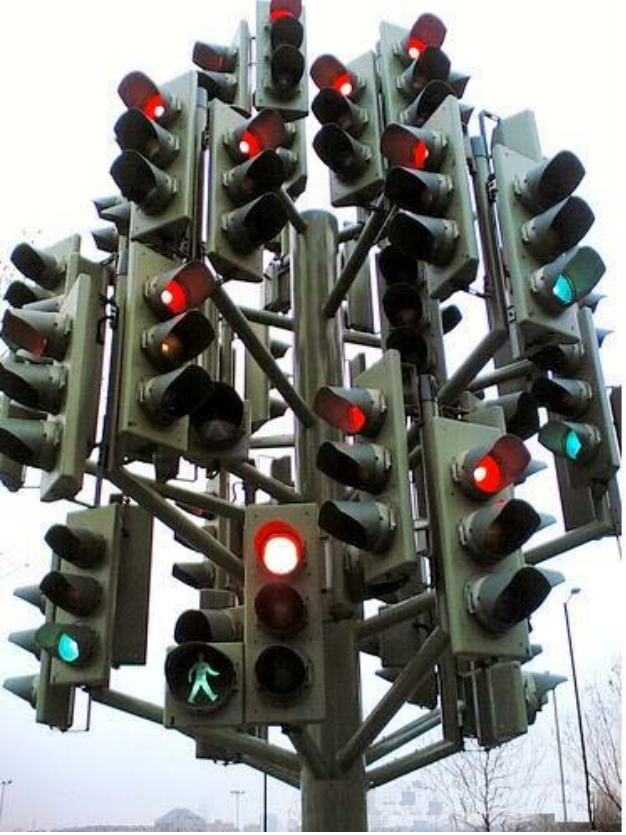

Introduction to Traffic Signals

North Dakota Water and Pollution Control Conference

October 11, 2011

Baker Consulting, LLC

Background and Introduction

- North Dakota State University
  - BS and MS in Civil Engineering
- Upper Great Plains Transportation Institute
  - Advanced Traffic Analysis Center
- Baker Consulting, LLC
  - Native American-Owned DBE
  - State, Tribal, and Private Agencies

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Relevance?

- There are over 275k traffic signals in the nation
- Pollution is greatest when vehicles stop, idle, and start at signals
- Optimizing traffic signals has resulted in travel-time and delay reductions of 5 to 20%, and fuel savings of 10 to 15%
- Better nationwide management would cut emissions of carbon monoxide and other pollutants by 22%

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Presentation Overview

- History of Traffic Signals
- How Traffic Signals Work
- Justification, Design, and Operations
- Vehicle Detection Technologies
- Benefits/Drawbacks

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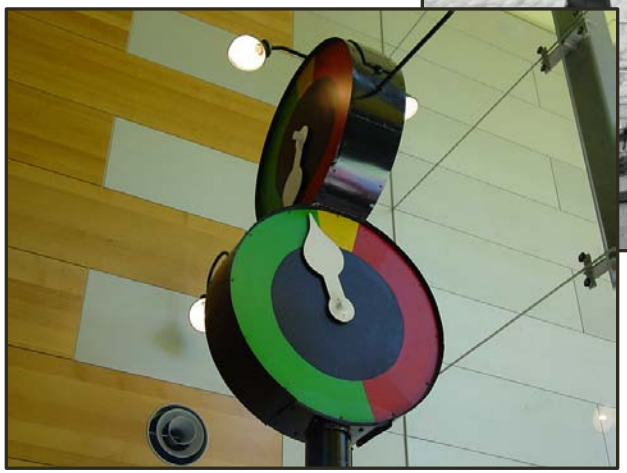
History of Traffic Signals

- The “modern” traffic signal was invented by a Detroit police officer in 1920
- Numerous versions of the signal were developed
  - Rotating Lantern
  - 1, 2, 3-Light Variations
  - Rotary



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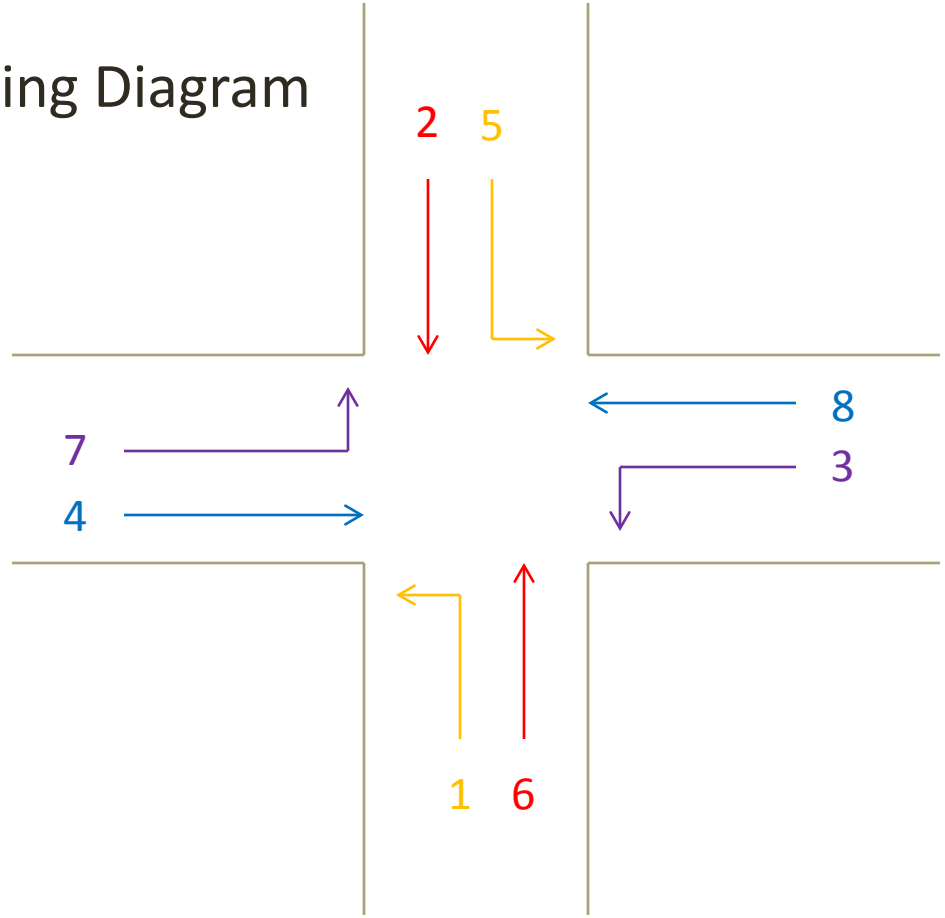
How Traffic Signals Work

Signal Phasing Diagram



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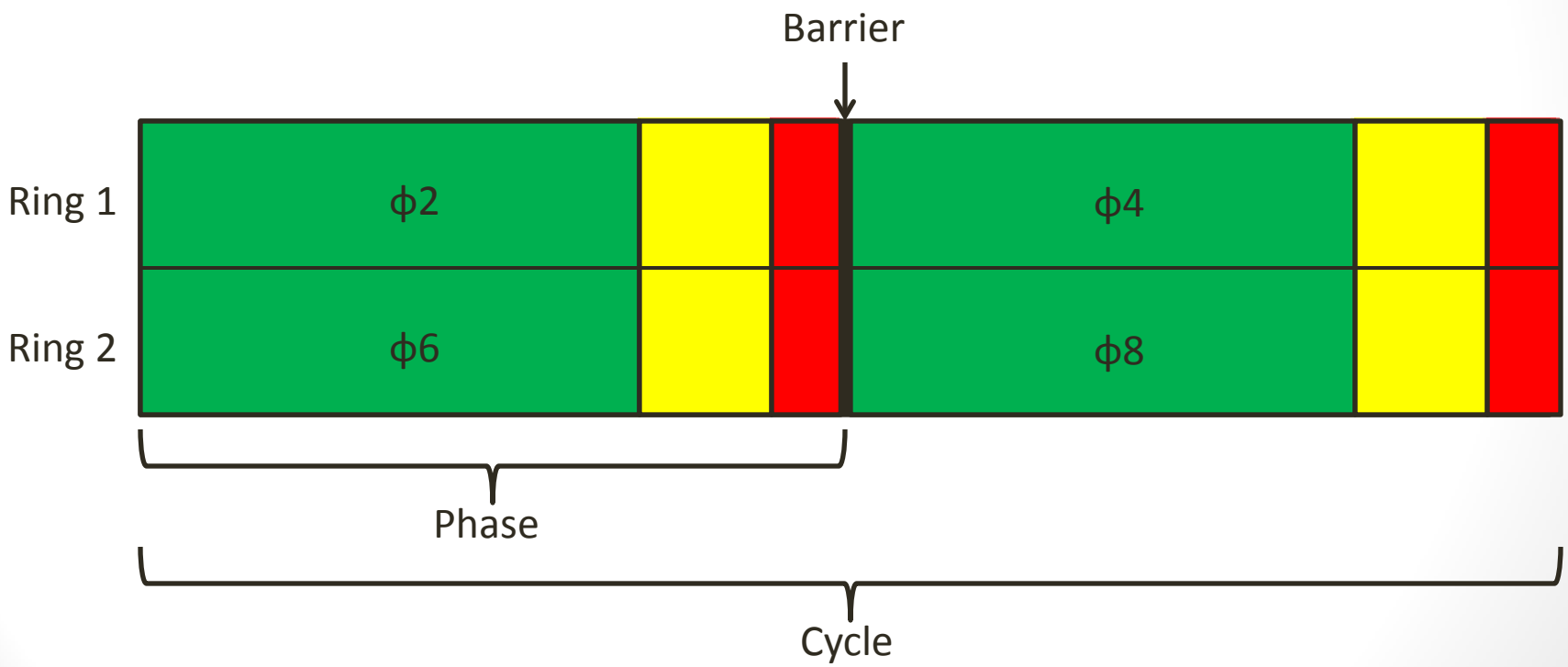
How Traffic Signals Work

"Ring-Barrier" Diagram



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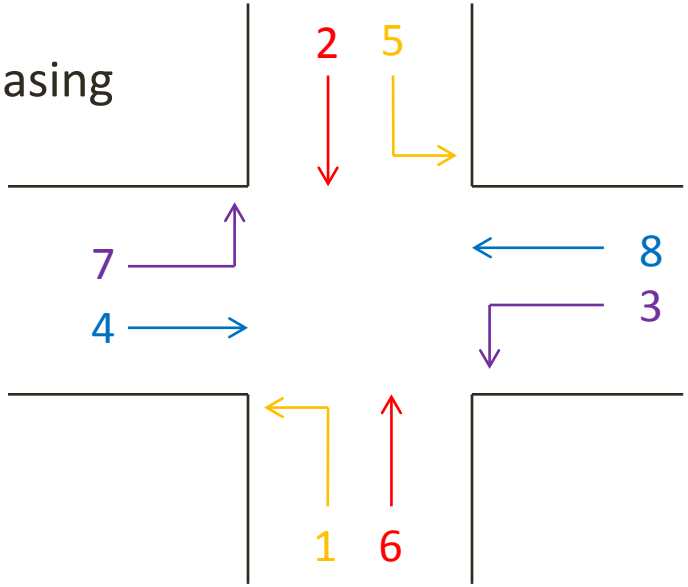
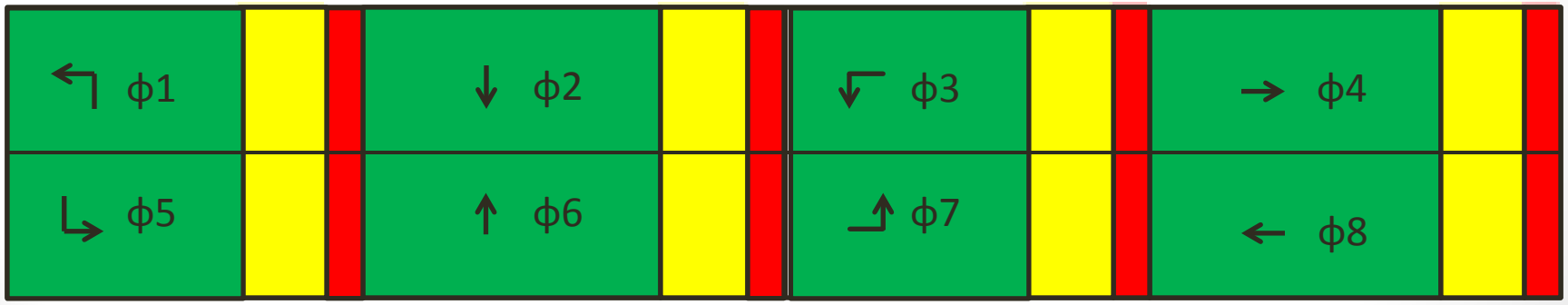
How Traffic Signals Work

Leading Left-Turn Phasing
(Pre-Timed)





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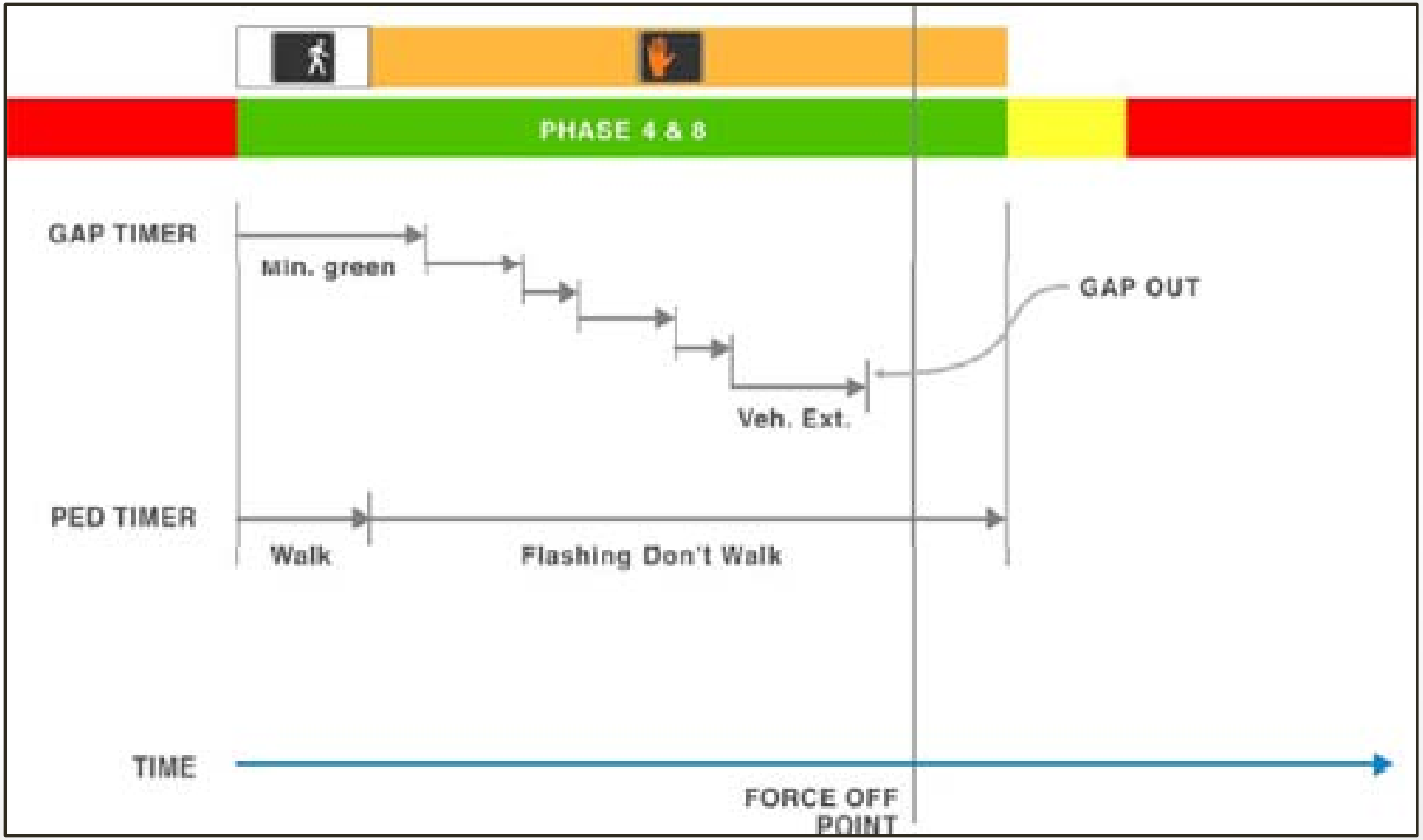
How Traffic Signals Work



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Justification

- Stop Controlled Intersection
- Intersection Control Evaluation
  - Consider All Options
- Warrants (Based on the Manual on Uniform Traffic Control Devices)
  - 9 Different Warrants
  - Traffic Volumes, Crash History, School Crossing, etc.

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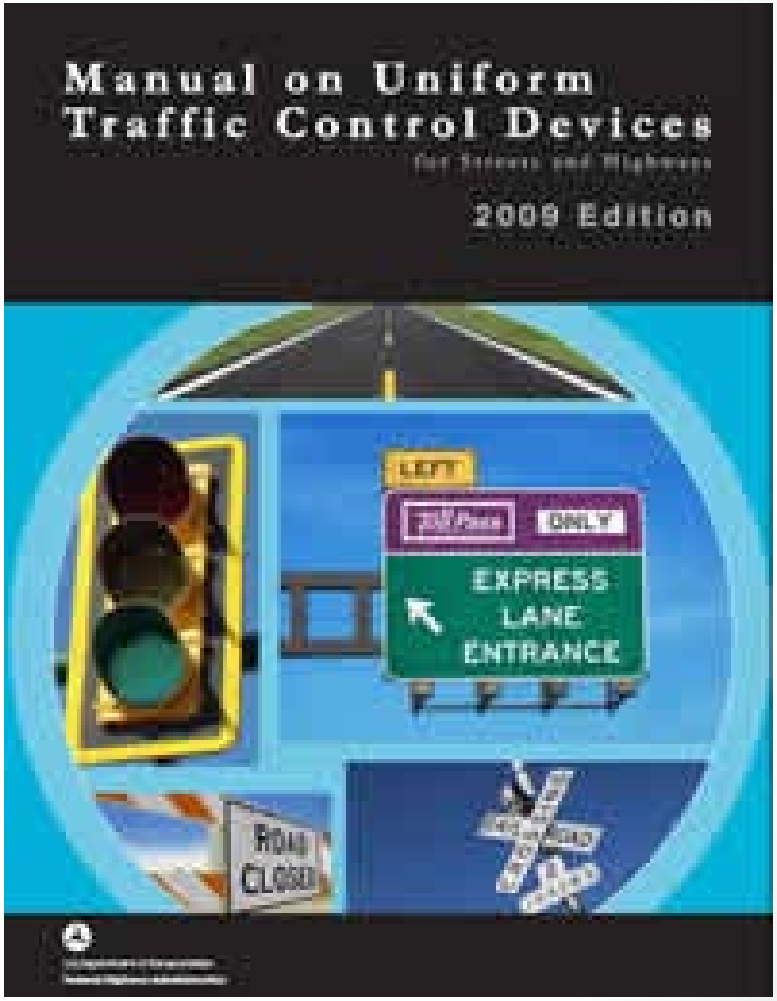
Justification

- Eight-Hour Volume
- Four-Hour Volume
- Peak Hour
- Pedestrian Volume
- School Crossing
- Coordinated Signal System
- Crash Experience
- Roadway Network
- Grade Crossing Proximity



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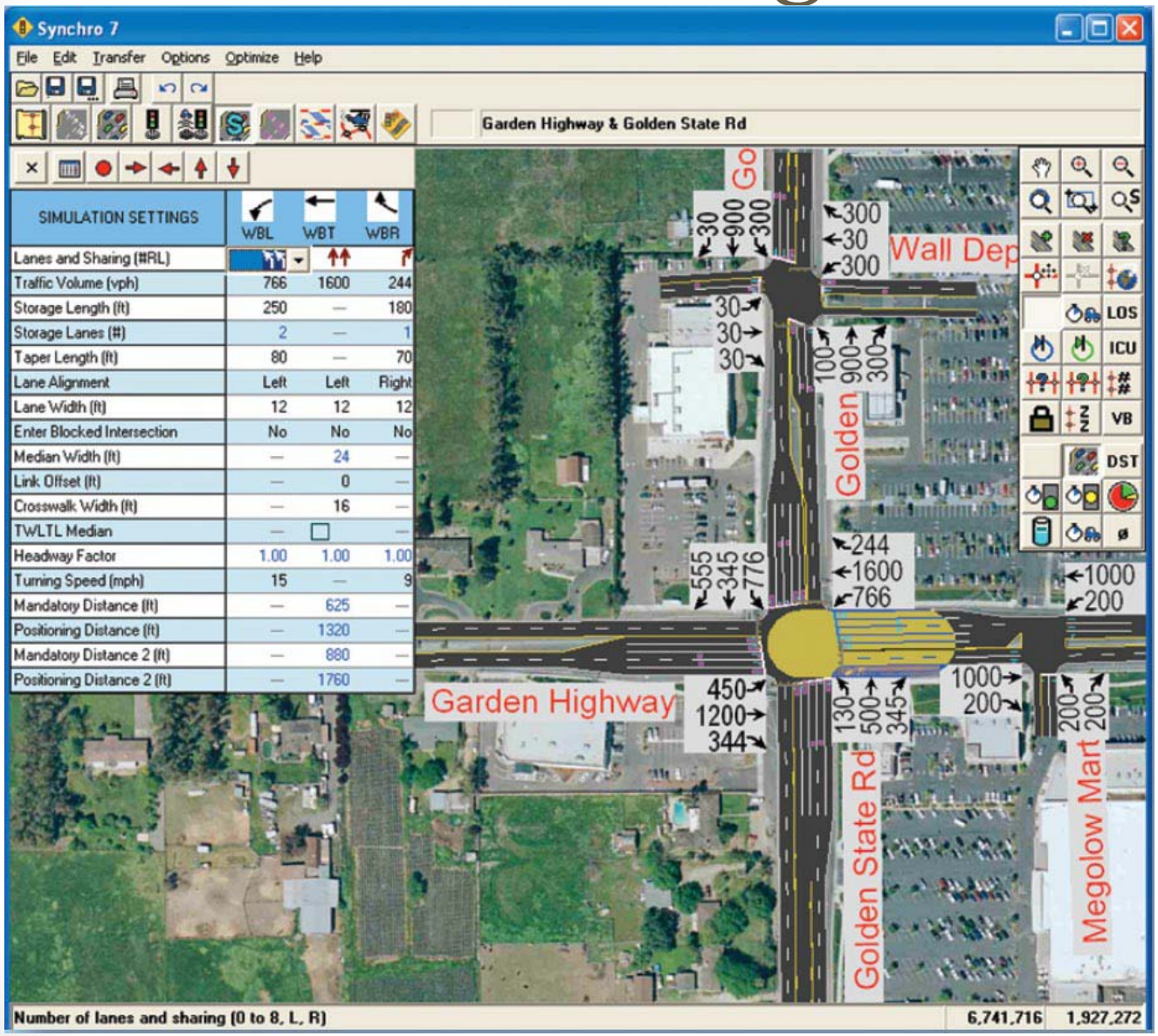
Design



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Design

Synchro 8 - C:\Program Files\Trafficware\Version8\Sample Files\Basic 2-Phase.syn

File Edit Transfer Options Optimize Help

0 hr 6 min 5 sec / 0 hr 22 min 46 sec

3 Main Street & 1st Street

Auto Mode | Pedestrian mode | Bicycle Mode

HCM 2010 INTERSECTION	
Node #	3
Description	
Control Type	Pretimed
Cycle Length (s):	50.0
Lock Timings:	☐
HCM Equilibrium Cycle(s):	50.0
HCM Control Delay(s):	23.7
HCM Intersection LOS:	C
Analysis Time Period (h):	0.25
Saturation Flow Rate (pc/h/ln):	1900
Sneakers Per Cycle (veh):	2.0
Number of Calc.Iterations:	35
Stored Passenger Car Length (ft):	25
Stored Heavy Vehicle Length (ft):	45
Probability Peds. Pushing Button:	0.51
Deceleration Rate (ft/s/s):	4.00
Acceleration Rate (ft/s/s):	3.50
Distance Between Stored Cars (ft):	8.00
Queue Length Percentile	50
Left-Turn Equivalency Factor:	1.05
Right-Turn Equivalency Factor:	1.18
Heavy Veh Equivalency Factor:	2.00
Critical Gap for Perm. Left Turn (s):	4.5
Follow-up Time for Perm. L Turn (s	2.5

HCM 2010 SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT
Lanes and Sharing (#RL)											
Traffic Volume (vph)	100	600	100	100	500	100	100	600	100	100	500
Lagging Phase?	✓	✓	✓	✓	✓	✓	✓	✓	—	✓	✓
Turn Type	Perm	—	Perm	Perm	—	Perm	Perm	—	—	Perm	—
Protected Phases		2			6			8	—		4
Permitted Phases	2		2	6		6	8		—	4	
Passage Time (s)	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	—	3.0	3.0
Minimum Green (s)	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	—	4.0	4.0
Maximum Split (s)	23.0	23.0	23.0	23.0	23.0	23.0	27.0	27.0	—	27.0	27.0
Yellow Time (s)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	—	3.5	3.5
All-Red Time (s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	—	0.5	0.5
Maximum Green (s)	19.0	19.0	19.0	19.0	19.0	19.0	23.0	23.0	—	23.0	23.0
Walk Time (s)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	—	5.0	5.0
Flash Dont Walk (s)	11.0	11.0	11.0	11.0	11.0	11.0	11.0	11.0	—	11.0	11.0
Walk+ ped. clear (s)	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	—	16.0	16.0
Recall Mode	Max	Max	Max	Max	Max	Max	Max	Max	—	Max	Max
Dual Entry?	✓	✓	✓	✓	✓	✓	✓	✓	—	✓	✓
Right Turn on Red Volume (vph)	—	—	67	—	—	67	—	—	0	—	—
Percent Heavy Vehicles (%)	2	2	2	2	2	2	2	2	2	2	2
Lane Utilization Adj.Factor	—	—	—	—	—	—	—	—	—	—	—
Peak Hour Factor	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Lost Time Adjust (s)	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	—	-1.0	-1.0
Startup Lost Time (s)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	—	2.0	2.0

ø2 23 s | ø4 27 s

ø6 23 s | ø8 27 s

Check On to have this phase come after its phase partner. | v/c > 1 | Mins ok

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Operations

- Computer Software/Simulation Programs
- Intersection Level of Service – A to F
  - Phasing (Protected vs. Permissive Left Turns)
  - Optimized Timings
  - Major Street / Minor Street
- Network Optimization
- Progression Analysis

LOS	Signalized Intersection	Unsignalized Intersection
A	≤10 sec	≤10 sec
B	10-20 sec	10-15 sec
C	20-35 sec	15-25 sec
D	35-55 sec	25-35 sec
E	55-80 sec	35-50 sec
F	≥80 sec	≥50 sec

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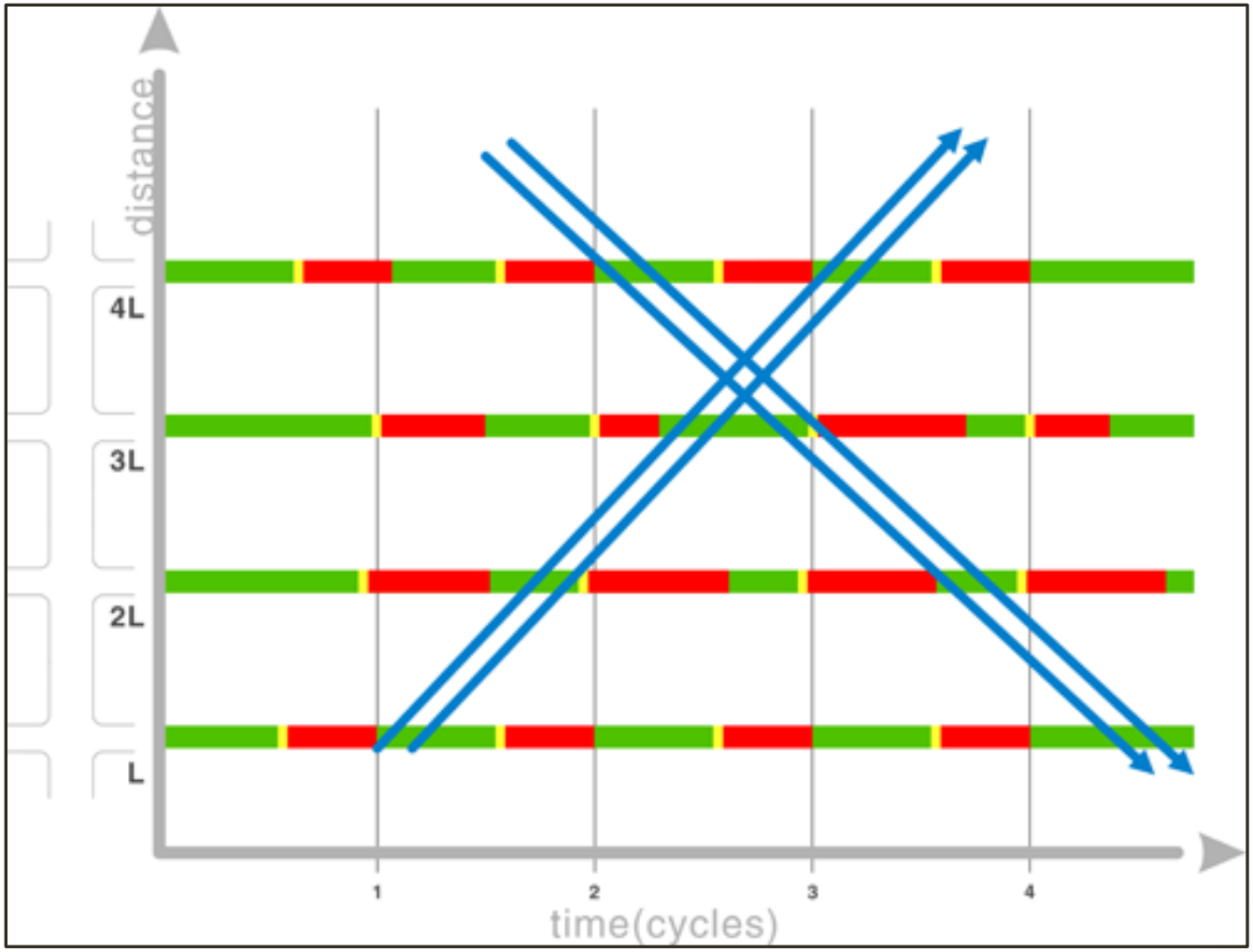
Operations



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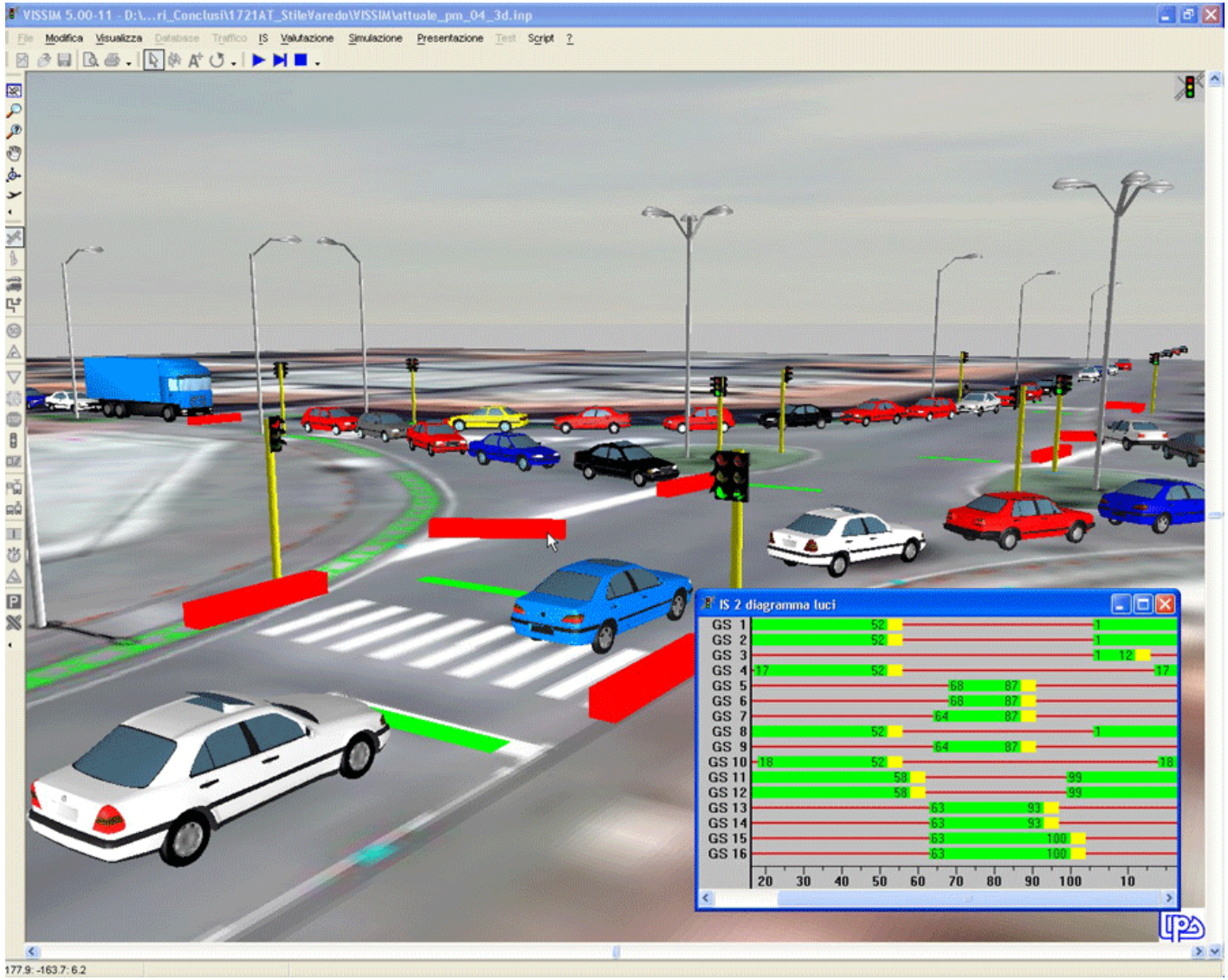
Operations



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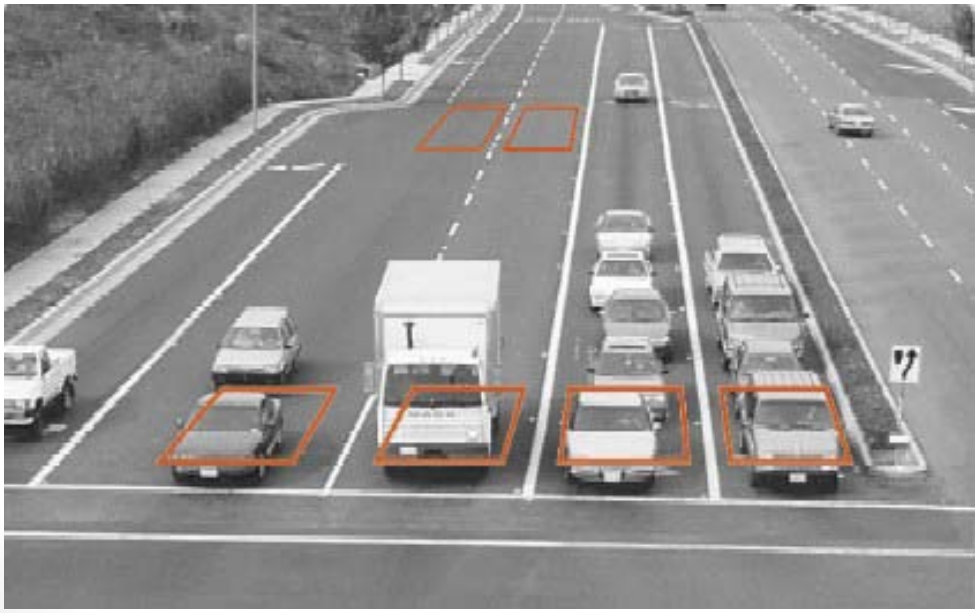
Vehicle Detection Technologies

- Inductive Loops
- Video Detection



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Benefits/Drawbacks

- Benefits
  - Reduces Certain Types of Accidents (Angle)
  - Increases Intersection Capacity
- Drawbacks
  - Increases Certain Types of Accidents (Rear End)
  - Initial Costs and Maintenance Costs
  - Operation during Non-Peak Hours

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Questions??

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