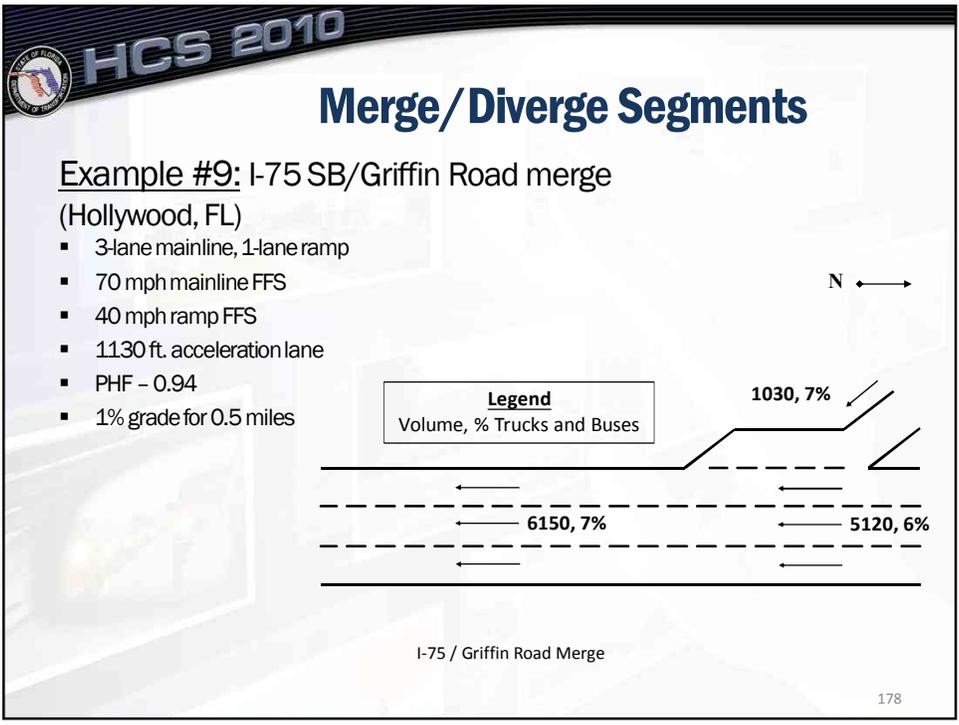
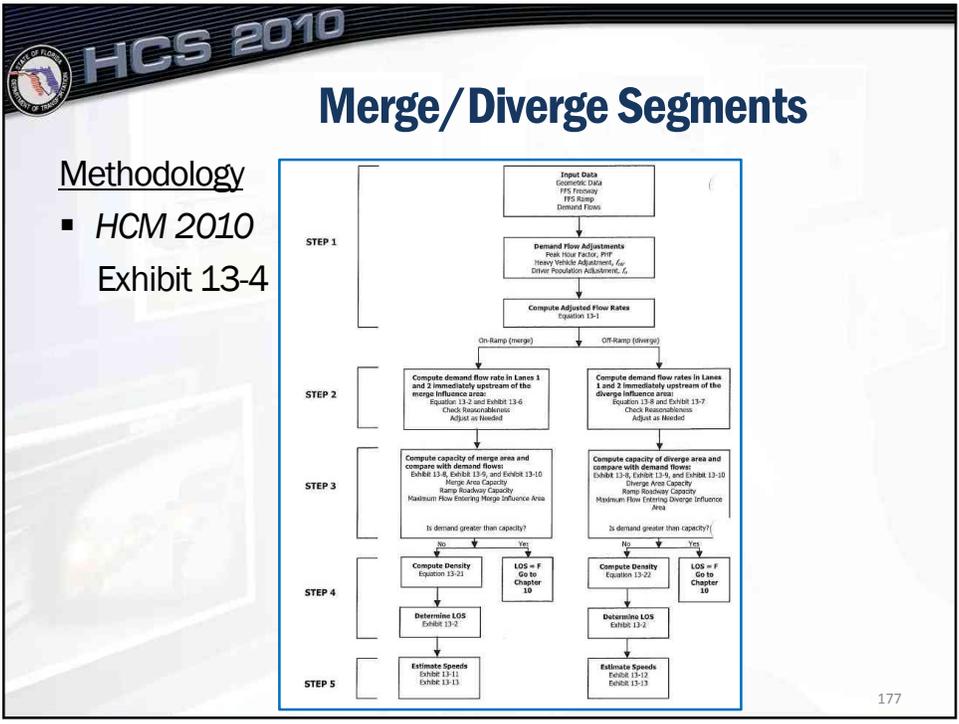
 **HCS 2010**

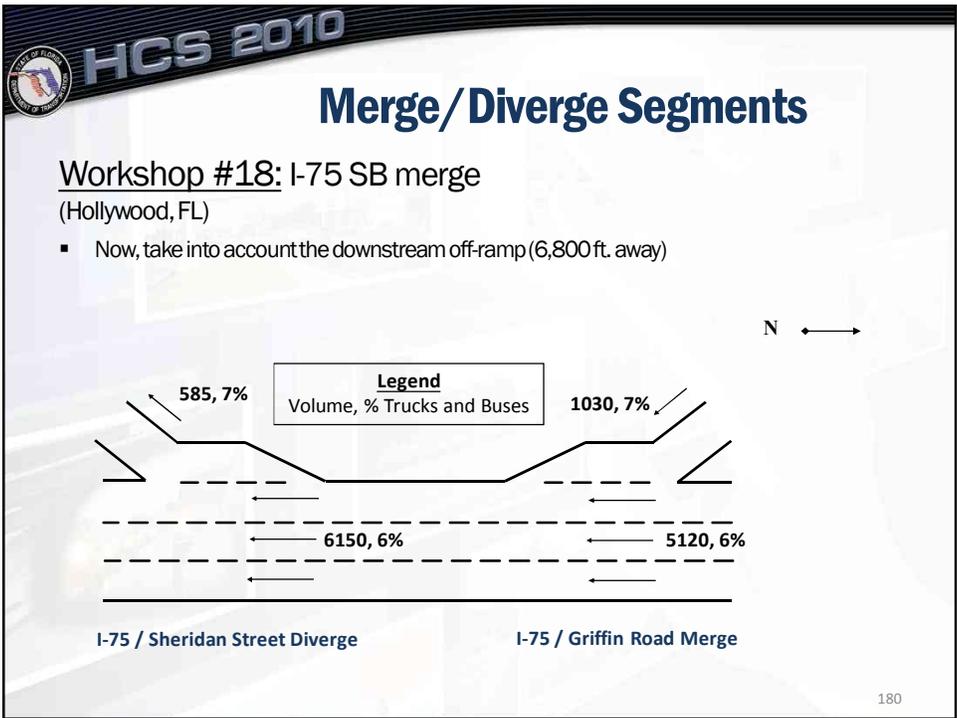
Merge/Diverge Segments

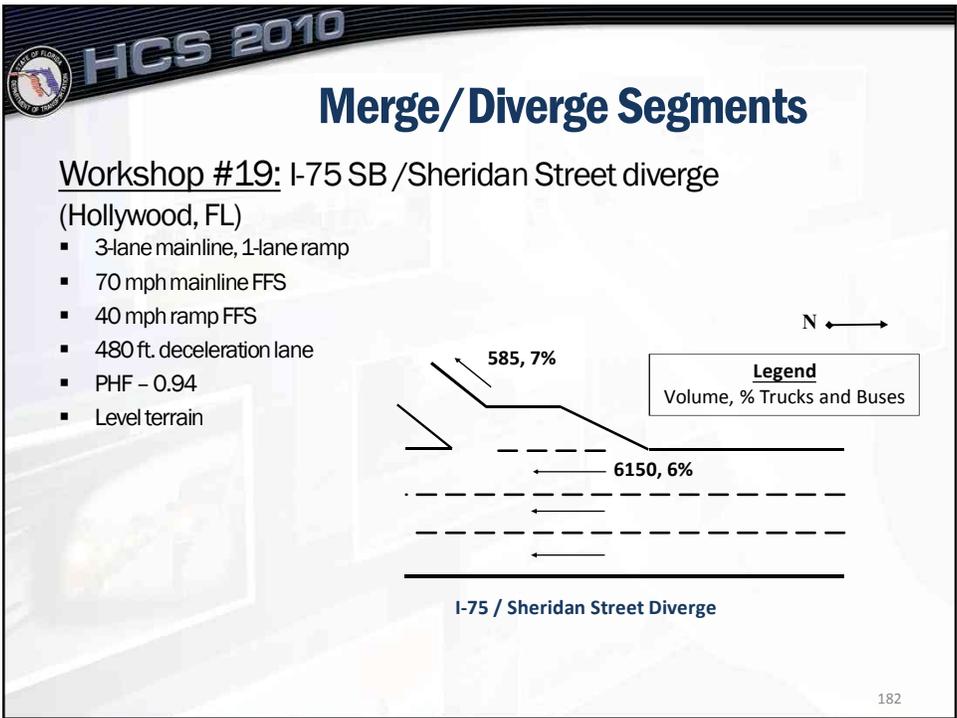
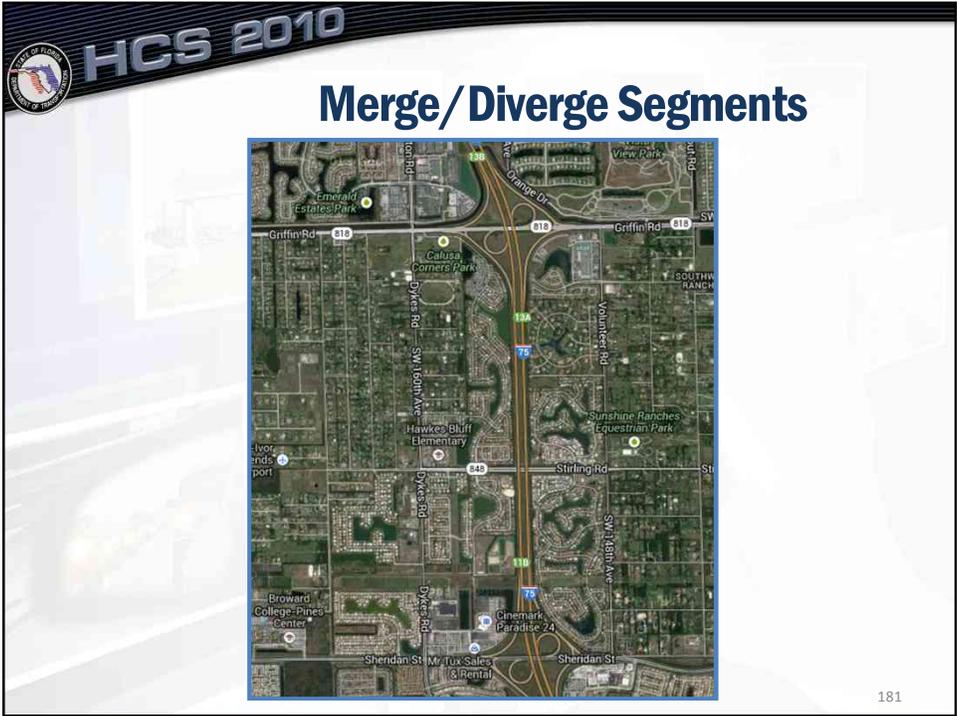
Limitations

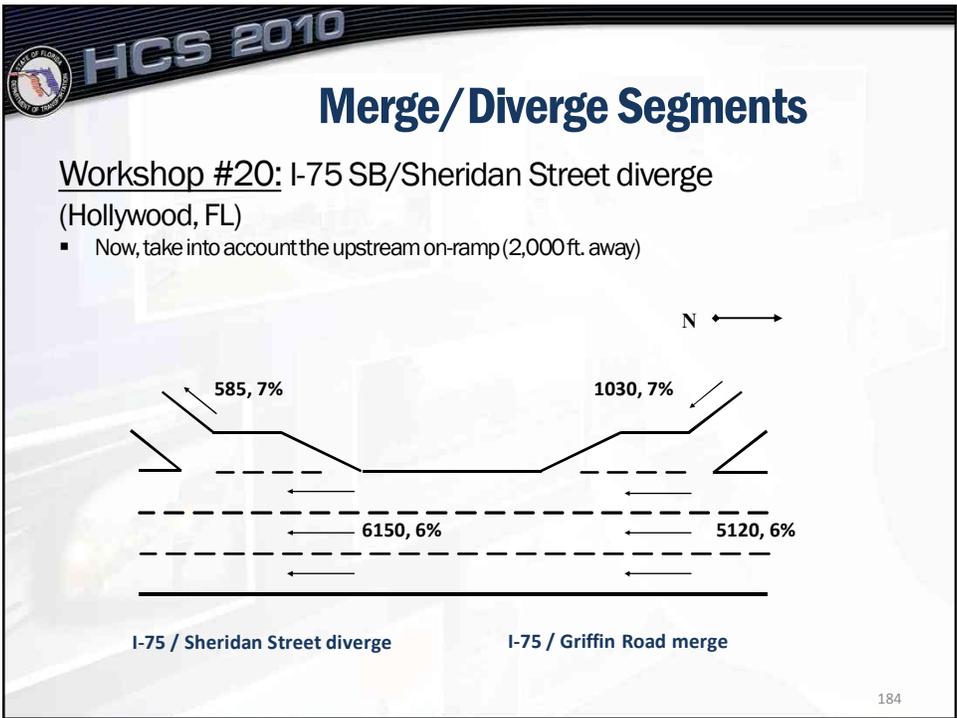
- Special lanes including HOV lanes
- Ramp metering
- Posted speed limit and enforcement
- Impacts of Intelligent Transportation Systems (ITS)

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HCS 2010

Merge/Diverge Segments

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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

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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)

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HCS 2010

Freeway Facilities

- HCM 2010 Exhibit 10-6

| Total Ramp Density (ramps/mi) | Base Capacity (pc/mi/ln) |
|-------------------------------|--------------------------|
| 0 | 2,400 |
| 1 | 2,400 |
| 2 | 2,400 |
| 3 | 2,375 |
| 4 | 2,350 |
| 5 | 2,325 |
| 6 | 2,300 |
| 7 | 2,275 |
| 8 | 2,250 |

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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_p/c ratio > 1.00 |

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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

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Freeway Facilities

Required Data

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

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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

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HCS 2010

Freeway Facilities

Methodology

- HCM 2010
- Exhibit 10-10

```

graph TD
    S1[Step 1: Input data  
Demand  
Geometry  
Time-Space Domain] --> S2[Step 2:  
Adjust demand according to spatial  
and time units established]
    S2 --> S3[Step 3:  
Compute segment capacities  
according to Chapter 11, 12, and 13  
methodologies]
    S3 --> S4[Step 4: Adjust segment capacities]
    S4 --> S5[Step 5:  
Compute demand-to-capacity ratios (v/c)  
All segments, on-ramps, and off-ramps]
    S5 -- Undersaturated --> S6A[Step 6A:  
Compute undersaturated segment  
service measures and other  
performance measures  
Assign segment levels of service]
    S5 -- Oversaturated --> S6B[Step 6B:  
Compute oversaturated segment  
service measures and other  
performance measures  
Assign segment levels of service]
    S6A --> S7[Step 7:  
Compute freeway facility service  
measures and other performance  
measures  
Assign appropriate level of service]
    S6B --> S7
    
```

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HCS 2010

Freeway Facilities

Example #10: 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 | - | - |

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Freeway Facilities

Workshop #21: NB I-275 (Tampa, FL)

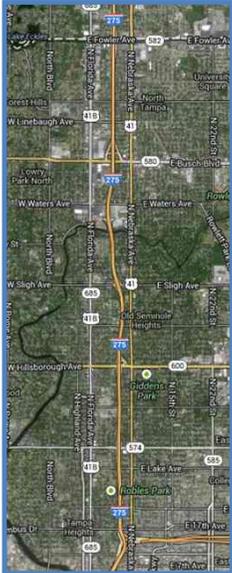
- 3-lane freeway
- Level terrain
- 75 mph freeway FFS
- 40 mph ramp FFS
- 8% trucks on mainline
- 3% trucks on ramps

| 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 | - | - |

N ↑

 **HCS 2010**

Freeway Facilities



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 **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

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 **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)

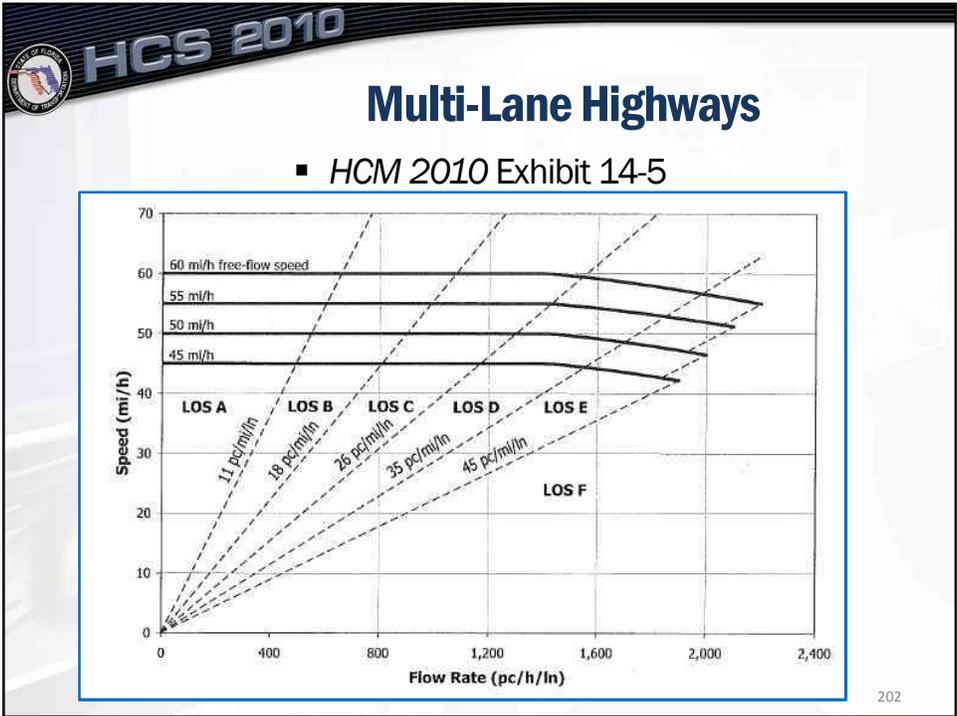
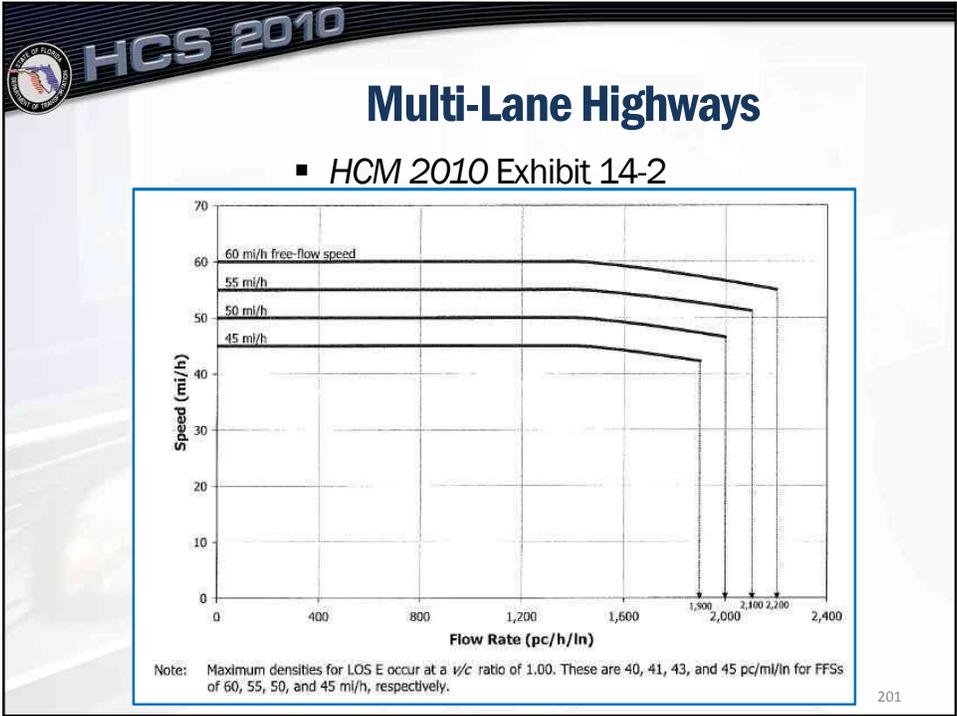
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 **HCS 2010**

Multi-Lane Highways



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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 |
| Demand Exceeds Capacity | | |
| F | 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 |

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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

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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

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HCS 2010

Multi-Lane Highways

Methodology

- *HCM 2010*
Exhibit 14-7

```

    graph TD
      Step1[Step 1: Input Data  
Geometric data  
Demand volume  
Measured FFS (if available)]
      Step2[Step 2: Compute FFS  
Lane width adjustment  
Lateral clearance adjustment  
Median type adjustment  
Access point adjustment  
Use Equation 14-1]
      Step3[Step 3: Select FFS Curve]
      Step4[Step 4: Adjust Demand Volume  
PHF  
Number of lanes (one direction)  
Heavy vehicle adjustment  
Driver population adjustment  
Use Equation 14-3  
Compare adjusted demand flow rates  
to base capacity]
      Step5[Step 5: Estimate Speed and Density  
Exhibit 14-3 or 14-5  
Equation 14-5]
      Step6[Step 6: Determine LOS  
Exhibit 14-4]
      Step7[LOS = F]

      Step1 -- "Measured FFS not available" --> Step2
      Step1 -- "Measured FFS available" --> Step3
      Step2 --> Step3
      Step3 --> Step4
      Step4 -- "Demand flow rate > base capacity" --> Step7
      Step4 -- "Demand flow rate ≤ base capacity" --> Step5
      Step7 --> Step6
      Step5 --> Step6
  
```

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HCS 2010

Multi-Lane Highways

Example #11: 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% |

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HCS 2010

Multi-Lane Highways

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HCS 2010

Multi-Lane Highways

Workshop #22: 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% |

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HCS 2010

Multi-Lane Highways

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HCS 2010

Multi-Lane Highways

Workshop #23: 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% |

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HCS 2010

Multi-Lane Highways



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HCS 2010

Multi-Lane Highways

Workshop #24: 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% |

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HCS 2010

Multi-Lane Highways

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HCS 2010

Multi-Lane Highways

Workshop #25: 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% |

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HCS 2010

Multi-Lane Highways

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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** ◀

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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

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 **HCS 2010**

Two-Lane Highways

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



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 **HCS 2010**

Two-Lane Highways

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



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 **HCS 2010**

Two-Lane Highways

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



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 **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

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HCS 2010

Two-Lane Highways

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

| LOS | Class I Highways | | Class II Highways | Class III Highways |
|-----|------------------|----------|-------------------|--------------------|
| | ATS (mi/h) | PTSF (%) | PTSF (%) | 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 |

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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

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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

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HCS 2010

Two-Lane Highways

Methodology

▪ *HCM2010*
Exhibit 15-6

```

    graph TD
      S1[Step 1: Input Data  
Geometric data  
Demand volume  
Highway class (I, II, or III)  
Field-measured speed (Sfm) or  
Base free-flow speed (BFFS)] --> S2[Step 2: Estimate Free-Flow Speed  
Field-measured speed adjustment: flow rate, heavy vehicles (Equations 15-1 and 15-4), or  
BFFS adjustments: lane and shoulder width, access-point density (Equation 15-2, Exhibits 15-7 and 15-8)]
      S2 --> S3L[Step 3: Demand Adjustment for Average Travel Speed (ATS)  
(Equations 15-3 to 15-5)  
Peak hour factor  
Heavy vehicle adjustment  
General terrain (Exhibit 15-11)  
Specific grade (Exhibits 15-12 to 15-14)  
Grade adjustment  
General terrain (Exhibit 15-9)  
Specific grade (Exhibit 15-10)]
      S2 --> S3R[Step 3: Demand Adjustment for Average Travel Speed (ATS)  
(Equations 15-3 to 15-5)  
Peak hour factor  
Heavy vehicle adjustment  
General terrain (Exhibit 15-11)  
Specific grade (Exhibits 15-12 to 15-14)  
Grade adjustment  
General terrain (Exhibit 15-9)  
Specific grade (Exhibit 15-10)]
      S3L --> S4L[Step 4: Estimate ATS  
(Equation 15-6)  
No passing-zone adjustment (Exhibit 15-15)]
      S3R --> S4R[Step 4: Estimate ATS  
(Equation 15-6)  
No passing-zone adjustment (Exhibit 15-15)]
      S4L --> S5L[Step 5: Demand Adjustment for Percent Time-Spent-Following (PTSF)  
(Equations 15-7 and 15-8)  
Peak hour factor  
Heavy vehicle adjustment  
General terrain (Exhibit 15-18)  
Specific grade (Exhibit 15-19)  
Grade adjustment  
General terrain (Exhibit 15-16)  
Specific grade (Exhibit 15-17)]
      S4R --> S5R[Step 5: Demand Adjustment for Percent Time-Spent-Following (PTSF)  
(Equations 15-7 and 15-8)  
Peak hour factor  
Heavy vehicle adjustment  
General terrain (Exhibit 15-18)  
Specific grade (Exhibit 15-19)  
Grade adjustment  
General terrain (Exhibit 15-16)  
Specific grade (Exhibit 15-17)]
      S5L --> S6L[Step 6: Estimate PTSF  
(Equations 15-9 and 15-10, Exhibit 15-20)  
No passing-zone adjustment (Exhibit 15-21)]
      S5R --> S6R[Step 6: Estimate PTSF  
(Equations 15-9 and 15-10, Exhibit 15-20)  
No passing-zone adjustment (Exhibit 15-21)]
      S6L --> S8[Step 8: Determine Level of Service and Capacity  
(Exhibit 15-3)]
      S6R --> S7[Step 7: Estimate Percent of Free-Flow Speed (PPFS)  
(Equation 15-11)]
      S7 --> S8
  
```

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HCS 2010

Two-Lane Highways

Example #12: 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% |

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HCS 2010

Two-Lane Highways

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HCS 2010

Two-Lane Highways

Workshop #26: SR 789 (Sarasota, FL)

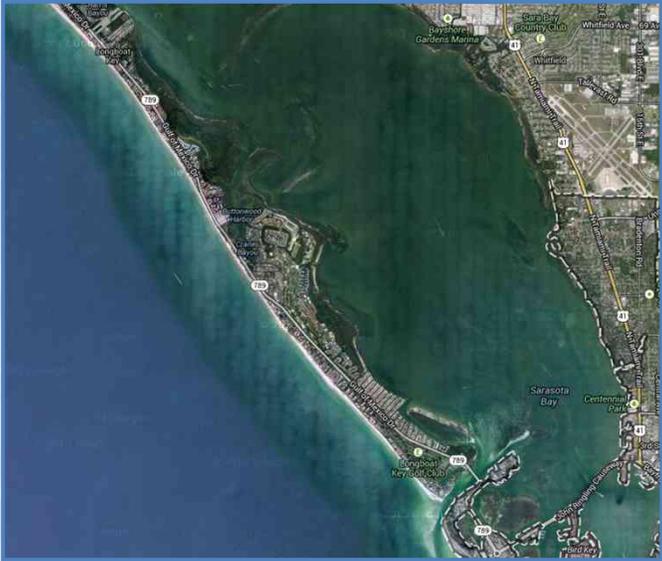
- Level terrain
- 4 ft. shoulder width
- 11 ft. lane width
- 17.7-mile corridor length
- Class III two-lane highway segment
- 70% no passing zones
- 25 access points per mile
- 55 mph base FFS (50 MPH posted)
- Pavement rating: 4

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

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HCS 2010

Two-Lane Highways



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HCS 2010

Two-Lane Highways

Workshop #27: 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 |
| Oposing Direction Volume | 182 vph |
| PHF | 0.88 |
| Trucks and Buses | 7% |

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HCS 2010

Two-Lane Highways

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HCS 2010

Two-Lane Highways

Workshop #28: 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 |
| Oposing Direction Volume | 180 vph |
| PHF | 0.90 |
| Trucks and Buses | 2% |

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HCS 2010

Two-Lane Highways

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HCS 2010

Two-Lane Highways

Workshop #29: 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% |

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HCS 2010

Two-Lane Highways

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Wrap-Up

HCS 2010 versus HCS+

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

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Wrap-Up

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