

Signal optimization using Highway Capacity Software (HCS) 2010



Overview and demonstration

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Highway Capacity Software

Developed and maintained by McTrans

- Originally founded by the FHWA in 1986 as the Center for Microcomputers in Transportation (McTrans)
- Now a full-service software support center, associated with the University of Florida

HCS 2010

- HCS 2010 implements the procedures defined in the Highway Capacity Manual (HCM) 2010 published by the Transportation Research Board (TRB)
- This release includes the new Streets module that combines the Signalized Intersections with the Urban Streets Segments, Facilities and Multimodal procedures.



Fourteen Modules



Intersection Module

Highway Module

- Synchro:
Cannot be used for
- Freeways
 - Interchange systems or ramps



Street Module

Signalized Intersections

- Signal analysis
- Interchange analysis
- Multimodal analysis
- LOS



Signalized intersections

- Traffic Conditions
 - Approach volumes (left, through, right)
 - Vehicle type (heavy vehicle, bicycles)
 - Pedestrian movement



Signalized intersections

- Roadway Conditions
 - Number and width of lanes
 - Grades
 - Lane use
- Traffic Signal Characteristics
 - Signal phasing
 - Signal timing
 - Type of control (Actuated/pre-timed)
 - Signal progression (un/co-ordinated)



Signalized intersections

- Total delay:
 - Difference between actual travel time and ideal travel time
 - In the absence of traffic control, delay due to roadway geometries, incidents and when there are no vehicles on the road
 - In HCS **control delay** is quantified
 - initial deceleration delay
 - Queue move-up time
 - Stopped delay
 - Final acceleration delay



Level of Service (LOS)

- LOS criteria are stated in terms of average control delay per vehicle
 - Delay on signal control depends on
 - Quality of progression
 - Cycle length
 - Green ratio
 - V/c ratio for lane group
 - ICU (Intersection Capacity Utilization)
- Designated by letters A - F



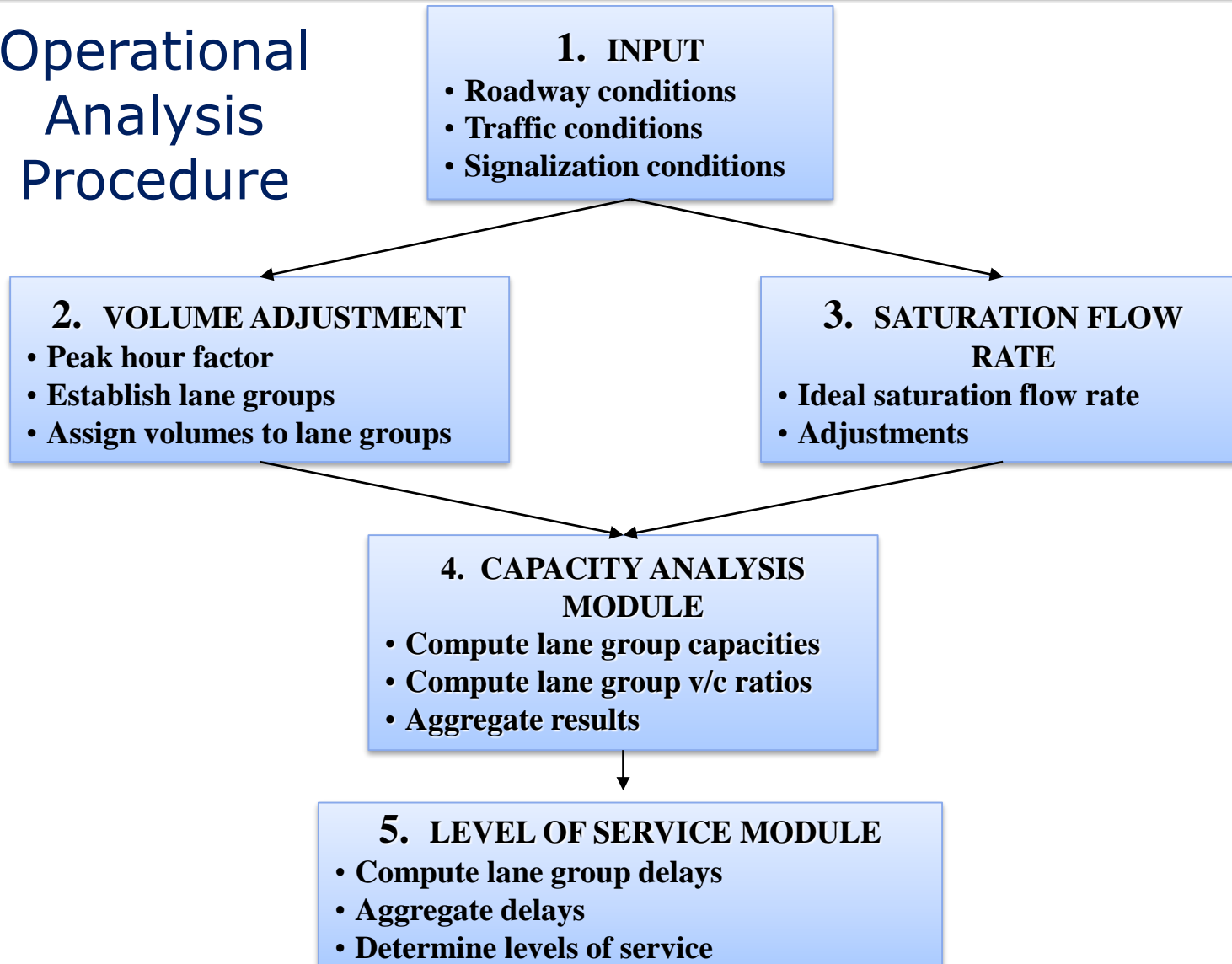
Level of Service (LOS)

| LEVEL OF SERVICE | CONTROL DELAY PER VEHICLE (SEC/VEHICLES) |
|------------------|---|
| A | ≤ 10 |
| B | >10 and ≤ 20 |
| C | >20 and ≤ 35 |
| D | >35 and ≤ 55 |
| E | >55 and ≤ 80 |
| F | > 80 |

| ICU | Level of Service |
|---------------|------------------|
| 0 to 55% | A |
| >55% to 64% | B |
| >64% to 73% | C |
| >73% to 82% | D |
| >82% to 91% | E |
| >91% to 100% | F |
| >100% to 109% | G |
| >109% | H |

Source: Highway Capacity Manual 2010

Operational Analysis Procedure



Getting Started:

1. Open HCS 2010
2. Select the Streets *(handles signals and signalized corridors)*



Getting Started:

3. Complete The Quick Start Screen

Quick Start

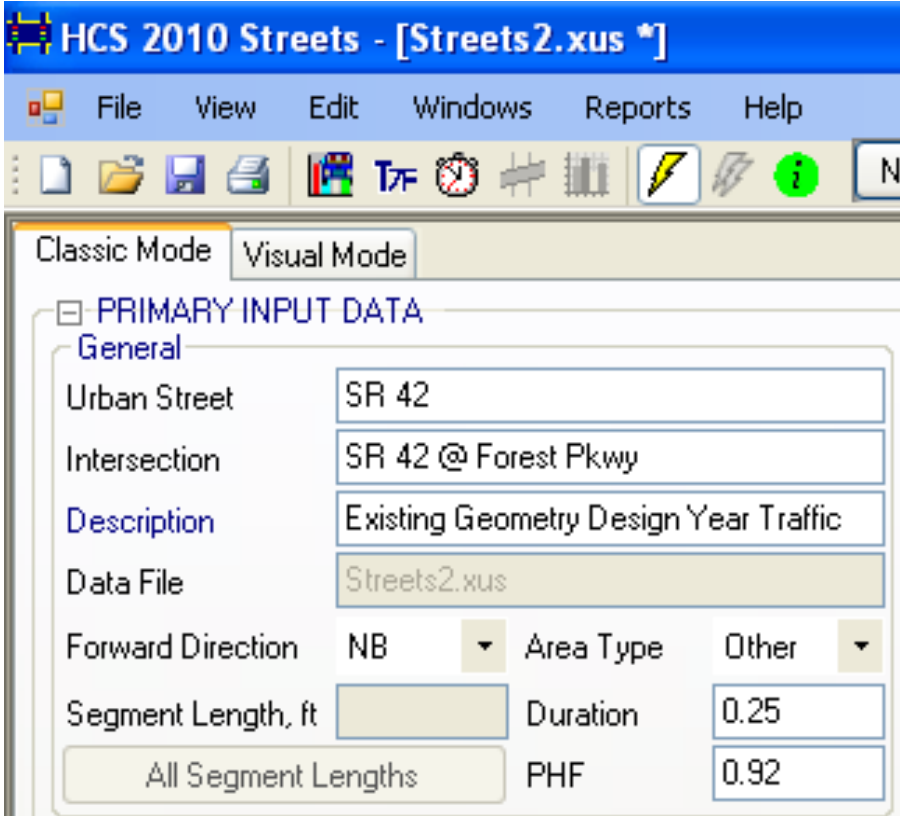
Default Selections

| | | | |
|------------------------------|------|---------------------|-----|
| Number of Intersections | 1 | Cycle Length, s | 100 |
| Forward Direction | NB | Minimum Green, s | 5 |
| Number of Periods | 1 | Yellow Change, s | 4.0 |
| Analysis Duration, h | 0.25 | Red Clearance, s | 1.0 |
| Base Saturation Flow, pcphpl | 1900 | Passage Time, s | 2.0 |
| Speed Limit, mi/h | 45 | Detector Length, ft | 40 |

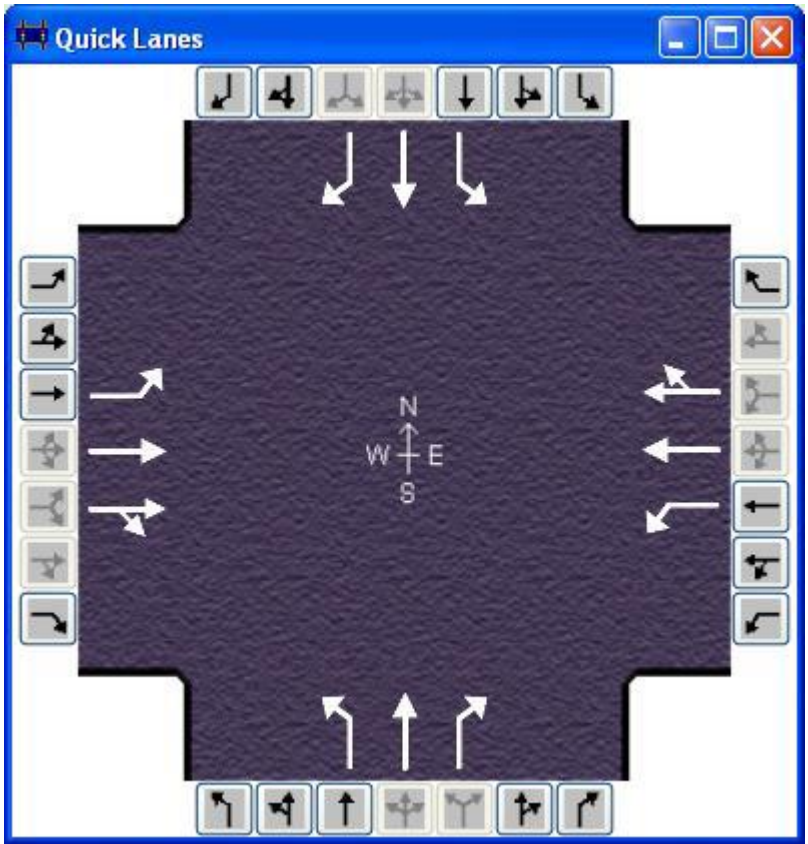
Template Help



4. Enter Information in the **General** Section



5. Enter Lane Configuration



6. Enter Traffic Data

| Traffic | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|------------------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Demand, veh/h | 350 | 1315 | 285 | 385 | 740 | 125 | 130 | 320 | 240 | 225 | 780 | 310 |
| Lane Width, ft | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 | 12.0 |
| Storage Length, ft | 350 | 0 | 0 | 300 | 0 | 0 | 190 | 0 | 300 | 200 | 0 | 370 |
| Saturation, pc/h/ln | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 | 1900 |
| Heavy Vehicles, % | 10 | 10 | 0 | 10 | 10 | 0 | 10 | 10 | 10 | 10 | 10 | 10 |
| Grade, % | | -2 | | | 1 | | | 6 | | | -2 | |
| Buses, per h | | | 0 | | | 0 | | | 0 | | | 0 |
| Parking, per h | 0 | N | 0 | 0 | N | 0 | 0 | N | 0 | 0 | N | 0 |
| Bicycles, per h | | 0 | | | 0 | | | 0 | | | 0 | |
| Pedestrians, per h | | 0 | | | 0 | | | 0 | | | 0 | |
| Arrival Type | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Upstream Filtering (I) | TSB | | 1.00 | TSWB | | 1.00 | TNB | | 1.00 | TNSB | | 1.00 |
| Initial Queue, veh | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Speed Limit, mi/h | | 45 | | | 45 | | | 45 | | | 45 | |
| Detector, ft | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |
| RTOR, veh/h | | | 0 | | | 0 | | | 0 | | | 0 |



7. Enter **Phasing** data

The screenshot shows a window titled "Quick Phases" with a 2x4 grid of phase diagrams. Each diagram is a black arrow path on a grey background, numbered 1 through 8. The paths represent different phasing configurations for a four-way intersection.

| | | | |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| 5 | 6 | 7 | 8 |



Quick Exercise on Phase Diagram



8. Enter Timing

Timing

| | EBL | EBT | WBL | WBT | NBL | NBT | SBL | SBT |
|------------------|------------------------------|--|-----------------------------|--|---|---|-----------------------------|--|
| Phase Split, s | 15.0 | 40.0 | 15.0 | 40.0 | 0.0 | 45.0 | 0.0 | 45.0 |
| Yellow Change, s | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Red Clearance, s | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Minimum Green, s | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Lag Phase | <input type="checkbox"/> EL | <input type="checkbox"/> ET | <input type="checkbox"/> WL | <input type="checkbox"/> WT | <input type="checkbox"/> NL | <input type="checkbox"/> NT | <input type="checkbox"/> SL | <input type="checkbox"/> ST |
| Passage Time, s | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Recall Mode | Off | Off | Off | Off | Off | Mir | Off | Mir |
| Dual Entry | <input type="checkbox"/> EL | <input checked="" type="checkbox"/> ET | <input type="checkbox"/> WL | <input checked="" type="checkbox"/> WT | <input type="checkbox"/> NL | <input checked="" type="checkbox"/> NT | <input type="checkbox"/> SL | <input checked="" type="checkbox"/> ST |
| Dallas Phasing | <input type="checkbox"/> EWY | <input type="checkbox"/> N/S | Simultaneous Gap | | <input checked="" type="checkbox"/> EWY | <input checked="" type="checkbox"/> N/S | | |

| | EBL | EBT | WBL | WBT | NBL | NBT | SBL | SBT |
|--------|------|------|------|-----|-----|-----|-----|-----|
| Green | 40.0 | 10.0 | 35.0 | 0.0 | 0.0 | 0.0 | | |
| Yellow | 4.0 | 4.0 | 4.0 | 0.0 | 0.0 | 0.0 | | |
| Red | 1.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | | |



9. Enter the Detailed Data

DETAILED INPUT DATA

General

Analyst:

Agency/Co:

Date: Wed, September 07, 2011

Time Period:

Analysis Year:

Jurisdiction:

Intersection

| | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|------------------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|--------------------------|
| Lanes | 1 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 0 | 1 | 2 | 0 |
| Shared Lane | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input checked="" type="checkbox"/> | <input type="checkbox"/> |
| Percent Turns in Shared Lane | 0 | | 0 | | 0 | | 0 | | 0 | 0 | | 0 |
| Percent Unopposed Left Turns | 0 | | | 0 | | | 0 | | | 0 | | |
| Heaviest Lane Volume, veh/h | 0 | 500 | 0 | 0 | 500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Start-Up Lost Time, s | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Extension of Effective Green, s | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 |
| Walk Interval, s | | 0.0 | | | 0.0 | | | 0.0 | | | 0.0 | |
| Pedestrian Clear Interval, s | | 0.0 | | | 0.0 | | | 0.0 | | | 0.0 | |
| Receiving Lanes | 2 | | | 2 | | | 2 | | | 2 | | |
| Heavy Vehicle Equivalency Factor | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Bus Blockage Time, s | | | 14.4 | | | 14.4 | | | 14.4 | | | 14.4 |
| Parking Maneuver Time, s | 18 | | 18 | 18 | | 18 | 18 | | 18 | 18 | | 18 |
| Opposing Right-Turn Lane Influence | <input type="checkbox"/> | | <input type="checkbox"/> | | <input type="checkbox"/> | | <input type="checkbox"/> | | <input type="checkbox"/> | | <input type="checkbox"/> | |

General

Number of Calculation Iterations: 15

Critical Merge Gap, s: 3.70

Stored Vehicle Lane Length, ft: 25.0

Length of Detected Vehicle, ft: 17.0

Stored Heavy Vehicle Length, ft: 45

Queue Length Percentile: 50

Acceleration Rate, ft/s²: 3.50

Stop Threshold Speed, mi/h: 5.0

Pedestrians Pushing Button, prop: 0.65

Speed Limit to Base FFS Ratio: 0.90

Sneakers per Cycle, veh: 2.0

Platoon Minimum Headway, s/veh: 1.50

Platoon Maximum Headway, s/veh: 3.60

Platoon Dispersion Factor: 0.138

Demand Growth, %: 0

Segment

Name:

| | EB | WB |
|--------------------------|-----|-----|
| Upstream Width, ft | 50 | 50 |
| Restrictive Median, ft | 0 | 0 |
| Right-Hand Curb, % | 70 | 70 |
| Right-Hand Access Points | 4 | 4 |
| Mid-Segment Delay, s/veh | 0.0 | 0.0 |

Signal

Exclusive Pedestrian Phase Time, s: 0.0

Right-Turn Equivalency Factor: 1.18

Left-Turn Equivalency Factor: 1.05

Deceleration Rate, ft/s²: 4.00

Critical Headway (permitted left turn), s: 4.5

Follow-Up Headway (permitted left turn), s: 2.5

Access Point

Critical Headway (left from major), s: 4.1

Follow-Up Headway (left from major), s: 2.2

Right-Turn Equivalency Factor: 2.20

Maximum Turn Bay Length, ft: 250

Deceleration Rate, ft/s²: 6.7

Right-Turn Speed, ft/s: 20

Access Points

Active

PHF: 1.00

Count: 2

| | EBL | EBT | EBR | WBL | WBT | WBR | NBL | NBT | NBR | SBL | SBT | SBR |
|----------------------------|-------------------|------|-----|-----|------|-----|-----|-----|-----|-----|-----|-----|
| Demand, veh/h | 80 | 1050 | 100 | 80 | 1050 | 100 | 80 | 0 | 100 | 80 | 0 | 100 |
| Lanes | 0 | 2 | 0 | 0 | 2 | 0 | 1 | 0 | 1 | 1 | 0 | 1 |
| Name: <input type="text"/> | Location, ft: 600 | | | | | | | | | | | |



10. Run **Full Optimization**

The screenshot shows a software dialog box titled "Full Optimization" with a blue header and a close button (X) in the top right corner. The dialog is organized into sections:

- Input Parameters:**
 - Global Optimization:** A rounded rectangle containing various settings.
 - Objective Function: Overall Delay (dropdown)
 - Minimum Cycle, s: 60 (text box)
 - Maximum Cycle, s: 120 (text box)
 - Cycle Increment, s: 10 (text box)
 - Master Intersection: 1 (text box)
 - Forward Weighting, %: 50 (text box)
 - Reverse Weighting, %: 50 (text box)
 - Number of Generations: 50 (text box)
 - Population Size: 10 (text box)
 - Crossover Probability, %: 30 (text box)
 - Mutation Probability, %: 4.0 (text box)
 - Convergence Threshold, %: 0.010 (text box)
 - Random Number Seed: 7781 (text box)
 - Cycle Length: (checkbox)
 - Splits: (checkbox)
 - Offsets: (checkbox)
 - Phasing Sequence: (checkbox)
 - Dallas Phasing: (checkbox)
- Optimization Status:** A collapsed section (indicated by a downward arrow).
- Diagnostic Messages:** A collapsed section (indicated by a downward arrow).

On the right side of the dialog, there are three buttons: "Start" (with a green play icon), "Info" (with a yellow question mark icon), and "Stop" (with a red stop icon). At the bottom center, there are "Save" and "Cancel" buttons.

11. Optimization Results

The screenshot shows a software window titled "Full Optimization" with a blue border. It contains two main sections: "Optimization Status" and "Diagnostic Messages".

Optimization Status

Overall Delay

| | |
|-------------|---------------|
| Original | 263.7 sec/veh |
| Optimum | 169.1 sec/veh |
| Average | 175.0 sec/veh |
| Improvement | 35.9% |

Run Status

| | |
|--------------------|----------------|
| Generation Number | 200 out of 200 |
| Generation Optimum | 101 |
| Total Time Elapsed | 43 sec |

Termination via max number of generations

Diagnostic Messages

No messages to report at this time.

Control buttons: Start (green dot), Info (yellow dot), Stop (red dot), Save, Cancel.



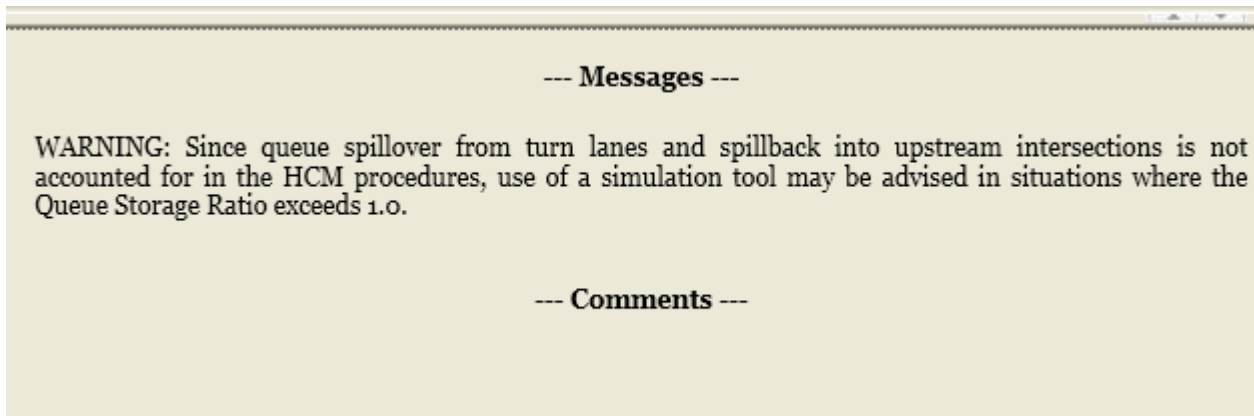
12. View/Print Results Summary Report

| HCS 2010 Signalized Intersection Results Summary | | | | | | | | | | | | | | |
|--|---------------------------------------|--|-----------------|--------------|-------|---------------------------------|---------|-------|-------|-------|-------|-------|-------|-------|
| General Information | | | | | | Intersection Information | | | | | | | | |
| Agency | GDOT | | | | | Duration, h | 0.25 | | | | | | | |
| Analyst | Design Engineer | | Analysis Date | Apr 12, 2012 | | Area Type | Other | | | | | | | |
| Jurisdiction | Clayton County | | Time Period | 2032 PM | | PHF | 0.92 | | | | | | | |
| Intersection | SR 42 @ Forest Pkwy | | Analysis Year | 2012 | | Analysis Period | 1> 7:00 | | | | | | | |
| File Name | pdt example.xus | | | | | | | | | | | | | |
| Project Description | Existing Geometry Design Year Traffic | | | | | | | | | | | | | |
| Demand Information | | | EB | | | WB | | | NB | | | SB | | |
| Approach Movement | | | L | T | R | L | T | R | L | T | R | L | T | R |
| Demand (v), veh/h | | | 350 | 1315 | 285 | 385 | 740 | 125 | 130 | 320 | 240 | 225 | 780 | 310 |
| Signal Information | | | | | | | | | | | | | | |
| Cycle, s | 110.0 | | Reference Phase | 2 | | | | | | | | | | |
| Offset, s | 0 | | Reference Point | End | | | | | | | | | | |
| Uncoordinated | No | | Simult. Gap E/W | On | | | | | | | | | | |
| Force Mode | Fixed | | Simult. Gap N/S | On | | | | | | | | | | |
| | | | Green | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| | | | Yellow | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| | | | Red | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | | | | |
| Timer Results | | | EBL | EBT | WBL | WBT | NBL | NBT | SBL | SBT | | | | |
| Assigned Phase | | | 7 | 4 | 3 | 8 | | 2 | | 6 | | | | |
| Case Number | | | 2.0 | 4.0 | 2.0 | 4.0 | | 5.0 | | 5.0 | | | | |
| Phase Duration, s | | | 32.2 | 50.0 | 21.0 | 38.8 | | 39.0 | | 39.0 | | | | |
| Change Period, (Y+R _c), s | | | 5.0 | 5.0 | 5.0 | 5.0 | | 5.0 | | 5.0 | | | | |
| Max Allow Headway (MAH), s | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | 0.0 | | | | |
| Queue Clearance Time (g _v), s | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | 0.0 | | | | |
| Green Extension Time (g _e), s | | | 0.0 | 0.0 | 0.0 | 0.0 | | 0.0 | | 0.0 | | | | |
| Phase Call Probability | | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | | 0.00 | | | | |
| Max Out Probability | | | 0.00 | 0.00 | 0.00 | 0.00 | | 0.00 | | 0.00 | | | | |
| Movement Group Results | | | EB | | | WB | | | NB | | | SB | | |
| Approach Movement | | | L | T | R | L | T | R | L | T | R | L | T | R |
| Assigned Movement | | | 7 | 4 | 14 | 3 | 8 | 18 | 5 | 2 | 12 | 1 | 6 | 16 |
| Adjusted Flow Rate (v), veh/h | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Adjusted Saturation Flow Rate (s), veh/h/ln | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Queue Service Time (g _v), s | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Cycle Queue Clearance Time (g _c), s | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Capacity (c), veh/h | | | 412 | 714 | 670 | 238 | 527 | 501 | 64 | 518 | 439 | 188 | 539 | 457 |
| Volume-to-Capacity Ratio (X) | | | 0.924 | 1.233 | 1.282 | 1.758 | 0.915 | 0.915 | 2.119 | 0.672 | 0.694 | 1.303 | 1.572 | 0.737 |
| Available Capacity (c _a), veh/h | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Back of Queue (Q), veh/ln (95th percentile) | | | 15.2 | 58.8 | 61.9 | 47.3 | 21.1 | 20.3 | 21.3 | 13.5 | 10.4 | 22.9 | 82.4 | 13.9 |
| Overflow Queue (Q _o), veh/ln | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Queue Storage Ratio (RQ) (95th percentile) | | | 1.17 | 0.00 | 0.00 | 4.25 | 0.00 | 0.00 | 3.09 | 0.00 | 0.94 | 3.09 | 0.00 | 1.01 |
| Uniform Delay (d _i), s/veh | | | 40.4 | 32.5 | 32.5 | 47.0 | 38.7 | 38.7 | 55.0 | 33.1 | 32.2 | 50.4 | 38.0 | 34.0 |
| Incremental Delay (d _i), s/veh | | | 3.9 | 116.9 | 138.0 | 357.7 | 20.2 | 21.0 | 568.5 | 6.8 | 5.8 | 169.7 | 266.4 | 10.2 |
| Initial Queue Delay (d _i), s/veh | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Control Delay (d), s/veh | | | 44.2 | 149.4 | 170.5 | 404.7 | 58.9 | 57.7 | 623.5 | 39.9 | 38.0 | 220.1 | 304.4 | 44.2 |
| Level of Service (LOS) | | | D | F | F | F | E | E | F | D | D | F | F | D |
| Approach Delay, s/veh / LOS | | | 139.1 | F | | 164.3 | F | | 149.2 | F | | 228.6 | F | |
| Intersection Delay, s/veh / LOS | | | 169.1 | | | | | | F | | | | | |

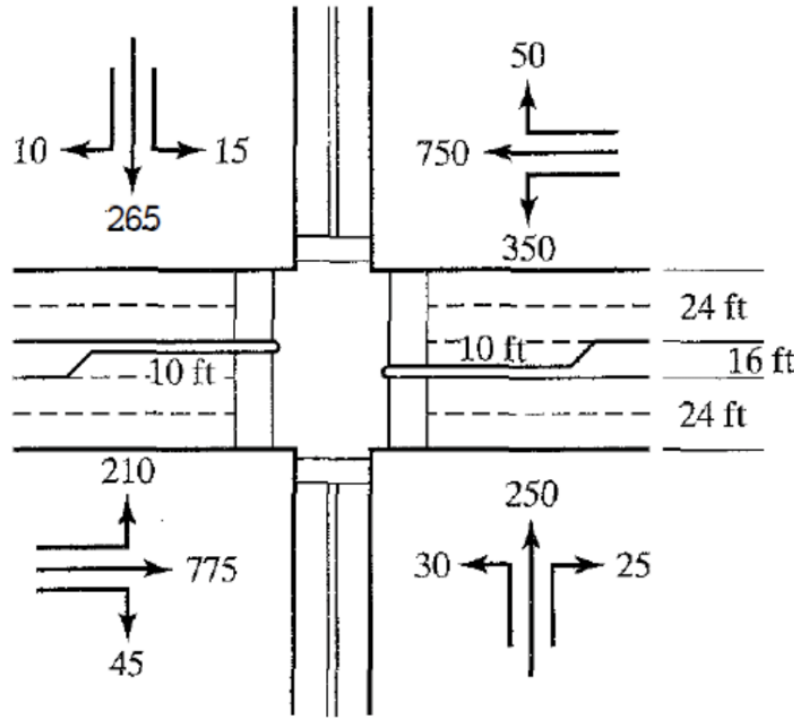


13. View Messages Report

- Look for any warnings



2. What should be your recommended phasing and cycle length for the following intersection?



$PHF = 0.98$

Target v/c ratio = 0.95

Moderate pedestrian activity

Speed limits:

30 mi/h N-S

40 mi/h E-W

Crosswalk widths = 10 ft

Questions?



References

Mctrans Center (2016, May 7), HCS 2010 Streets - Tutorial [Video file]. Retrieved from <https://www.youtube.com/watch?v=OjgB-ufDPfk>

GDOT (2013), Getting Started: HCS 2010, retrieved from: <http://www.dot.ga.gov/PartnerSmart/DesignManuals/ElectronicPlanProcess/Getting%20Started%20HCS2010.pdf>