

Highway Capacity Software

- Based on the Highway Capacity Manual (HCM)
 - Special Report 209
 - Transportation Research Board (TRB), National Research Council (NRC)

Ten Modules

1. Freeways
2. Weaving
3. Ramps
4. Multi-lane Highways
5. Two-lane Highways
6. Signalized Intersections
7. Unsignalized Intersections
8. Arterials
9. Transit
10. Pedestrians

Modules Included in CE 4640

- Signalized Intersections
- Unsignalized Intersections
- Multi-lane Highways
- Two-lane Highways

Signalized Intersections

■ Capacity

■ Defined for each lane group

- Lane group: one or more lanes that accommodate traffic and have a common stopline

■ Lane group capacity: maximum rate of flow for the subject lane group that may pass through the intersection under prevailing traffic, roadway and signalized conditions

■ Traffic Conditions

- Approach volumes (left, through, right)
- Vehicle type
- Location of bus stops
- Pedestrian crossing flows
- Parking movement

■ Roadway Conditions

- Number and width of lanes
- Grades
- Lane use
 - Including parking lanes

■ Signalized Conditions

- Signal phasing
- Signal timing
- Type of control
- Signal progression

Level of Service (LOS)

- Defined in terms of delay as a measure of
 - driver discomfort
 - Driver frustration
 - Fuel consumption
 - Lost travel time

Signalized Intersections

- Delay experienced by a motorist includes many factors:
 - Signal control
 - Geometrics
 - Incidents

- Total delay:

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

-
- Previous versions of HCM/HCS (1994 version or earlier)
 - Only included stopped time delay

LOS

- LOS criteria are stated in terms of average control delay per vehicle
 - Delay is dependent on
 - Quality of progression
 - Cycle length
 - Green ratio
 - V/c ratio for lane group
- Designated by letters A - F

LOS Criteria for Signalized Intersections

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

LOS A

- Describes operations with very low control delay, up to 10 sec/veh
 - Occurs when progression is extremely favorable
 - When most cars arrive during the green
 - Most vehicles do not stop at all
 - Short cycle lengths may also contribute to low delay

LOS B

- Describes operations with control delay > 10 and up to 20 sec/veh
 - Occurs with good progression, short cycle lengths or both
 - More vehicles stop than with LOS A
 - Causing higher levels of average delay

LOS C

- Describes operations with control delay greater than 20 and up to 35 sec/veh
 - Fair progression, longer cycle lengths, or both
 - Individual cycle failures may begin to appear at this level
 - No. of vehicles stopping is significant
 - Many still pass without stopping

LOS D

- Describes operations with control delay > 35 and up to 55 sec/veh
 - Influence of congestion becomes more noticeable
 - Longer delays result
 - Unfavorable progression
 - Long cycle lengths
 - High v/c ratios
 - Many vehicles stop
 - Proportion of vehicles not stopping declines
 - Individual cycle failures are noticeable

LOS E

- Describes operations with delay > 55 and up to 80 sec/veh
 - The limit of acceptable delay
 - Indicate poor progression, long cycle lengths and high v/c ratios
 - Individual cycle failures are frequent occurrences

LOS F

- Describes operations with delay > 80 sec/veh
 - Considered unacceptable to most drivers
 - Occurs with oversaturation
 - When arrival flow rates exceed the capacity of the intersection
 - Occurs at high v/c ratios below 1.0 with many individual cycle failures
 - Poor progression and long cycle lengths may also contribute

Operational Analysis Procedure

1. INPUT

- Geometric conditions
- Traffic conditions
- Signalization conditions

2. VOLUME ADJUSTMENT

- Peak hour factor
- Establish lane groups
- Assign volumes to lane groups

3. SATURATION FLOW RATE

- Ideal saturation flow rate
- Adjustments

4. CAPACITY ANALYSIS MODULE

- Compute lane group capacities
- Compute lane group v/c ratios
- Aggregate results

5. LEVEL OF SERVICE MODULE

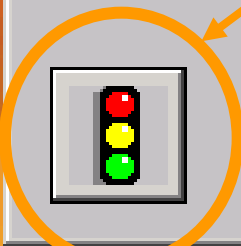
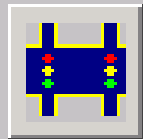
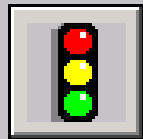
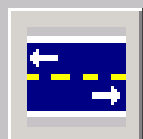
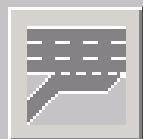
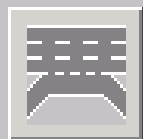
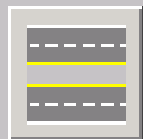
- Compute lane group delays
- Aggregate delays
- Determine levels of service

HCS

Highway Capacity Software™

by *McTrans*™

Signals





Input Quick Jump

Report Quick Jump

Open

SIGNALIZED INTERSECTIONS OPERATIONAL ANALYSIS

Intersection	<input type="text"/>	Project No.	<input type="text"/>
City/State	<input type="text"/>	Time Period Analyzed	<input type="text"/>
Analyst	<input type="text"/>	Date	<input type="text" value="9/10/2001"/> Units: U. S. Customary
East/West Street Name	<input type="text"/>	North/South Street Name	<input type="text"/>

HCS: Signalized Intersections Release 3.2

Inter: City/St:
 Analyst: Proj #:
 Date: 9/10/2001 Period:
 E/W St: N/S St:

SIGNALIZED INTERSECTION SUMMARY

	Eastbound			Westbound			Northbound			Southbound		
	L	T	R	L	T	R	L	T	R	L	T	R
No. Lanes	0	0	0	0	0	0	0	0	0	0	0	0
LGConfig												
Volume												
Lane Width												
RTOR Vol												

Duration 0.25 Area Type: All other areas

Signal Operations

Phase Combination	1	2	3	4	5	6	7	8
EB Left								
NB Left								

Intersection: []

SIGNALIZED INTERSECTIONS OPERATIONAL ANALYSIS

Intersection

Project No.

City/State

Time Period Analyzed

Analyst

Date

9/10/2001

Units: U. S. Customary

East/West Street Name

North/South Street Name

VOLUME

Duration hours

Eastbound			Westbound		
Left	Thru	Right	Left	Thru	Right

Northbound			Southbound		
Left	Thru	Right	Left	Thru	Right

Number of Lanes and Usage

<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Shared		Shared		Shared	

<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
Shared		Shared		Shared	

Volume (vph)

<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
--------------------------------	--------------------------------	--------------------------------	--------------------------------	--------------------------------	--------------------------------

<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>	<input type="text" value="0"/>
--------------------------------	--------------------------------	--------------------------------	--------------------------------	--------------------------------	--------------------------------

Peak Hour Factor, PHF

<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>
-----------------------------------	-----------------------------------	-----------------------------------	-----------------------------------	-----------------------------------	-----------------------------------

<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>	<input type="text" value="0.90"/>
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Peak-15 Minute Volume (v)

<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
----------------------	----------------------	----------------------	----------------------	----------------------	----------------------

<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
----------------------	----------------------	----------------------	----------------------	----------------------	----------------------

Right Turns on Red (vph)

RTOR <input type="text" value="0"/>	RTOR <input type="text" value="0"/>
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RTOR <input type="text" value="0"/>	RTOR <input type="text" value="0"/>
-------------------------------------	-------------------------------------

OPERATING PARAMETERS

Eastbound

Westbound

TR

R

L

LT

Northbound

Southbound

L

T

R

Initial Unmet Demand (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

Arrival Type or Percent Arriving during Green

3 3 3 3 3 3

3 3 3 3 3 3

Unit Extension (sec)

3.0 3.0 3.0 3.0 3.0 3.0

3.0 3.0 3.0 3.0 3.0 3.0

Upstream Filtering/Metering Adjustment Factor, I

I = 1.000 I = 1.000

I = 1.000 I = 1.000

Start-up Lost Time (sec)

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 (sec)

2.0 2.0 2.0 2.0 2.0 2.0

2.0 2.0 2.0 2.0 2.0 2.0

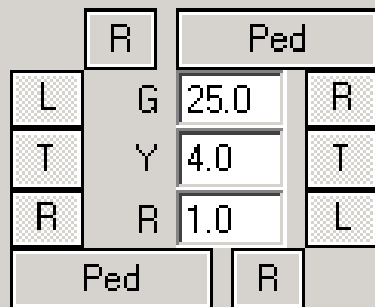
Pedestrian Speed (ft/sec), Travel Distance (ft), and Minimum Green (sec)

4.0 0.0 0.0 4.0 0.0 0.0

4.0 0.0 0.0 4.0 0.0 0.0

PHASING DESIGN

Phase 1



Phase 2



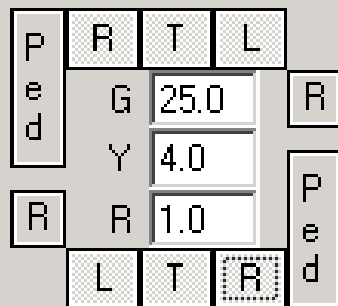
Phase 3



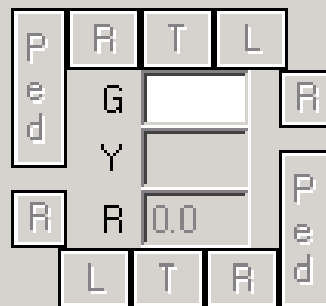
Phase 4



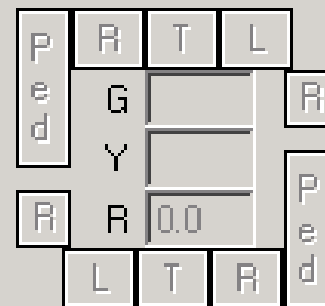
Phase 5



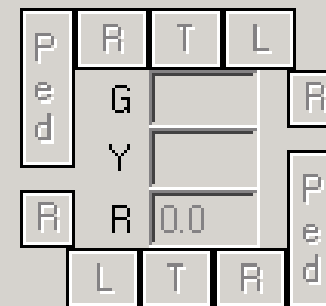
Phase 6



Phase 7

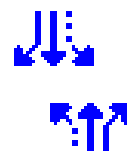
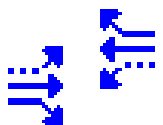


Phase 8



Cycle Length

60.0



Ideal Saturation Flow Rate (pcphgpl)

1900 1900 1900 1900 1900 1900

1900 1900 1900 1900 1900 1900

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

Percent Heavy Vehicles (%)

0 0 0 0 0 0

0 0 0 0 0 0

Percent Grade (%)

0 0

0 0

Parking Maneuvers per hour

Yes 20 Yes 20 Yes 20 Yes 20

Yes 20 Yes 20 Yes 20 Yes 20

Bus Stops per hour

0 0 0 0 0 0

0 0 0 0 0 0

Area Type CBD or Similar

Highest Single Lane Volume in Lane Group (vph). Field data available.

Conflicting Pedestrians per hour

Peds 0 Peds 0

Peds 0 Peds 0

Percent Right-Turns Using Protected Phase

0 0

0 0

Adjustment Factors

f_w	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
f_{dv}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
f_g	1.000			1.000			1.000			1.000		
f_p	1.000		1.000	1.000		1.000	1.000		1.000	1.000		
f_{bb}	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000		
f_a	1.00			1.00			1.00			1.00		
f_{JU}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00		
f_{RT}	1.000		1.000	1.000		1.000	1.000		1.000	1.000		
f_{LT}	1.000	1.000	Pri.	1.000	1.000	Pri.	1.000	1.000	Pri.	1.000	1.000	
f_{LT}	1.000	Sec.		1.000	Sec.		1.000	Sec.		1.000	Sec.	

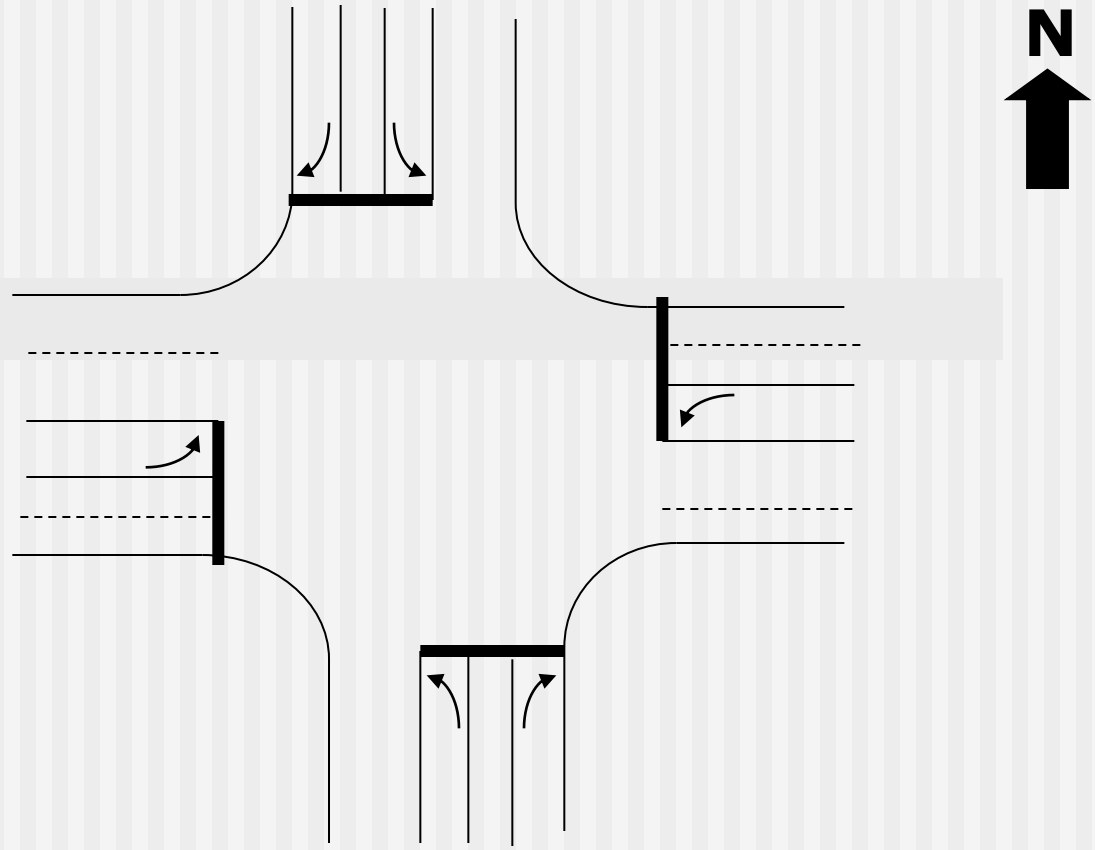
Adjusted Saturation Flow Rate, vphg

0	0	0	0	0	0	0	0	0	0	0	
0	Secondary		0	Secondary		0	Secondary		0	Secondary	

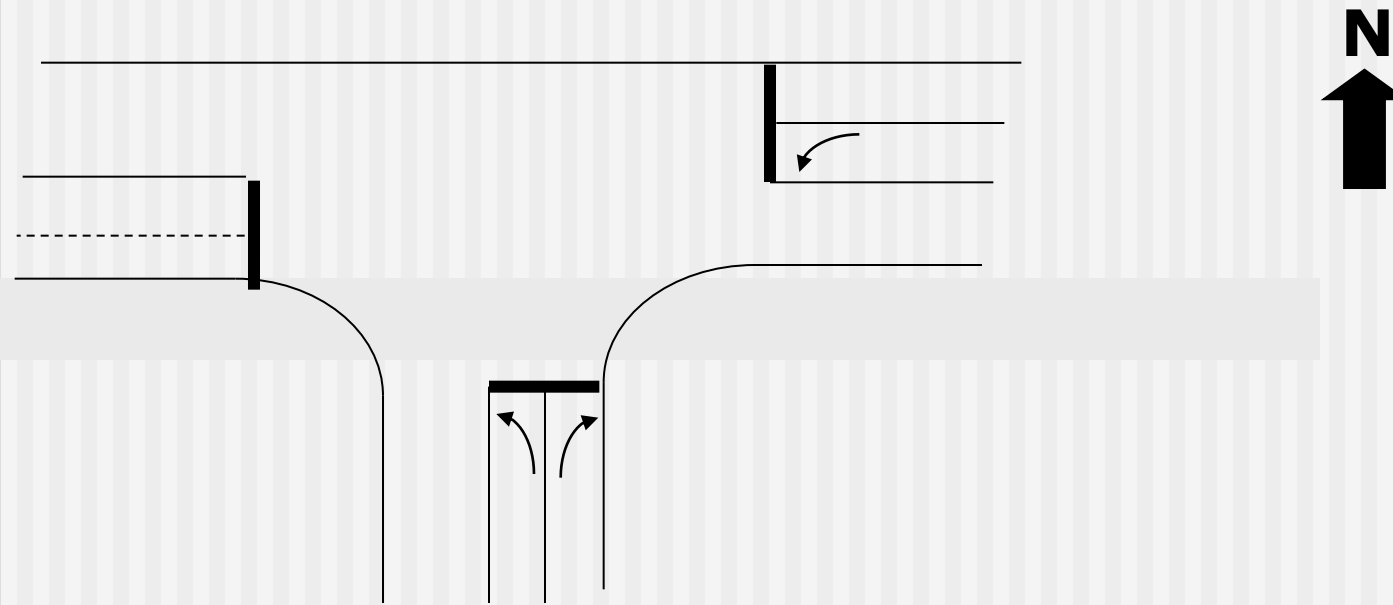
RESULTS

Eastbound			Westbound			Northbound			Southbound		
Lane Group Capacity, (vph)											
0	0	0	0	0	0	0	0	0	0	0	0
Lane Group v/c Ratio											
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Critical Lane Group											
Lane Group Delay, (sec/veh)											
Lane Group Level of Service											
Final Unmet Demand, (v)											
Approach Delay, (sec/veh)											
Approach Level of Service											
Cycle Length	0.0	sec	Intersection Delay			sec/veh			Intersection LOS		

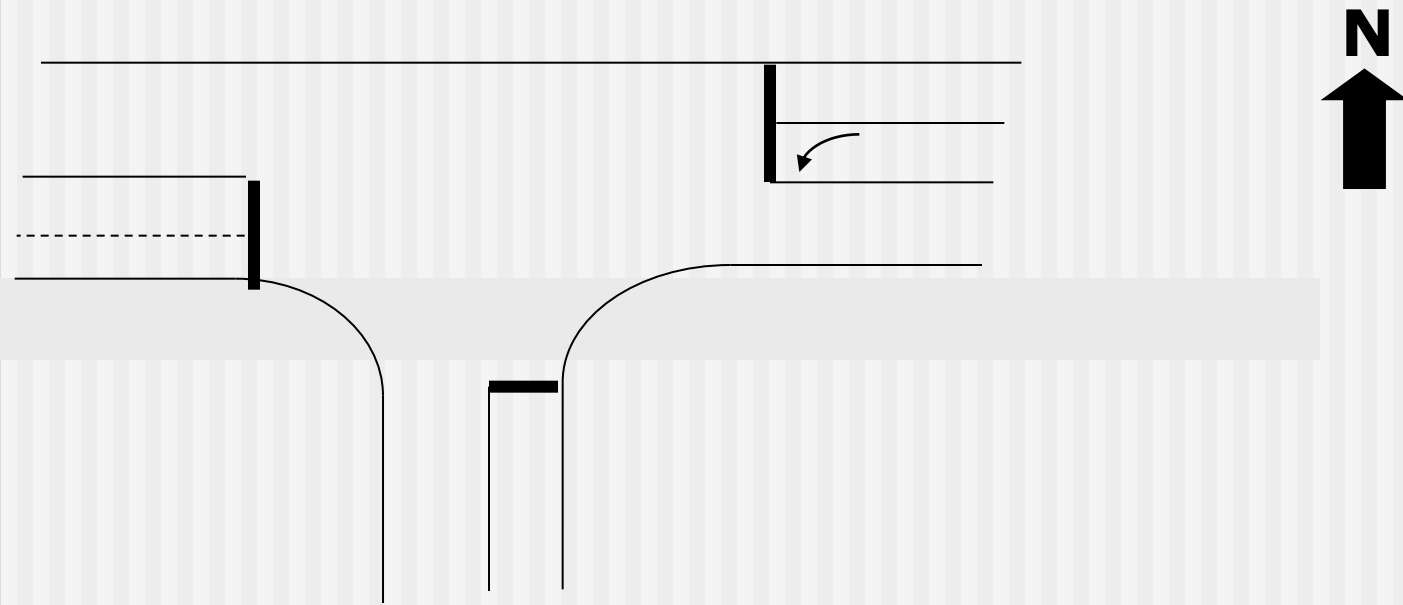
Laneage Coding Examples



Eastbound			Westbound			Northbound			Southbound		
Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Number of Lanes and Usage			Number of Lanes and Usage			Number of Lanes and Usage			Number of Lanes and Usage		
1	2	0	1	2	0	1	1	1	1	1	1
Shared		Shared	Shared		Shared	Shared		Shared	Shared		Shared
L	TR		L	TR		L	T	R	L	T	R



Eastbound			Westbound			Northbound			Southbound		
Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Number of Lanes and Usage											
0	2	0	1	1	0	1	0	1	0	0	0
Shared		Shared	Shared		Shared	Shared		Shared	Shared		Shared
TR			L T			L R					



Eastbound

Westbound

Northbound

Southbound

Left Thru Right

Left Thru Right

Left Thru Right

Left Thru Right

Number of Lanes and Usage

0 2 0

1 1 0

0 0 0

0 0 0

Shared Shared

Shared Shared

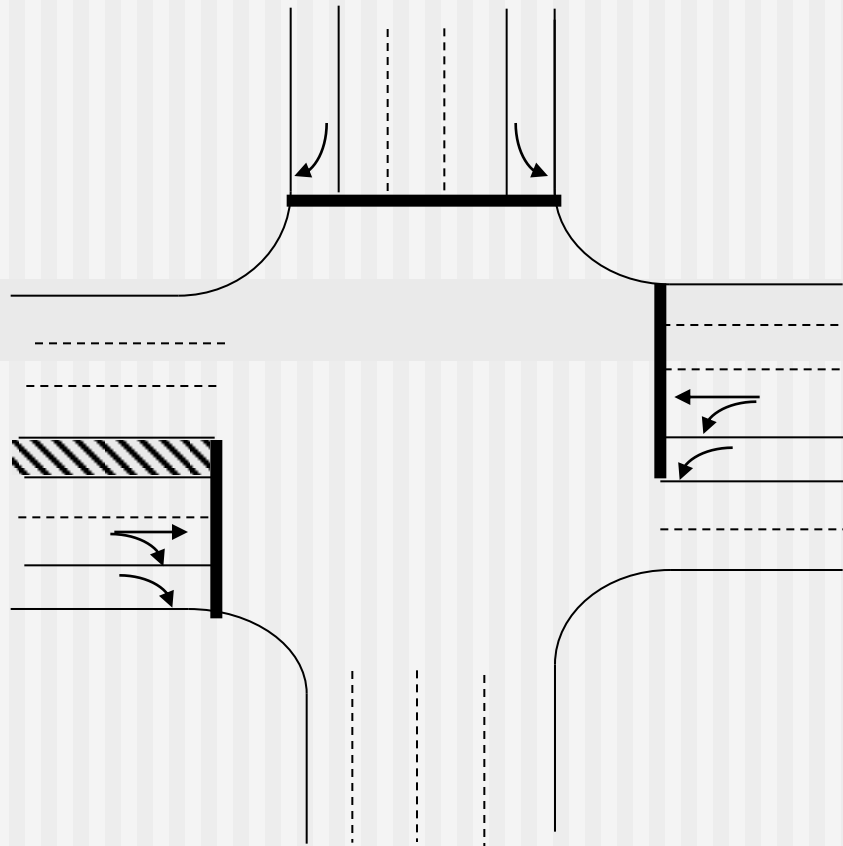
Shared Shared

Shared Shared

TR

L T

LR



Eastbound			Westbound			Northbound			Southbound		
Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Number of Lanes and Usage			Number of Lanes and Usage			Number of Lanes and Usage			Number of Lanes and Usage		
0	2	1	1	3	0	0	0	0	1	3	1
Shared		Shared	Shared		Shared	Shared		Shared	Shared		Shared
TR	R		L	LT		L	T	R	L	T	R

Default Values

- May be used without compromising analysis
- Results become approximate
 - As more default values are used

Default Values for Use

- Ideal saturation flow rate = 1,900 pcphpgpl
- Conflicting pedestrian volume
 - None: 0 peds/hr
 - Low: 50 peds/hr
 - Moderate: 200 peds/hr
 - High: 400 peds/hr
- Percent heavy vehicles = 2
- Grade = 0
- No. of stopping buses = 0/hr

-
- Parking conditions: No Parking
 - Parking maneuvers = 20/hr, where parking exists
 - Arrival type
 - Lane groups with through movements:
 - 3 if isolated
 - 4 if coordinated
 - Lane group without through movement = 3
 - Peak-hour factor = 0.90
 - Lane width = 12 feet
 - Area type = non CBD

Right Turns on Red (RTOR)

- When RTOR is permitted
 - Right turn volume may be reduced
- Number of vehicles able to turn right on red is a function of:
 - Approach lane uses
 - Right turn demand
 - Sight distance
 - Left-turn phasing on conflicting street
 - Conflicts with pedestrians

Arrival Types

- Quantifies the quality of progression
 - Type 1: dense platoon, arriving at the start of the red, *very poor progression*
 - Type 2: Moderately dense platoon arriving in the middle of the red phase, *unfavorable progression*
 - Type 3: random arrivals, isolated intersections

-
- Type 4: Moderately dense platoon arriving at the start of the green phase, *favorable progression*
 - Type 5: Dense to moderately dense platoon, arriving at the start of the green phase, *highly favorable progression*
 - Type 6: *exceptional progression quality* on routes with near-ideal characteristics

■ Effective green time

- Time that is effectively available to a movement,

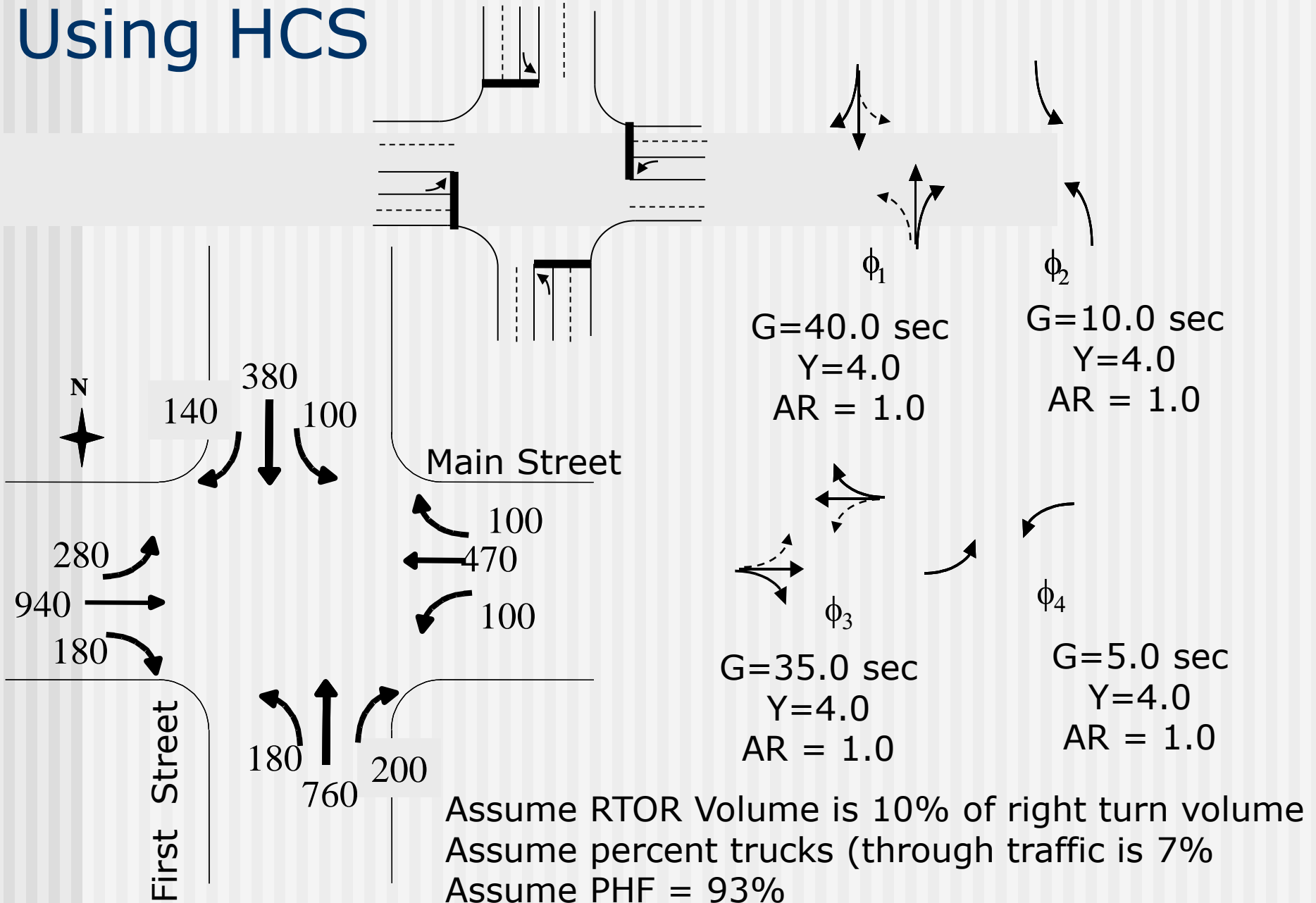
- generally taken to be the green time plus the clearance interval minus the lost time

■ Lost time

- Time during which the intersection is not effectively used by any movement, which occurs

- During the clearance interval
- Start-up delay

Example: Evaluate Intersection LOS, Using HCS



Unsignalized Intersections

- Two types
 - Two-Way Stop Controlled Intersections (TWSC)
 - All-Way Stop Controlled Intersections (AWSC)
- Capacity- TWSC
 - Depends on driver interaction of drivers on the minor street approach and drivers on the major street
 - Gap acceptance models are used in HCS to describe this interaction

Level of Service (LOS)-TWSC

- Determined by the computed control delay and is defined for each minor movement.
- LOS is not defined for an intersection as a whole

LOS Criteria for Unsignalized Intersections

LEVEL OF SERVICE	AVG CONTROL DELAY PER VEHICLE (SEC/VEHICLES)
A	≤ 10
B	>10 and ≤ 15
C	>15 and ≤ 25
D	>25 and ≤ 35
E	>35 and ≤ 50
F	> 50

-
- LOS Criteria for unsignalized intersections is slightly different than for signalized intersections
 - Because driver perception is different
 - Expectation is that a signalized intersection is designed to carry higher traffic volumes and experience greater delay than at unsignalized intersections

Data Input

- Similar to those for signalized intersections
 - Geomerty
 - Intersection control
 - Traffic volumes
- Key features
 - Number and uses of lanes
 - Channelization
 - Two-way left turn lane (TWLTL)
 - Raised or striped median storage
 - Existence of flared approaches on the minor street

-
- Presence of upstream traffic signals on the major street
 - Produce nonrandom flows
 - Affect the capacity of the minor street approaches if the signal is within 0.25 miles of the intersection

Critical Gap and Follow Up Time

- Critical gap
 - Minimum time interval in the major street traffic that allows one vehicle in the minor street traffic to enter the main street traffic.
 - Minimum gap that would be acceptable
 - A driver would reject any gaps less than the critical gap and would accept gaps greater than or equal to the critical gap.
- Follow up time
 - The time needed for more than one vehicle to complete a turn if an adequate gap is available.

Critical Gaps

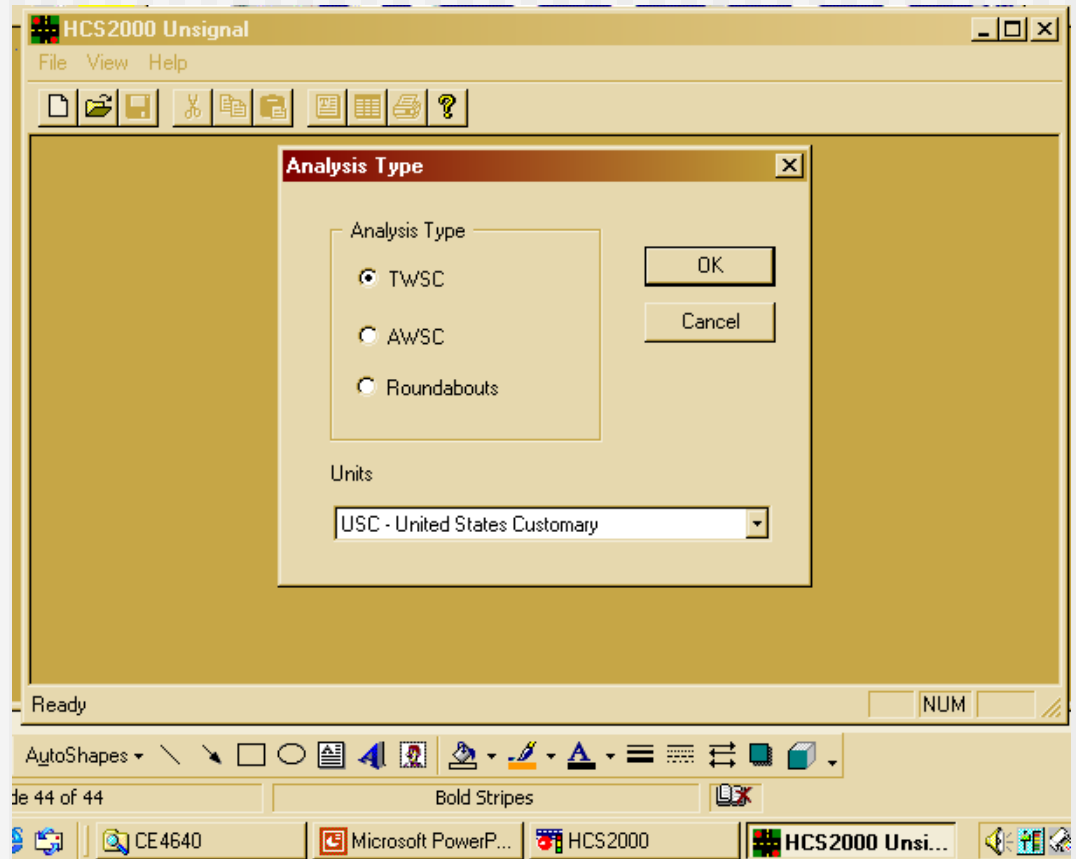
	Two-Lane Major Street	Four Lane Major Street	Base Follow-up Time
Left turn from vehicles	4.1	4.1	2.2
Right turn from minor	6.2	6.9	3.3
Through traffic on minor	6.5	6.5	4.0
Left turn traffic from minor	7.1	7.5	3.5

Unsignalalized Intersections



Commands

■ File: New



General Information

The screenshot shows a software window titled "HCS2000 Unsignal - [Unsign1]". The menu bar includes "File", "Edit", "View", "Window", and "Help". The toolbar contains icons for file operations and a help icon. Two dropdown menus are visible: "Input Quick Jump" and "Report Quick Jump". The main content area is titled "UNSIGNALIZED INTERSECTIONS TWO-WAY STOP-CONTROLLED" and contains a form with the following fields:

Analyst	<input type="text"/>	Intersection	<input type="text"/>
Agency/Co	<input type="text"/>	Jurisdiction	<input type="text"/>
Date	11/26/2002	Units: U. S. Customary	
Time Period Analyzed	<input type="text"/>	Analysis Year	<input type="text"/>
East/West Street Name	<input type="text"/>	North/South Street Name	<input type="text"/>
Project ID	<input type="text"/>		

Lane Designation

HCS2000 Unsignal - [Unsign1] File Edit View Window Help

Input Quick Jump Report Quick Jump

LANE DESIGNATION, VEHICLE VOLUMES AND ADJUSTMENTS

Quick Entry Duration 0.25 hours

Eastbound			Westbound			Northbound			Southbound		
Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right

Major Street Direction East-West

Number of Lanes and Usage

Eastbound		Westbound		Northbound		Southbound	
0	0	0	0	0	0	0	0
Shared	Shared	Shared	Shared	Shared	Shared	Shared	Shared
Right Turn	Channelized	Right Turn	Channelized	Right Turn	Channelized	Right Turn	Channelized

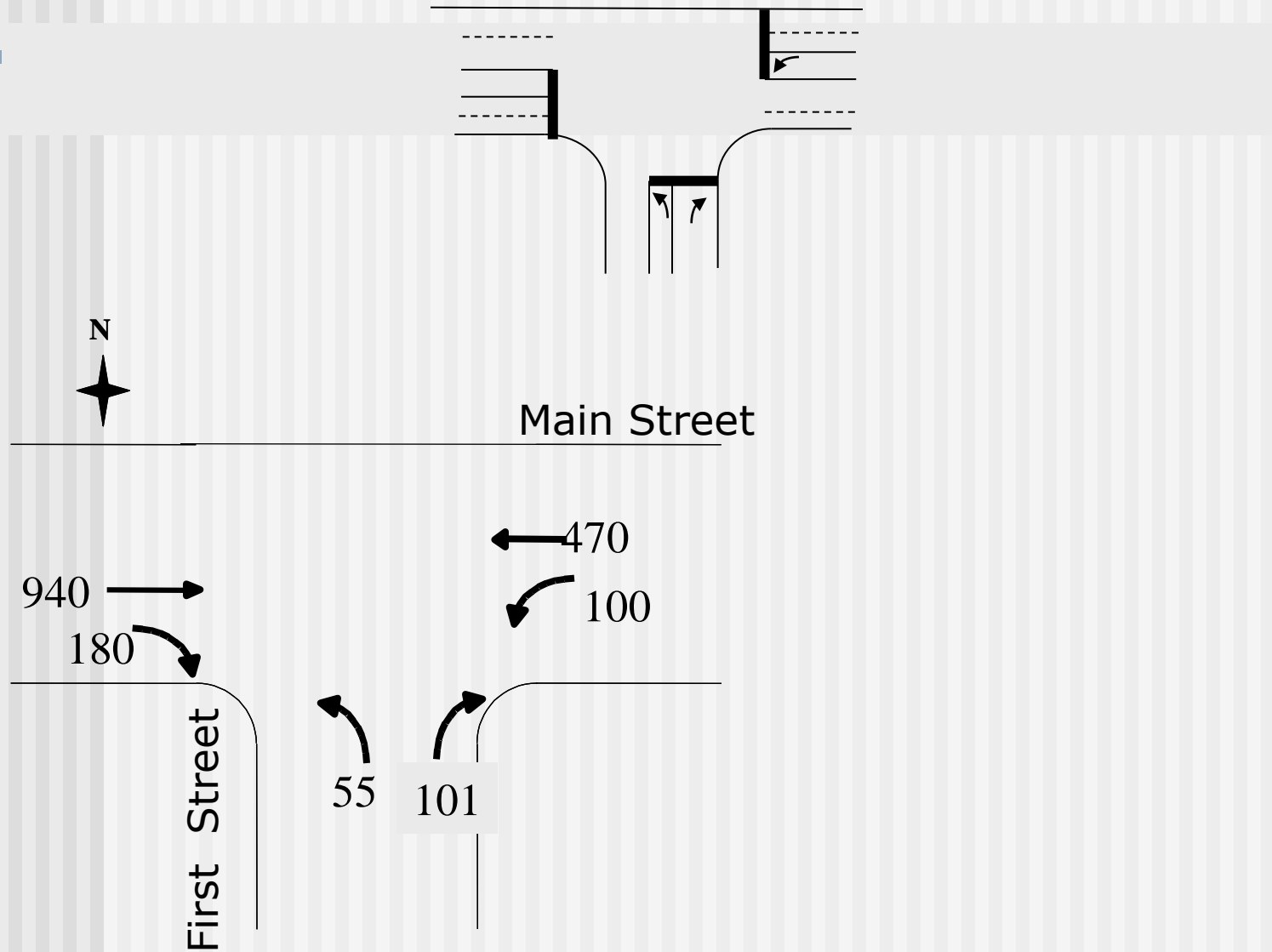
Flared Minor-Street Approach and Storage

Eastbound		Westbound		Northbound		Southbound	
<input type="checkbox"/> Yes	Storage	<input type="checkbox"/> Yes	Storage	<input type="checkbox"/> Yes	Storage 0	<input type="checkbox"/> Yes	Storage 0

Median Type

Eastbound		Westbound	
Undivided	Median Storage 1	Undivided	Median Storage

Example: Evaluate Intersection LOS, Using HCS



AWSC Intersections

- Each approach is analyzed independently
- Opposing approach and the conflicting approaches creates conflicts with vehicles on the subject approach (the approach under study)
- Drivers on all approaches are required to stop before entering the intersection

AWSC Intersections

HCS2000 Unsignal - [Unsign1]

File Edit View Window Help

AWSC Report Quick Jump

UNSIGNALIZED INTERSECTIONS ALL-WAY STOP-CONTROLLED

Analyst	<input type="text"/>	Intersection	<input type="text"/>
Agency/Co.	<input type="text"/>	Jurisdiction	<input type="text"/>
Date Performed	11/26/2002	Units: U. S. Customary	
Time Period Analyzed	<input type="text"/>	Analysis Year	<input type="text"/>
East/West Street Name	<input type="text"/>	North/South Street Name	<input type="text"/>
Project ID	<input type="text"/>		

HCS2000: Unsignalized Intersections Release 4.1a

Phone: _____ Fax: _____
E-Mail: _____

_____ ALL-WAY STOP CONTROL(AWSC) ANALYSIS _____

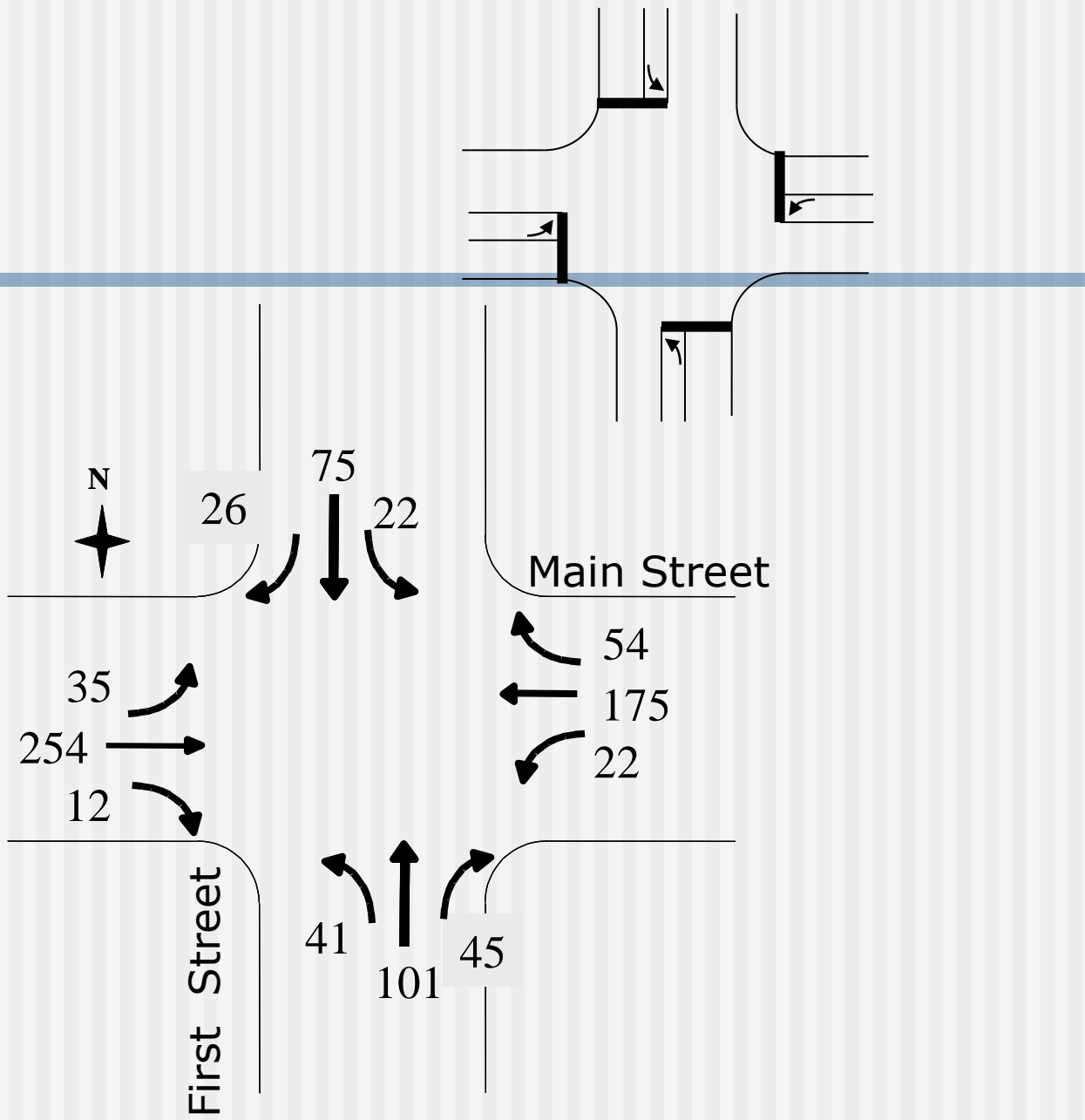
Analyst:
Agency/Co.:
Date Performed: 11/26/2002
Analysis Time Period:
Intersection:

Analyst: []

Ready

NUM

Start | Microsoft Po... | HCS2000 | C_Shared on... | HCS2000 Si... | HCS2000 ... | 2:33 PM



RESULTS

Intersection Performance Summary

Appr/ Lane Grp	Lane Group Capacity	Adj Sat Flow Rate (s)	Ratios		Lane Group		Approach	
			v/c	g/C	Delay	LOS	Delay	LOS
Eastbound								
L	458		0.68	0.500	39.3	D		
TR	1284	3531	0.95	0.364	50.0	D	47.8	D
Westbound								
L	315		0.35	0.500	42.4	D		
TR	1281	3523	0.49	0.364	28.4	C	30.5	C
Northbound								
L	356		0.56	0.409	39.6	D		
TR	1116	3506	0.94	0.318	51.7	D	49.8	D
Southbound								
L	233		0.48	0.409	50.4	D		
TR	1106	3475	0.51	0.318	32.2	C	35.2	D
Intersection Delay = 43.3 (sec/veh)					Intersection LOS = D			