CAMBRIDGE SYSTEMATICS

Think Forward

Synchro Training – Day 1

Caltrans On-Call Traffic Simulation Training

presented to

Caltrans District 9

presented by

Cambridge Systematics, Inc.

John Duesing and Richard Ge

June 5th, 2018

Introductions

- Cambridge Systematics Instructors
- Workshop Participants
- Workshop Format
- Attendee Expectations

Training Session Overview

- Traffic Analysis Basics
- Synchro Introduction
- Data Preparation
- Synchro Operations
- Hands-On Exercise
- Advanced Applications

Agenda

- **Day 1/Part 1: Traffic Analysis Basics (9am –Noon)**
  - Review of Basic Traffic and Capacity Analysis
  - Review of Traffic Analysis Tools
  - Review of Analysis Tool Selection
  - Review of FHWA and Caltrans Traffic Analysis Guidance

Caltrans

CAMBRIDGE SYSTEMATICS

Agenda

- **Day 1/Part 2: Basic Synchro Functions and Operations (1pm – 4pm)**
  - Data Collection Plan and Requirements
  - Data Reduction and Calculating the peak hour factor
  - Synchro Data Entry
  - Signal Timings
  - Synchro Performance Measures and how to read them

Agenda

- **Day 2/ Part 3: Hands-on Exercise: Main Street Corridor Synchro Model (9am –Noon)**
  - Data Preparation
  - Model Coding
  - Extract and Report Existing Conditions

Agenda

- **Day 2/Part 4: Advanced Synchro Applications (1pm – 4pm)**
  - Incorporating Future Year Forecasts
  - Signal Timing optimization
  - Geometric changes in lanes, turning bays, lane diets;
- **June 7 – Advanced applications, Review and Questions (9am-noon)**
- Richard will be available for the last day to review any procedures, software questions, or demonstrate analyzing other alternatives.

Caltrans

CAMBRIDGE SYSTEMATICS

Project Background and Objectives

- **Senate Bill (SB) 375 (Sustainable Community), SB 743 (CEQA Reform), and SB 391 (California Transportation Plan)** require a more robust quantitative and analytic evaluation to describe the relative performance of transportation policies, strategies, and programs.
- **SB 1, now in force;** Caltrans will be collaborating with regional partners to identify and develop fixes for key corridors, which cannot be analyzed using static methods alone.
- **On-call traffic simulation training** will enable Caltrans to meet the mandate of these bills by educating Caltrans staff about how to perform complex analyses of our facilities for critical planning, operations, and capital improvement projects using the latest generation of traffic analysis tools.

Caltrans

CAMBRIDGE SYSTEMATICS

Training Session Overview

- Traffic Analysis Basics
  - » Overview of Traffic/Simulation
- Synchro Introduction
- Data Preparation
- Synchro Operations
- Hands-On Exercise
- Advanced Applications

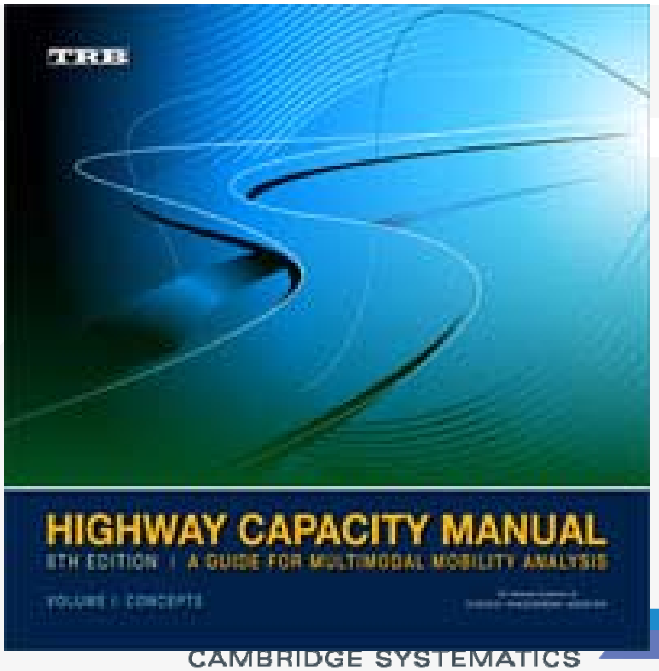
Caltrans

CAMBRIDGE SYSTEMATICS

What is Capacity ?

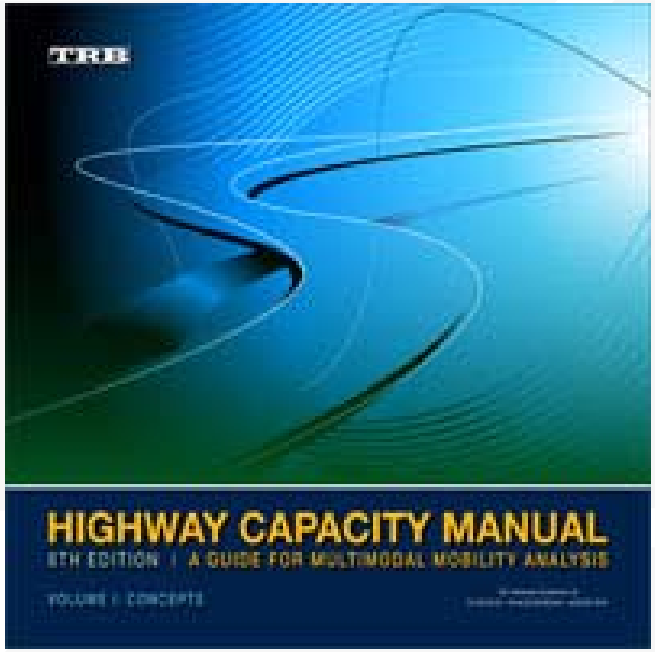
The capacity of a facility is the maximum hourly rate at which persons or vehicles reasonably can be expected to traverse a point or a uniform section of a lane or roadway during a given time period under prevailing roadway, traffic, and control conditions.

Vehicle capacity is the maximum number of vehicles that can pass a given point during a specified period under prevailing roadway, traffic, and control conditions. This assumes that there is no influence from downstream traffic operation, such as the backing up of traffic into the analysis point.



Quality and Level of Service

- Capacity is Measured in Quality of Flow and Level Of Service
  - LOS is a measurement of quality
  - In terms of flow, ability and freedom to maneuver
  - Speed, travel time and interruptions
- 6 Levels of LOS A to F
- Many Factors effecting LOS
- Interrupted Flow – Control Device aka Signalized Intersections.



Caltrans

CAMBRIDGE SYSTEMATICS

Interrupted Flow MOE's

- Delay is preferred over speed in controlled intersection analysis;
- Control Delay computed by Saturation Rate and Lost Time

SATURATION FLOW RATE AND LOST TIME

Saturation flow rate is defined as the flow rate per lane at which vehicles can pass through a signalized intersection. By definition, it is computed by Equation 7-9:

$$s = \frac{3600}{h} \qquad (7\text{-}9)$$

where

s = saturation flow rate (veh/h), and
h = saturation headway (s).

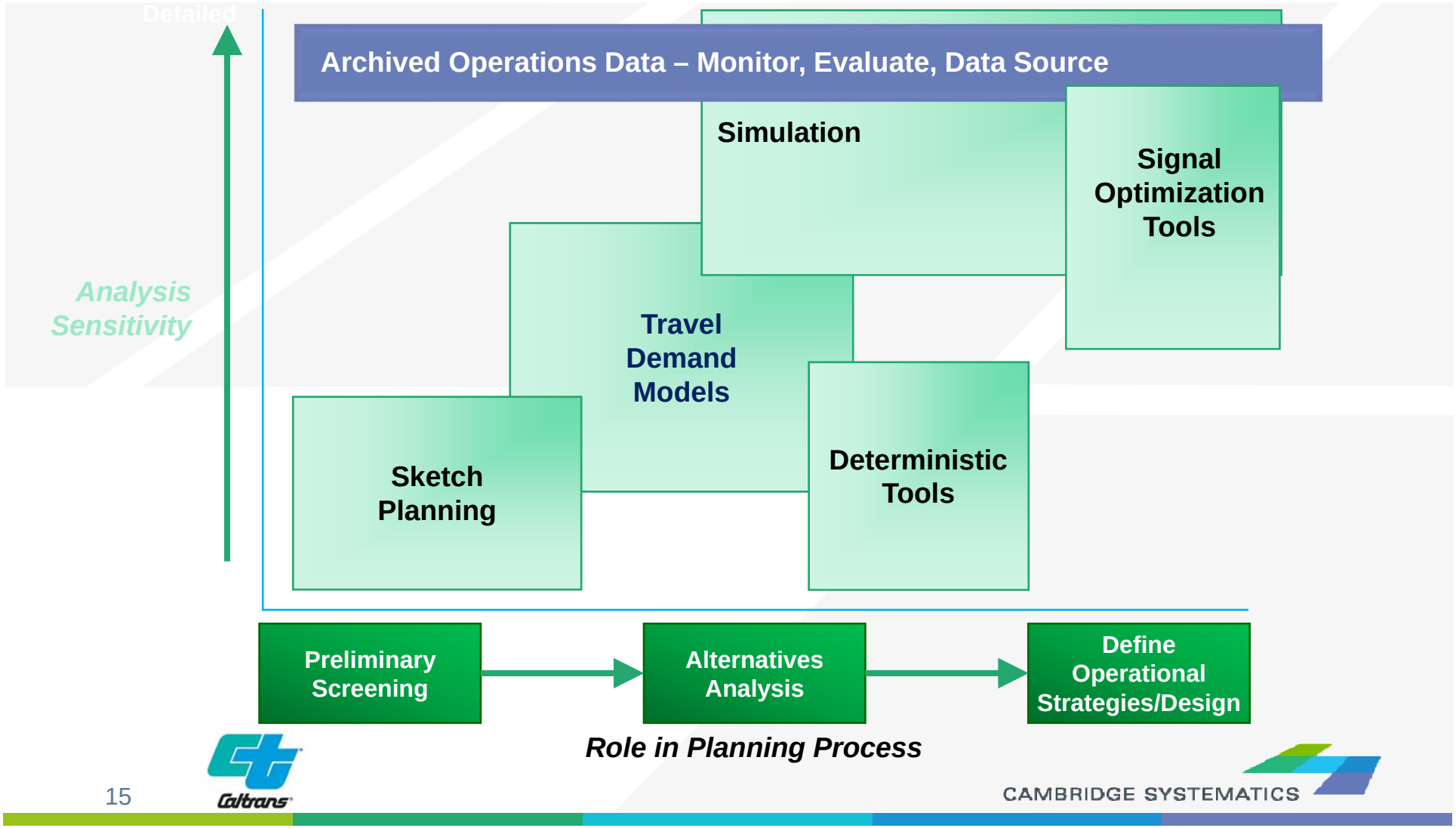
Interrupted Flow MOE's

- Saturation Flow Rate is the number of vehicles per lane per hour that could pass through the intersection if the signal was constantly green;
- Lost Time is whenever the signal stops traffic and interrupts the flow. Flow must then be started up again;
- Queuing is occurs when demand exceeds capacity;
- These are the main calculations that are going on inside HCM or Synchro to compute LOS and Queuing MOE's;

Type of Traffic Analysis Tool for Main Street

- Deterministic or Dynamic?
- Micro, Meso or Macro?
- Data availability?
- Model expertise and budget considerations?

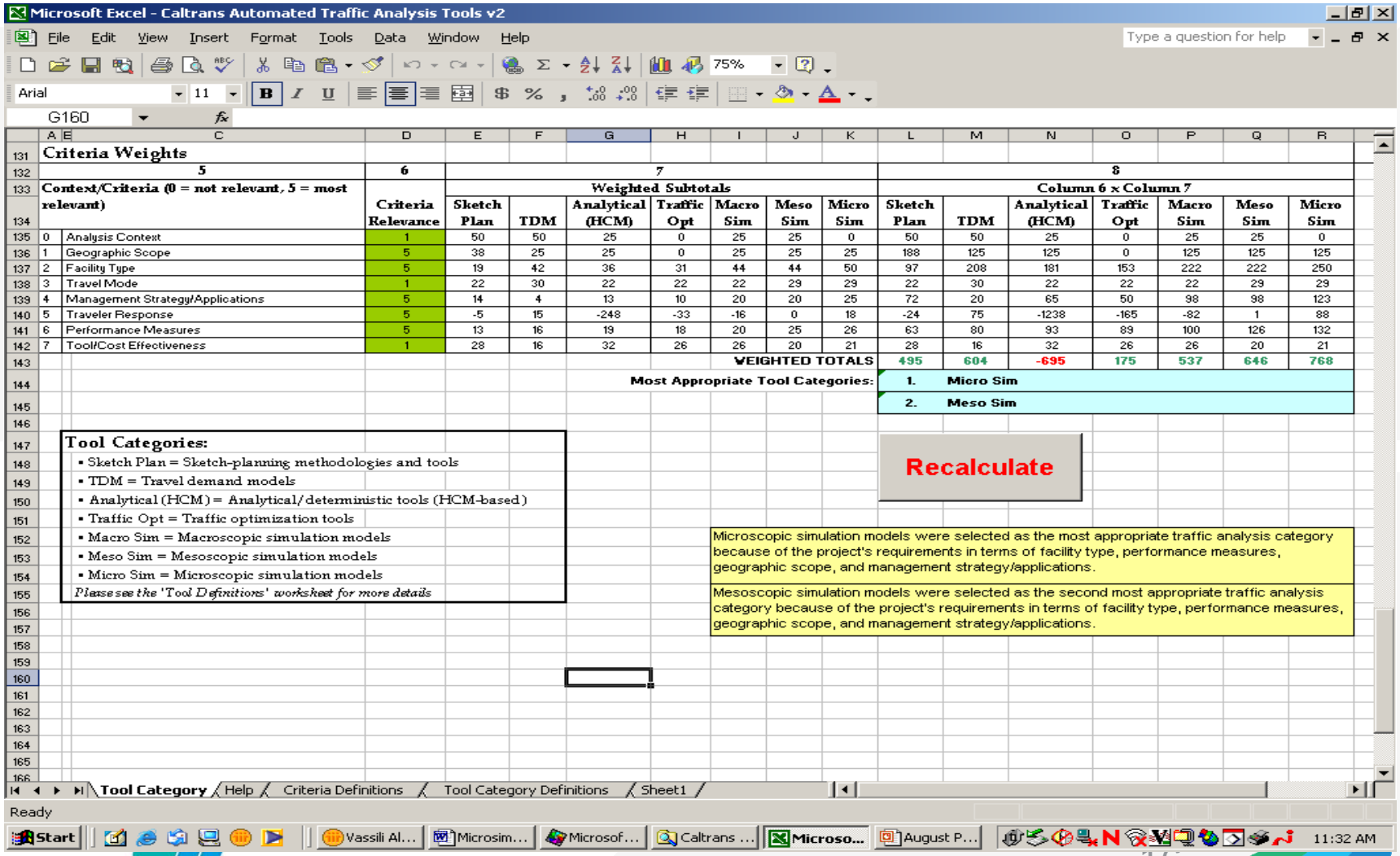
Analysis Tool Capabilities



Caltrans

CAMBRIDGE SYSTEMATICS

Which Tool Type to Use – Leveraging Caltrans Selection Tool



Caltrans

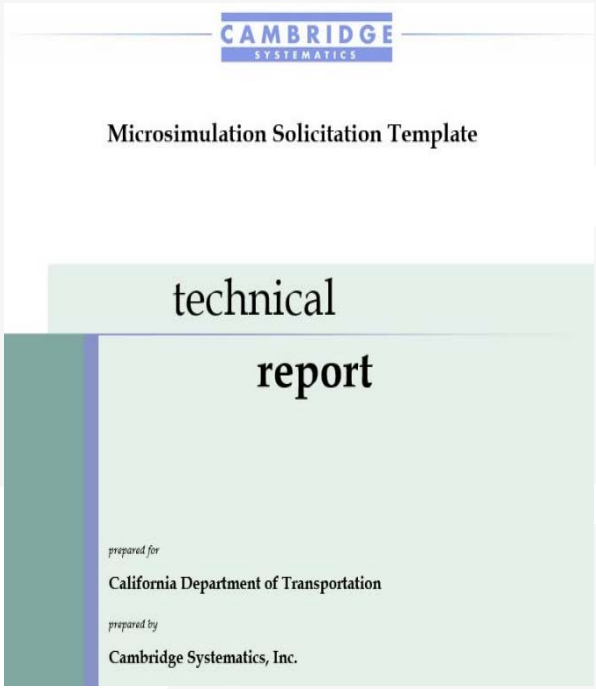
16

CAMBRIDGE SYSTEMATICS

Analysis Context: Planning, Design, or Operations/Construction

1	2	3	4	5	6	7
Geographic Scope	**Facility Type**	**Travel Mode**	**Management Strategy**	**Traveler Response**	**Performance Measures**	**Traveler Response**
What is your study area?	Which facility types do you want to include?	Which travel modes do you want to include?	Which mgmt strategies should be analyzed?	Which traveler responses should be analyzed?	What performance measures are needed?	What operational characteristics are important?
• Isolated Location • Segment • Corridor/ small network • Region	• Isolated intersection • Roundabout • Arterial • Highway • Freeway • HOV lane • HOV bypass lane • Ramp • Auxiliary lane • Reversible lane • Truck lane • Bus lane • Toll plaza • Light rail	• SOV • HOV (2, 3, 3+) • Bus • Rail • Truck • Motorcycle • Bicycle • Pedestrian	• Freeway mgmt • Arterial intersections • Arterial mgmt • Incident mgmt • Emergency mgmt • Work zone • Special event • APTS • ATIS • Electronic payment • RRX • CVO • AVCSS • Weather mgmt • TDM	• Route diversion (pre-trip and en-route) • Mode shift • Departure time choice • Destination change • Included/ foregone demand	• LOS • Speed • Travel time • Volume • Travel distance • Ridership • AVO • v/c ratio • Density • VMT/PMT • VJJT/PHT • Delay • Queue length • # stops • Crashes/duration • TT reliability • Emissions/fuel • Noise • Mode shift • Benefit/cost	• Tool capital cost • Effort (cost/training) • Ease of use • Popular/well-trusted • Hardware requirements • Data requirements • Run time • Post-processing • Documentation • User support • Key parameters user definable • Default values • Integration • Animation

Data and Resources - Leveraging Caltrans Non-IT Microsimulation TAC



Caltrans

CAMBRIDGE SYSTEMATICS

Components of a Scoping Plan

- Project definition
- Geographic and temporal scope
- Selection of the appropriate analysis tool type
- Performance measures to be used in the analysis
- Analysis data requirements
- Preliminary list of alternatives to be studied, including analysis scenarios and transportation mitigation strategies
- Expected cost, schedule, and responsibilities for the analysis

Caltrans

CAMBRIDGE SYSTEMATICS

Project Scoping Summary Elements

Project Definition	A concise statement of the overall system problem includes cross-validation and other insights from stakeholders on the nature of the issue and potential solutions.
Geographic Scope	The geographic area to be covered by the analytical project includes a statement of the required detail of representation within this geographical area.
Temporal Scope	The times of day, days of week, seasonality, and years of operation are assessed in the analytical effort. This includes an assessment of the simulation horizon.
Candidate Hypothesis	The candidate hypothesis represents the leading underlying cause of the system performance issue.
Analytical Approach	This element describes of the proposed method for evaluating the effectiveness of the mitigating strategies in resolving the system performance issue.
Selected Tool Type(s)	The one or more tool types will be used in the analytical approach. This section should identify if existing models are to be employed, or if new models must be developed.
Data Requirements	A summary of data will be used to characterize operational conditions, represent alternatives, and model the geographic and temporal aspects of the system.

Project Scoping Summary Elements (Cont'd)

Preliminary List of Alternatives	High-level description of the alternative solutions and/or operational practices will be assessed within the analytical project.
Key Operational Conditions	The set of travel demand, incident, and weather conditions under which a meaningful examination of alternative impacts must be conducted.
Selected Performance Measures	The measures of system performance selected for the effort. These measures should be most suited to differentiate alternatives, be meaningful to stakeholders, and can be well-represented/estimated within the proposed analytical approach.
Expected Costs	The projected cost of the analytical project, including data collection.
Expected Schedule	The projected time to conduct the analysis, including data collection.
Expected Assignment of Responsibilities	An assessment of responsibilities related to the project and how those responsibilities are allocated among departments, contractors, and other organizations engaged in the effort.
Risks	A summary of risks comprising risks in data collection, technical risks, and non-technical risks.

Analysis Scoping Tool

Summary of Example User Inputs

Transportation Analysis Project Costing Tool

Press This Button to Start

Summary of User Inputs:

1	Name of Study Area:	Standard TIS
2	Number of Intersections:	5
3	Number of Freeway Ramps:	10
4	Base Model Availability:	Yes
5	Is the Base Model Calibrated:	Yes
6	Number of Analysis Horizons:	2
7	Number of Alternatives:	2
8	Number of Representative Days:	2
9	Number of Peak Periods	2
10	Data Processing Requirements:	Low
11	Complexity of Analysis Scenarios:	Simple
12	Complexity of Methodology:	Deterministic
13	Complexity of Outputs:	Comprehensive
14	Analyst Experience:	Considerable

Note: This Transportation Analysis Costing Tool is provided "as is" without warranty of any kind, and without any documentation, user's guide, or mai

Caltrans

CAMBRIDGE SYSTEMATICS

Analysis Costing Tool
Example Output

	Transportation Analysis Project Costing Tool						
OUTPUT REPORT							
Estimate of Labor Hours Required to Complete the Analysis of:							
	Standard TIS						
			Engineer/				
		Manager	Planner	Technician	Total	Lower	Upper
	Project Task	Hours	Hours	Hours	Hours	Bound	Bound
1	Develop workplan, analysis plan, and project management	30	30	10	**70**	**60**	**80**
2	Select analysis tool	10	10	-	**20**	**20**	**20**
3	Develop data plan and process data	-	-	40	**40**	**40**	**40**
4	Define clusters and representative days	30	50	-	**80**	**70**	**90**
5	Develop and calibrate baseline model(s)	20	40	70	**130**	**120**	**170**
6	Develop future baseline model(s)	30	30	30	**90**	**80**	**100**
7	Analyze alternatives	90	180	90	**360**	**320**	**400**
8	Reports and presentations	30	30	10	**70**	**60**	**80**
	Total Labor Hours	**240**	**370**	**250**	**860**	**770**	**980**

Caltrans

CAMBRIDGE SYSTEMATICS

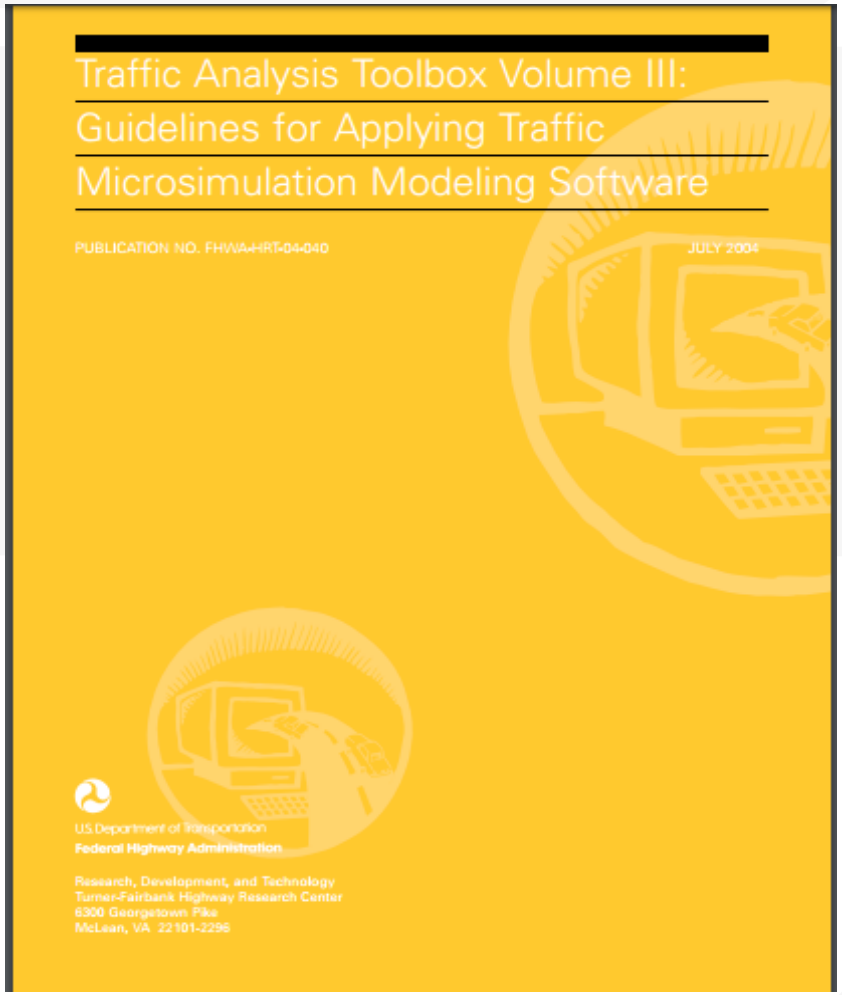
Training Session Overview

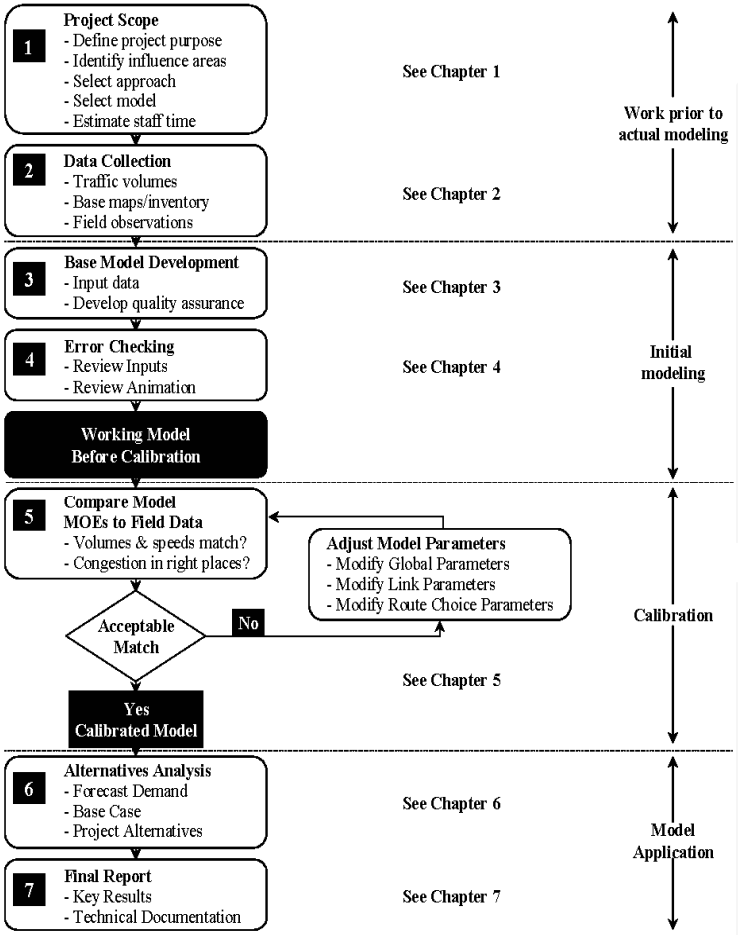
- Traffic Analysis Basics
  - » Traffic Analysis Output
- Synchro Introduction
- Data Preparation
- Synchro Operations
- Hands-On Exercise
- Advanced Applications

Caltrans

CAMBRIDGE SYSTEMATICS

Model Calibration Requirements Leveraging FHWA Microsimulation Guidance





Developed by the FHWA Traffic Analysis Tools Team and later adapted from *Advanced Corsim Training Manual*, Short, Elliott, Hendrickson, Inc., Minnesota Department of Transportation, September 2003.

Caltrans

CAMBRIDGE SYSTEMATICS

Project Results Summary Elements

Project Definition	A concise statement of the overall system problem including cross-validation and other insights from stakeholders on the nature of the issue and potential solutions.
Geographic Scope	The geographic area covered by the analytical project, including a statement of the required detail of representation within this geographical area.
Temporal Scope	The times of day, days of week, seasonality, and years of operation assessed in the analytical effort. This includes an assessment of the simulation horizon.
Hypotheses	The hypotheses represents the leading underlying cause of the system performance issue.
Results Summary	A text description summarizing the analytical results of the effort. This section should reference the final report that details project findings.
Analytical Approach	A description of the method used for evaluating the effectiveness of the mitigating strategies in resolving the system performance issue.
Developed Models	The one or more tool types used in the analytical approach, and the models developed to represent the system. This section should identify where these data are archived and documented.
Data Resources	A summary of data used to characterize operational conditions, represent alternatives, and model the geographic and temporal aspects of the system. This section should identify where these data are archived and documented.

Project Results Summary Elements (Cont'd)

Alternatives Modeled	Detailed description of the alternative solutions and/or operational practices assessed within the analytical project.
Key Operational Conditions	The set of travel demand, incident, and weather conditions under which a meaningful examination of alternative impacts were conducted.
Selected Performance Measures	The measures of system performance used in the effort.
Actual and Expected Costs	The actual and projected cost of the analytical project, including data collection.
Actual and Expected Schedule	The actual and projected time to conduct the analysis, including data collection.
Lessons Learned	An assessment of lessons learned regarding technical and non-technical issues.
Risks	A summary of risks comprising risks in data collection, technical risks, and non-technical risks—and how they were overcome or mitigated in the effort.

Analysis Tool Selection – HCS/Synchro

- Incorporation of HCM into Synchro 10
  - HCM 2000
  - HCM 2010
  - HCM 6th Edition
- Caltrans Guidelines
  - "*Multimodal Mobility Analysis Desk Reference*" from Caltrans Transportation Analysis Guide/Transportation Impact Studies Guide, June 2017
  - "*Guide for the Preparation of Traffic Impact Analysis*", December 2002
  - Synchro for Signalized Intersection Analysis

Training Session Overview

- Traffic Analysis Basics
- Synchro Introduction
- Data Preparation
- Synchro Operations
- Hands-On Exercise
- Advanced Applications

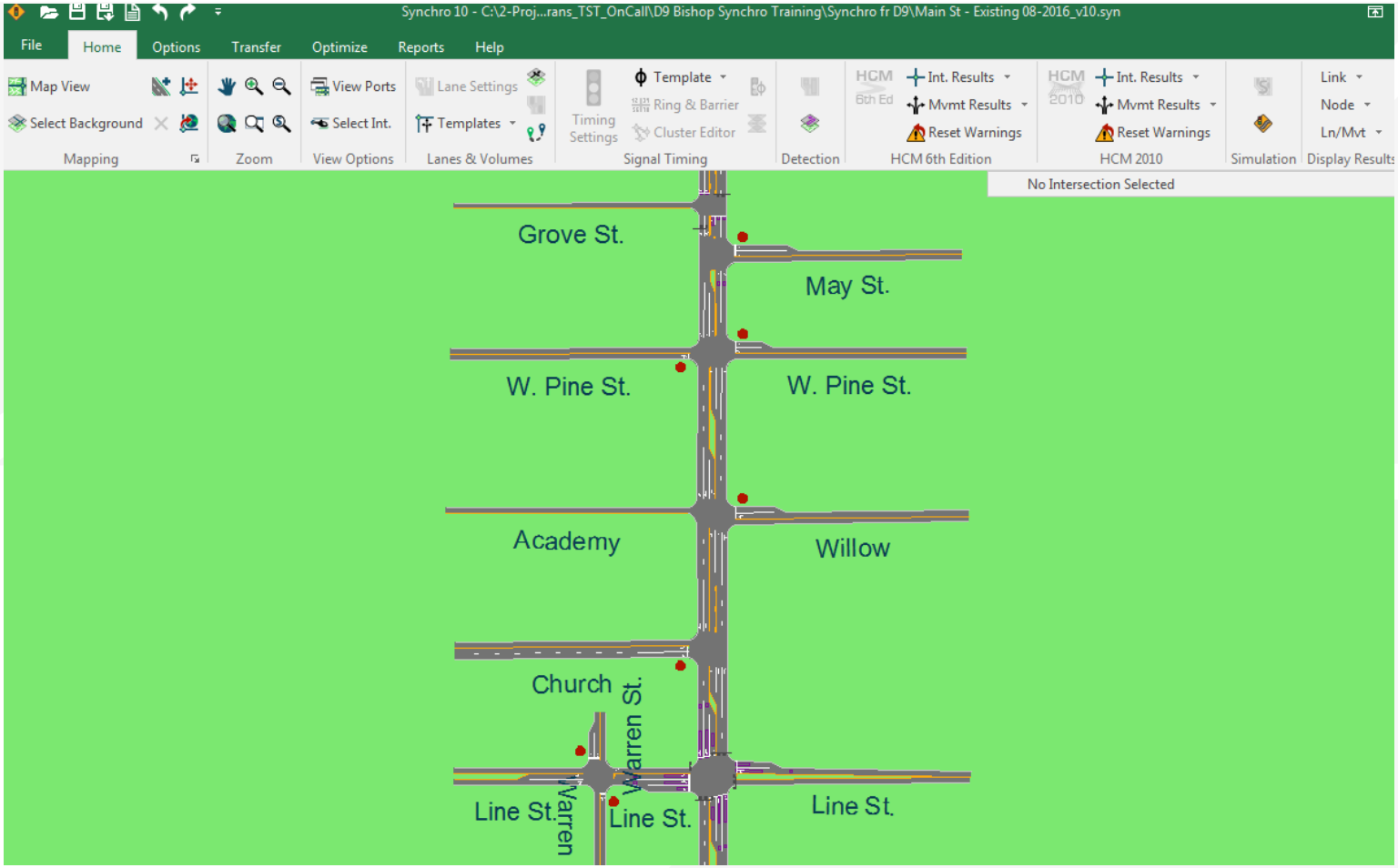
Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Introduction

- What is Synchro
  - Traffic analysis tool
    - Macroscopic
    - Deterministic
  - Used for
    - Capacity Analysis
    - Signal Coordination & Optimization
    - Actuated Signals
  - Primarily a signal-timing software

Synchro Introduction



Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Introduction - What is Synchro

- Capacity Analysis
  - » HCM
    - HCM 2000, HCM 2010 and HCM 6
    - Delay-based
    - Urban Streets
    - Signalized and Unsignalized Intersections
  - » ICU
    - Intersection Capacity Utilization
    - Volume-to-capacity (v/c) ration-based
    - Percentile Delay
    - Queue Blocking Delays

TIMING SETTINGS	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	5	60
Future Volume (vph)	60	5	60
Turn Type	Perm	—	—
Protected Phases		4	—
Permitted Phases	4		—
Permitted Flashing Yellow	—	—	—
Detector Phases	4	4	—
Switch Phase	0	0	—
Leading Detector (ft)	—	25	—
Trailing Detector (ft)	—	0	—
Minimum Initial (s)	6.0	6.0	—
Minimum Split (s)	24.7	24.7	—
Total Split (s)	35.0	35.0	—
Yellow Time (s)	3.2	3.2	—
All-Red Time (s)	0.5	0.5	—
Lost Time Adjust (s)	—	-0.7	-0.7
Lagging Phase?	—	—	—
Allow Lead/Lag Optimize?	—	—	—
Recall Mode	None	None	—
Speed limit (mph)	—	25	—
Actuated Effct. Green (s)	—	19.2	—
Actuated g/C Ratio	—	0.16	—
Volume to Capacity Ratio	—	0.47	—
Control Delay (s)	—	35.2	—

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Introduction - What is Synchro

- Coordination Software
  - » Offsets
  - » Controller Information
- Optimization Methods
  - » Intersection Cycle, Splits
  - » Network Coordination

Control Type	Actd-Coord
Cycle Length (s):	118.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle(s):	118.0
Natural Cycle(s):	55.0
Max v/c Ratio:	0.59
Intersection Delay (s):	13.5
Intersection LOS:	B
ICU:	0.55
ICU LOS:	B
Offset (s) :	68.0
Referenced to:	Begin of Yellow
Reference Phase:	2+6 - NBT SBT
Coordination Mode:	Fixed

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Introduction - What is Synchro

- Actuated Signal Software
  - » Minimum/Maximum Cycle Length Information
  - » Recall Mode
  - » Vehicle Extension & Gap
  - » Loop Detector Information

PHASING SETTINGS	1-SBL	2-NBT
Minimum Initial (s)	4.0	8.0
Minimum Split (s)	8.0	20.7
Maximum Split (s)	23.0	60.0
Yellow Time (s)	3.2	3.2
All-Red Time (s)	0.0	0.5
Lagging Phase?	☐	☑
Allow Lead/Lag Optimize?	☐	☐
Optimize Phs Weights - Delays	1.0	1.0
Vehicle Extension (s)	3.0	6.7
Minimum Gap (s)	2.0	2.0
Time Before Reduce (s)	0.0	5.3
Time To Reduce (s)	0.0	37.6
Recall Mode	None	C-Max
Pedestrian Phase	☐	☑
Walk Time (s)	—	7.0
Flash Dont Walk (s)	—	10.0
Pedestrian Calls (#/hr)	—	30
Dual Entry?	☐	☑
Fixed Force Off?	☑	☑

Caltrans

CAMBRIDGE SYSTEMATICS

Training Session Overview

- Traffic Analysis Basics
- Synchro Introduction
- Data Preparation
- Synchro Operations
- Hands-On Exercise
- Advanced Applications

Caltrans

CAMBRIDGE SYSTEMATICS

Data Preparation

- Geometry Information
  - Needs
    - Approach Lane Configuration
    - Turn Bay Length
    - Arterial Lane Configuration
    - Intersection Locations to Scale
    - Link Speed
    - …
  - Sources
    - Aerial imagery
    - In-field verification

Data Preparation

- Traffic Counts
  - Vehicular turning movement counts
    - During peak hour in 15-min intervals on weekdays
    - By vehicle class
    - 2 year or newer counts recommended
  - Pedestrian counts if applicable
  - Bus information if applicable

Data Preparation – Collecting Turning Movement Counts

Sample Data Collection Sheet

Study Name	**Mannheim & IL 19 AM**
Start Date	**05/02/2018**
Start Time	**7:00 AM**

	Southbound St. Southbound			Westbound St. Westbound			Northbound St. Northbound			Eastbound St. Eastbound		
Start Time	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
7:00 AM	32	261	131	129	187	33	20	265	132	135	190	14
7:15 AM	22	272	113	143	163	16	16	365	188	161	160	14
7:30 AM	28	253	121	120	235	29	22	350	153	191	193	21
7:45 AM	37	312	123	131	190	21	14	429	145	180	158	19
8:00 AM	21	220	96	127	193	36	14	351	131	201	133	15
8:15 AM	26	230	115	104	173	30	18	370	143	170	118	13
8:30 AM	23	230	90	138	165	18	13	383	150	211	147	16
8:45 AM	16	226	96	104	166	34	21	344	132	143	128	18

Lights | Mediums | Articulated Trucks | **Totals**

Caltrans

CAMBRIDGE SYSTEMATICS

Data Preparation – Processing Turning Movement Counts

- Sample Data Calculation Sheet
  - » Identifying Peak Hour
  - » Heavy Vehicle %
  - » Peak Hour Factor (PHF): busies 15-min period

Study Name	Mannheim & IL 19 AM
Start Date	05/02/2018
Start Time	7:00 AM

	Southbound St. Southbound			Westbound St. Westbound			Northbound St. Northbound			Eastbound St. Eastbound						
Start Time	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	All Mvnts	Hourly Volume	Heavy Veh %	PHF
7:00 AM	32	261	131	129	187	33	20	265	132	135	190	14	1529	6637		
7:15 AM	22	272	113	143	163	16	16	365	188	161	160	14	1633	6646	0.09	0.94
7:30 AM	28	253	121	120	235	29	22	350	153	191	193	21	1716	6523		
7:45 AM	37	312	123	131	190	21	14	429	145	180	158	19	1759	6391		
8:00 AM	21	220	96	127	193	36	14	351	131	201	133	15	1538	6060		
8:15 AM	26	230	115	104	173	30	18	370	143	170	118	13	1510			
8:30 AM	23	230	90	138	165	18	13	383	150	211	147	16	1584			
8:45 AM	16	226	96	104	166	34	21	344	132	143	128	18	1428			
Max Hourly														6646		
AM Peak Hour	108	1057	453	521	781	102	66	1495	617	733	644	69				

Caltrans

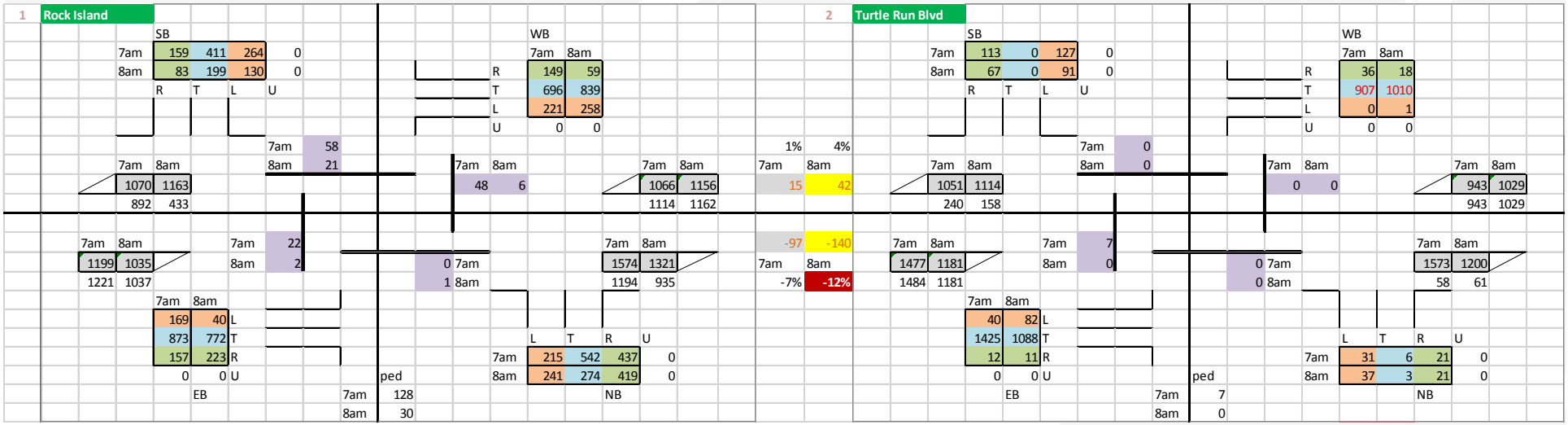
CAMBRIDGE SYSTEMATICS

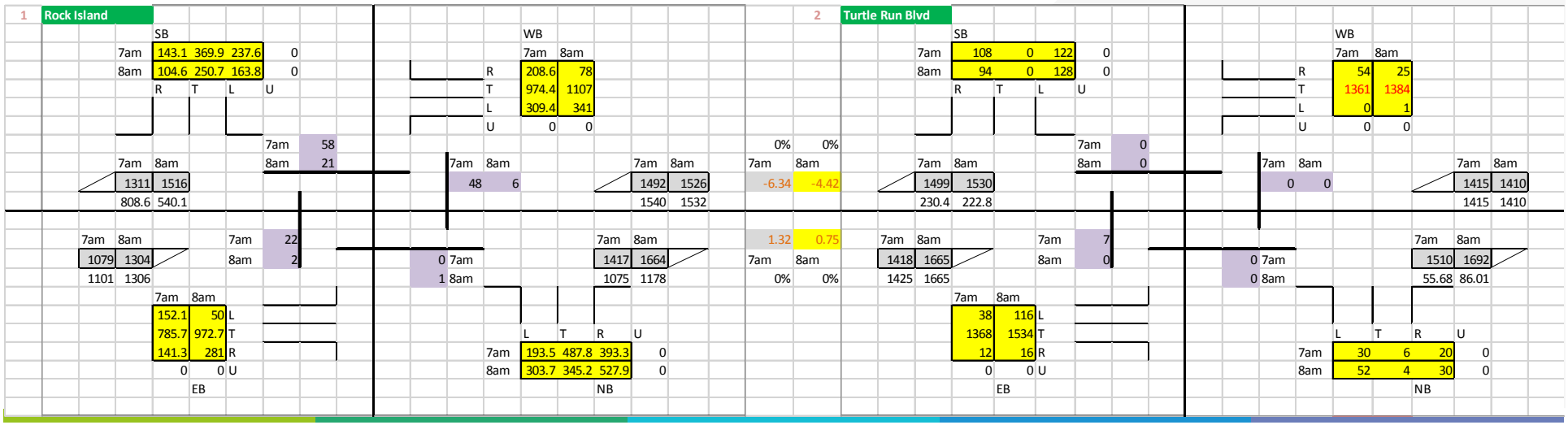
Data Preparation – Volume Balancing

- Volume Balancing
  - Imbalances because:
    - Peak hour selection method: selecting peak hours for individual intersections vs. universal peak hour for all intersection
    - Existence of driveways and parking lots along the corridor
    - Variations in traffic counts collected at different days/weeks/months and/or from different sources
  - Threshold for volume balancing
    - 10% of the total approach traffic volumes

Data Preparation – Volume Balancing

Sample Volume Balancing Sheet





Data Preparation

- Signal Information
  - Timing
  - Phasing
  - Coordinat

LOS ANGELES COUNTY
DEPARTMENT OF PUBLIC WORKS
TRAFFIC AND LIGHTING DIVISION
TRAFFIC SIGNAL TIMING

LACO - 3H

TYPE 170 PROGRAM

Page 1 of 6

Intersection: VALLEY BL. @ ATHENS ACCESS
T.S. No.: 5355

Date Requested: 1-7-13 MCH By: DTA
Date Completed: 2/11/13 By: TY

PHASE TIMING		Keystrokes: F + Phase + Interval							
Phase #		1	2	3	4	5	6	7	8
Minimum Walk	0		0		0	0	7		
Flashing Don't Walk	1		0		0	0	14		
Minimum Green	2		10		7	8	10		
Queue Maximum	3		0		0	0	0		
Added Green/Actuation	4		2.2		0.0	0.0	2.2		
Vehicle Extension	5		4.5		3.5	2.5	4.5		
Maximum Gap	6		5.5		3.5	2.5	5.5		
Minimum Gap	7		3.0		3.5	2.5	3.0		
Max Extension 1 (Free)	8		50		35	20	50		
Max Extension 2 (Coord)	9		130		35	20	130		
		OVLP A	OVLP B	OVLP C	OVLP D	OVLP E	OVLP F		
Ovlp Green Extension	A	*		3.0		0.0			
Ovlp Yellow Clearance	b	*		5.0		3.0			
Ovlp Red Clearance	C	*		1.0		1.0			
Reduce 0.1 Sec. Every...	d		1.5		0.0	0.0	1.5		
Yellow Clearance	E		5.0		3.0	3.0	5.0		
Red Clearance	F		1.0		1.0	1.0	1.0		

Red Rest Delay	F-0-7	0
Green Rest Delay	F-0-8	0
Max Added Green	F-0-E	25
Red Revert	F-0-F	2.0

Remarks:
*OLA - HARDWIRED CONTIUOUS GREEN ARROW.
OLC = ϕ6
OLE = ϕ4 + ϕ5

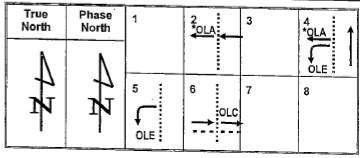
PREEMPTION	
Keystrokes: F + E + Function	
RxR Select (0, 1, 2, 3)	0
RxR Track Clearance	1
RxR1 All Red	2
RxR2 Maximum (Minutes)	3
Free Time After Preempt	4
EV - A Delay	5
EV - A Clearance	6
EV - B Delay	7
EV - B Clearance	8
EV - C Delay	9
EV - C Clearance	A
EV - D Delay	b
EV - D Clearance	C
EV Maximum (Seconds)	d
EV Delay/Clearance Timer	E
RxR Delay/Clear/Mark Timer	F

EV AFTER RxR PREEMPTION	
EV Type Select	F-C-0
Select : EV - A Enter 16	
EV - B Enter 32	
EV - C Enter 64	
EV - D Enter 128	
Keystrokes: F + d + Function	
EV After RxR Delay	7
EV After RxR Clearance	8
EV After RxR Maximum	9

PREEMPTION PHASES									
Keystrokes: F + d + Function									
		1	2	3	4	5	6	7	8
EV- A	0								
EV- B	1								
EV- C	2								
EV- D	3								
RR Track Clear	4								
RR2 Ltd Service	5								
RR1 Exit Phase	6								

PHASE FUNCTION FLAGS									
Keystrokes: F + F + Function									
		1	2	3	4	5	6	7	8
Phases Permitted	0		X		X	X	X		
Red Lock	1				X				
Red & Yellow Lock	2		X				X		
Minimum Vehicle Recall	3		X				X		
Pedestrian Recall + Rest in Walk	4								
Green Rest (Set Delay F-0-8)	5								
Red Rest (Set Delay F-0-7)	6								
Semi Traffic Actuated Mode	7								
Double Entry	8								
Maximum Vehicle Recall	9								
Restricted Phases	A								
Protected/Permissive Left Turn	b								
Barrier Recall	C								
First Phases After Start Up	d								
Yellow Start Up	E		X				X		
Overlap Yellow Start Up: →		A	b	C	d	E	F		
(Parents must be Yellow Start Up)	F	X		X					

LAG PHASE FLAGS									
		1	2	3	4	5	6	7	8
Lag Free	d-F-0		X		X		X		X
Lag Dial 1	d-F-1		X		X		X		X
Lag Dial 2	d-F-2		X		X		X		X
Lag Dial 3	d-F-3		X		X		X		X
PEDESTRIAN PHASES		1	2	3	4	5	6	7	8
2 Ped Load Switch	d-F-4								
4 Ped Load Switch	d-F-5								
6 Ped Load Switch	d-F-6						X		
8 Ped Load Switch	d-F-7								



Caltrans

CAMBRIDGE SYSTEMATICS

Training Session Overview

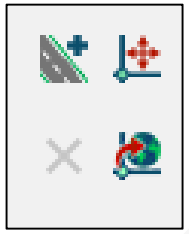
- Traffic Analysis Basics
- Synchro Introduction
- Data Preparation
- Synchro Operations
- Hands-On Exercise
- Advanced Applications

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Navigation & Editor

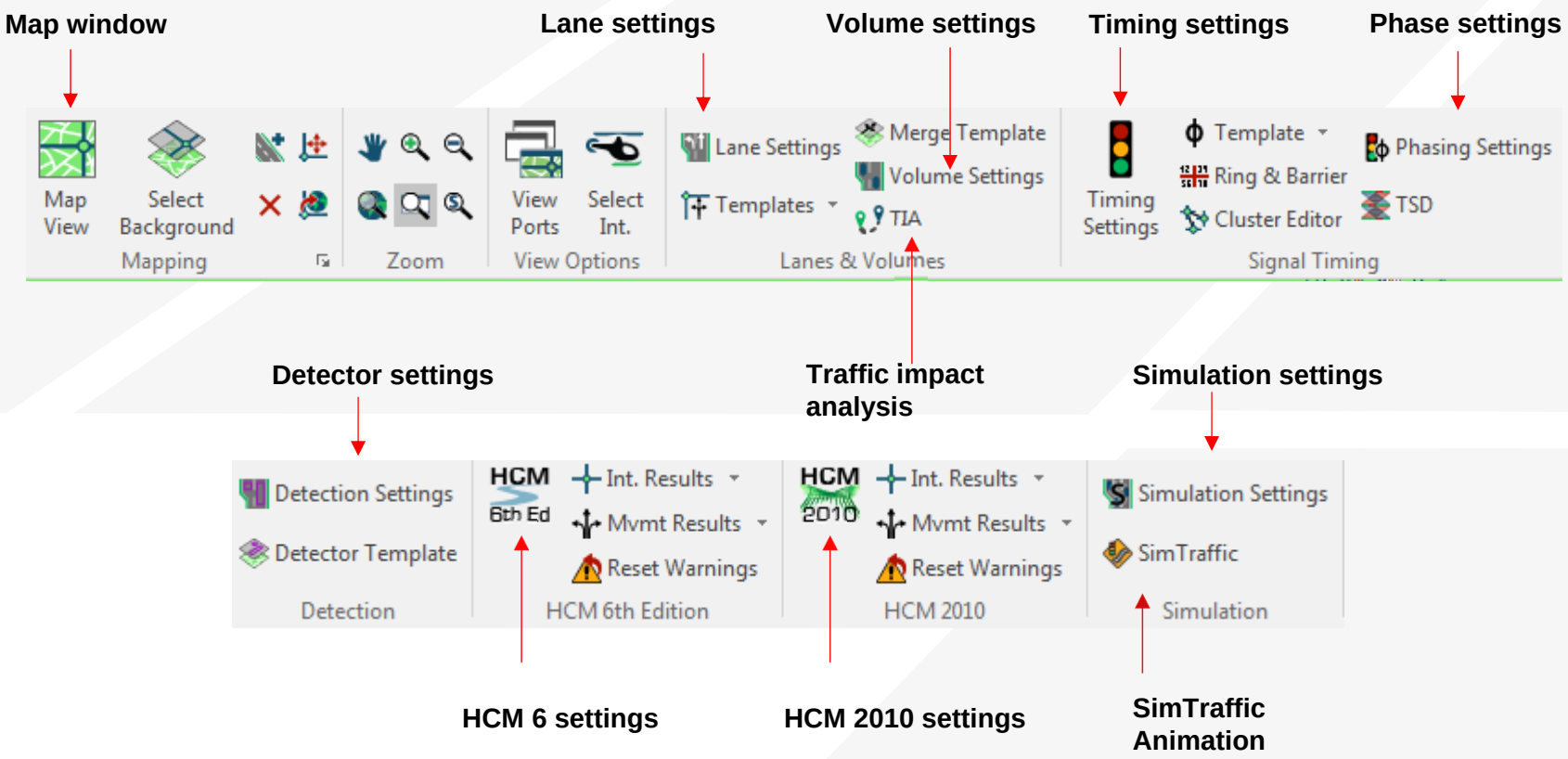
- Navigation
  - Drag Map
  - Zoom In/Out
  - Zoom All
  - Zoom Window
  - Zoom Scale
- Editor
  - Add Link
  - Move Node
  - Transform Map



Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Data Entry

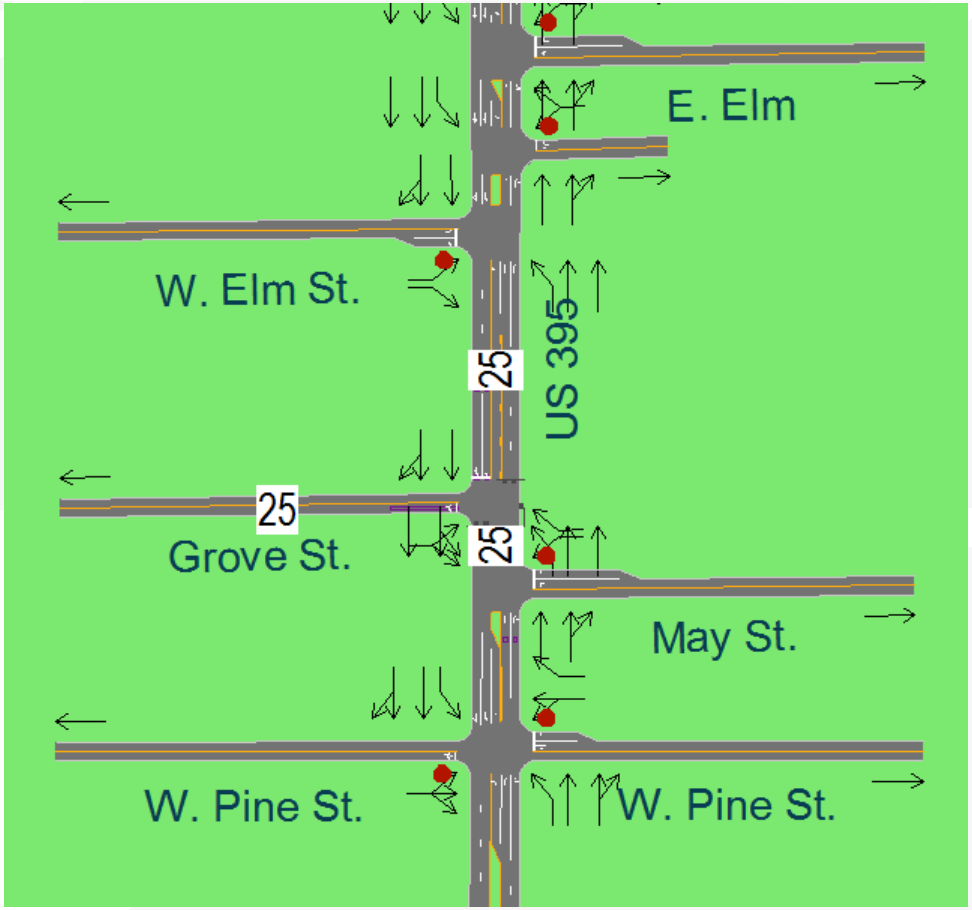


Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Display Information

- Link
  - Speed
  - Link Length
  - Coordinatability Factors
  - …
- Node
  - Node Number
  - Cycle Length
  - LOS
  - …
- Lane/Movement
  - Geometry (arrows)
  - Volumes
  - …



Caltrans

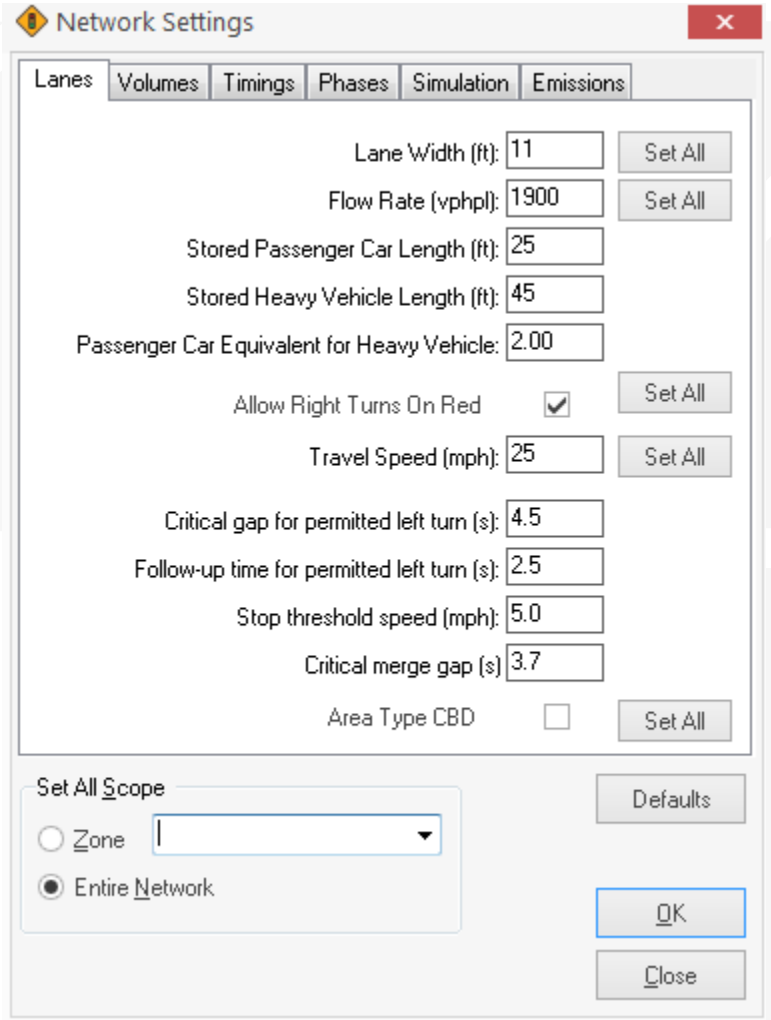
CAMBRIDGE SYSTEMATICS

Synchro Operations – Links & Nodes

- Synchro models streets and intersections as links and nodes
- Links
  - Labeled with ‘nearest’ direction
  - Curved Links and Grade Separations allowed
- Nodes
  - Signalized: Pretimed or Actuated
  - Unsignalized: Stop Control
  - Roundabouts: Limited Analysis
  - External: Dead Ends
- Create in Map Window

Synchro Operations – Global Network Settings

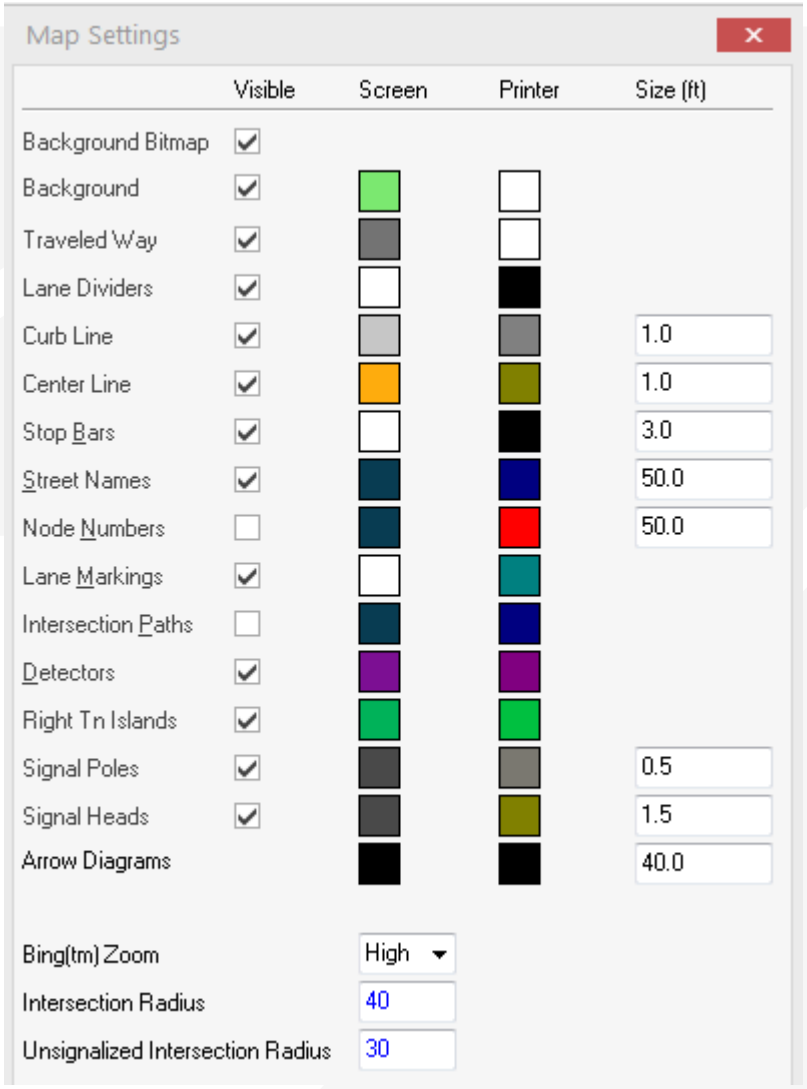
- Lanes
- Volumes
- Timings
- Phases
- Simulation
- Emissions



Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Global Map Settings



Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Lane Settings

- User Inputs
  - Approach Name
  - Lanes and Sharing
  - Traffic Volumes
  - Link Speed
  - Ideal Saturated Flow
  - Storage Length
  - Storage Lanes
  - Right Turn Channelized
  - Curb Radius
  - Add Lanes
  - RTOR
- Synchro Calculated Values

LANE SETTINGS	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	40	60
Future Volume (vph)	60	40	60
Street Name	Yaney		
Link Distance (ft)	—	517	—
Link Speed (mph)	—	25	—
Set Arterial Name and Speed	—	EB	—
Travel Time (s)	—	14.1	—
Ideal Satd. Flow (vphpl)	1900	1900	1900
Lane Width (ft)	11	11	11
Grade (%)	—	0	—
Area Type CBD	—	☑	—
Storage Length (ft)	0	—	25
Storage Lanes (#)	—	—	1
Right Turn Channelized	—	—	None
Curb Radius (ft)	—	—	—
Add Lanes (#)	—	—	—
Lane Utilization Factor	1.00	1.00	1.00
Right Turn Factor	1.000	1.000	0.850
Left Turn Factor (prot)	0.950	1.000	1.000
Saturated Flow Rate (prot)	1540	1621	1378
Left Turn Factor (perm)	0.611	1.000	1.000
Right Ped Bike Factor	1.000	1.000	0.971
Left Ped Factor	0.985	1.000	1.000
Saturated Flow Rate (perm)	975	1621	1337
Right Turn on Red?	—	—	☑
Saturated Flow Rate (RTOR)	0	0	60

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Volume Settings

- User Inputs
  - Peak Hour Factor
  - Growth Factor
  - Heavy Vehicle %
  - Bus Blockages (#/hr)
  - Adjacent Parking Lane
  - Parking Maneuvers
- Synchro Calculated Values

VOLUME SETTINGS	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	40	60
Development Volume (vph)	0	0	0
Combined Volume (vph)	60	40	60
Future Volume (vph)	60	40	60
Conflicting Peds. (#/hr)	10	—	10
Conflicting Bicycles (#/hr)	—	—	0
Peak Hour Factor	1.00	1.00	1.00
Growth Factor	1.00	1.00	1.00
Adjusted Flow (vph)	60	40	60
Heavy Vehicles (%)	2	2	2
Bus Blockages (#/hr)	0	0	0
Adj. Parking Lane?	☐	☐	☐
Parking Maneuvers (#/hr)	—	—	—
Traffic from mid-block (%)	—	100	—
Link OD Volumes	—	—	—
Traffic in shared lane (%)	—	—	—
Lane Group Flow (vph)	60	40	60

Caltrans

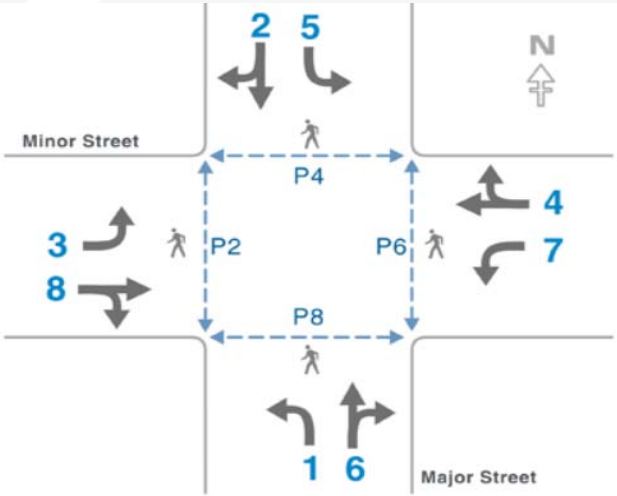
CAMBRIDGE SYSTEMATICS

Synchro Operations – Timing Settings Signalized Intersection Controller

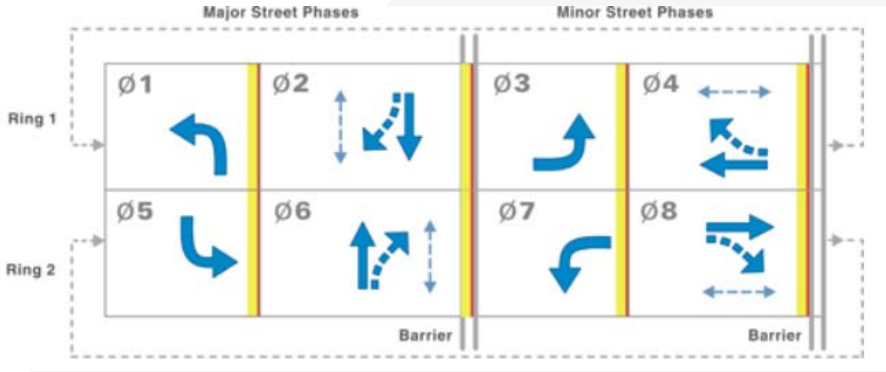
- Pre-timed
  - Fixed cycle
  - No detector actuations
- Semi Actuated-Uncoordinated
  - Side street is actuated
  - Cycle length vary therefore uncoordinated
- Actuated Uncoordinated
  - All phases fully actuated and no recall set
  - Cycle length vary
- Actuated Coordinated
  - All phases except coordinate phases are fully actuated
  - Cycle length fixed

Synchro Operations – Timing Settings
Ring and Barrier Diagram

- Ring and Barrier Diagram
  - Specifies safe sequencing of phases
  - Ring
    - A sequence of conflicting phase that are not compatible
  - Barrier
  - Permitted/Protected Movements



Typical vehicular and pedestrian movements at 4-leg intersection



Standard ring-and-barrier diagram

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Timing Settings

- User Inputs
  - Node #
  - Control Type
  - Cycle Length
  - Offset
  - Reference to
  - Reference Phase

NODE SETTINGS	
Node #	12
ATMS.now Controller ID	0
Import from ATMS.now:	Import
Export to ATMS.now:	Export
Zone:	1
X East (ft):	0
Y North (ft):	2924
Z Elevation (ft):	0
Description	
Control Type	Actd-Coord
Cycle Length (s):	118.0
Lock Timings:	☐
Optimize Cycle Length:	Optimize
Optimize Splits:	Optimize
Actuated Cycle(s):	118.0
Natural Cycle(s):	60.0
Max v/c Ratio:	0.48
Intersection Delay (s):	13.8
Intersection LOS:	B
ICU:	0.61
ICU LOS:	B
Offset (s) :	56.0
Referenced to:	Begin of Yellow
Reference Phase:	2+6 - NBT SBT
Coordination Mode:	Fixed
Master Intersection:	☐
Yield Point:	Single
Mandatory Stop On Yellow:	☐

Synchro Operations – Timing Settings

- User Inputs
  - Turn Type:
    - LT: split, permitted, protected, protected-permitted and custom
    - RT: permitted, protected, overlap,
  - Protected/Permitted Phases
  - Detector Phases
  - Min Initial: Min Green
  - Min Split: considers
    - Ped crossing (walk + FDW)
    - Clearance (yellow + all red)
  - Total split: total phase time

TIMING SETTINGS	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	40	60
Future Volume (vph)	60	40	60
Turn Type	Perm	—	Perm
Protected Phases		4	
Permitted Phases	4		4
Permitted Flashing Yellow	—	—	—
Detector Phases	4	4	None
Switch Phase	0	0	0
Leading Detector (ft)		105	20
Trailing Detector (ft)	0	0	0
Minimum Initial (s)	6.0	6.0	6.0
Minimum Split (s)	23.7	23.7	23.7
Total Split (s)	28.0	28.0	28.0
Yellow Time (s)	3.2	3.2	3.2
All-Red Time (s)	0.5	0.5	0.5
Lost Time Adjust (s)	-0.7	-0.7	-0.7
Lagging Phase?	—	—	—
Allow Lead/Lag Optimize?	—	—	—
Recall Mode	None	None	None
Speed limit (mph)	—	25	—
Actuated Effct. Green (s)	15.2	15.2	13.6
Actuated g/C Ratio	0.13	0.13	0.12
Volume to Capacity Ratio	0.48	0.19	0.29
Control Delay (s)	58.8	45.6	14.2

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Timing Settings

- User Inputs (Cont'd)
  - Yellow
  - All-red
  - Lost Time Adjust
  - Lagging Phase: in prot+perm phase
  - Recall Mode: None, Min, Ped and Max
- Synchro Calculated Values
  - v/c
  - $50^{th}/95^{th}$ Percentile Queues
    - Queues with $50^{th}/95^{th}$ percentile traffic volumes

Synchro Operations – Phasing Settings

- User Inputs
  - Vehicle Extension (Max Gap)
  - Min Gap
  - Time Before Reduce
  - Time to Reduce
  - Pedestrian Phase
  - Walk Time
  - Flash Don't Walk
  - Pedestrian Calls
  - Dual Entry

PHASING SETTINGS	1-SBL	2-NBT
Minimum Initial (s)	4.0	12.0
Minimum Split (s)	8.0	19.7
Maximum Split (s)	8.0	82.0
Yellow Time (s)	3.2	3.2
All-Red Time (s)	0.0	0.5
Lagging Phase?	☐	☑
Allow Lead/Lag Optimize?	☐	☐
Optimize Phs Weights - Delays	1.0	1.0
Vehicle Extension (s)	3.0	6.1
Minimum Gap (s)	2.0	2.0
Time Before Reduce (s)	0.0	4.4
Time To Reduce (s)	0.0	24.6
Recall Mode	None	C-Max
Pedestrian Phase	☐	☑
Walk Time (s)	—	5.0
Flash Dont Walk (s)	—	11.0
Pedestrian Calls (#/hr)	—	20
Dual Entry?	☐	☑
Fixed Force Off?	☑	☑
90th %ile Green Time (s)	9 mx	78 cd
70th %ile Green Time (s)	9 mx	78 cd
50th %ile Green Time (s)	9 gp	85 cd
30th %ile Green Time (s)	7 gp	89 cd
10th %ile Green Time (s)	0 sk	114 cd

Synchro Operations – Detector Settings

- User Inputs
  - Number of Detectors
  - Leading/Trailing Detectors
    - Distances relative to stop bar
  - Detector Type
    - Call, Extend and Call+Extend

DETECTOR SETTINGS	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	40	60
Future Volume (vph)	60	40	60
Number of Detectors (#)	1	2	1
Detector Phases	4	4	None
Switch Phase	0	0	0
Leading Detector (ft)	5	105	20
Trailing Detector (ft)	0	0	0
Detector Template	(none)	(none)	(none)
Add/Update Template			
Detector 1 Position (ft)	0	0	0
Detector 1 Size (ft)	5	55	20
Detector 1 Type	Cl+Ex	Cl+Ex	Cl+Ex
Detector 1 Channels			
Detector 1 Extend	0.0	0.0	0.0
Detector 1 Queue	0.0	0.0	0.0
Detector 1 Delay	0.0	0.0	0.0
Detector 2 Position (ft)	—	99	—
Detector 2 Size (ft)	—	6	—
Detector 2 Type	—	Cl+Ex	—
Detector 2 Channels	—		—
Detector 2 Extend	—	0.0	—

Synchro Operations – Simulation Settings

- SimTraffic
  - Microsimulation module of Synchro
  - Provides visualization
  - Error Checking and Fine Tuning
- User Inputs
  - Taper Length
  - Lane Alignment
  - Enter Blocked Intersection
  - Link Offset
  - Two-Way Left Turn Lane (TWLTL)
    - Visual only
  - Turning Speed

SIMULATION SETTINGS	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	40	60
Future Volume (vph)	60	40	60
Storage Length (ft)	0	—	25
Storage Lanes (#)	—	—	1
Taper Length (ft)	—	—	25
Lane Alignment	Left	Left	Right
Lane Width (ft)	11	11	11
Enter Blocked Intersection	No	No	No
Median Width (ft)	—	11	—
Link Offset (ft)	—	0	—
Crosswalk Width (ft)	—	16	—
TWLTL Median	—	☐	—
Headway Factor	1.19	1.19	1.19
Turning Speed (mph)	15	—	9
Mandatory Distance (ft)	—	491	—
Positioning Distance (ft)	—	1101	—
Mandatory Distance 2 (ft)	—	734	—
Positioning Distance 2 (ft)	—	1468	—

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – HCM 6th Edition Settings

- Signalized Intersections
  - Auto, Pedestrian, and Bike modes
  - NEMA Phasing adherence
  - Calibration parameters available
  - Coordination effects

  for intersections within 0.60 miles
  - Platoon ratio adjustment available
  - RTOR treated as volume deduction
- TWSC Intersections
- AWSC Intersections
- Roundabouts
  - Follow-up Headway and

  Critical Headway adjustable

HCM 6th Settings	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	40	60
Future Volume (vph)	60	40	60
Turn Type	Perm	—	Perm
Protected Phases		4	
Permitted Phases	4		4
Lagging Phase?	☑	☑	☑
Opposing right-turn lane influence	Yes	—	—
+ Signal Timing Details			
Recall Mode	None	None	None
+ Adjusted Flow Rate (veh/h)	60	40	60
Adjusted No of Lanes	1	1	1
Pedestrian volume (p/h)	—	—	10
Bicycle volume (bicycles/h)	—	—	0
Right Turn on Red Volume (vph)	—	—	0
+ Ideal Satd. Flow (vphpl)	1900	1900	1900
Work zone on approach?	—	☐	—
Total Approach Width	—	—	—
Lanes open during work zone	—	—	—
HCM Platoon Ratio	1.00	1.00	1.00
HCM Upstream Filtering Factor	1.00	1.00	1.00
Initial Queue (veh)	0	0	0
Include Unsignalized Delay?	—	—	—
Unsig. Movement Delay (s/veh)	—	—	—
Right Turn Channelized	—	—	None
HCM 6th Capacity (veh/h)	165	243	201
HCM Volume/Capacity	0.363	0.165	0.298
HCM Lane Group Delay(s/veh)	53.7	44.8	46.5
HCM Lane Group LOS	D	D	D
HCM Approach Delay (s/veh)	—	48.8	—
HCM Approach LOS	—	D	—

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – HCM 2010 Settings

- Signalized Intersections
  - Auto, Pedestrian, and Bike modes
  - NEMA Phasing adherence
  - Calibration parameters available
  - Coordination effects

  for intersections within 0.60 miles
  - Platoon ratio adjustment available
  - RTOR treated as volume deduction
- TWSC Intersections
- AWSC Intersections
- Roundabouts
  - Follow-up Headway and

  Critical Headway adjustable

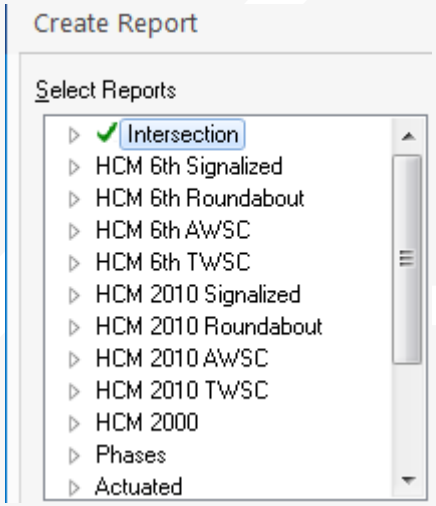
HCM 2010 SETTINGS	EBL	EBT	EBR
Lanes and Sharing (#RL)			
Traffic Volume (vph)	60	40	60
Future Volume (vph)	60	40	60
Lagging Phase?	☑	☑	☑
Turn Type	Perm	—	Perm
Protected Phases		4	
Permitted Phases	4		4
Passage Time (s)	4.4	4.4	4.4
Minimum Green (s)	6.0	6.0	6.0
Maximum Split (s)	28.0	28.0	28.0
Yellow Time (s)	3.2	3.2	3.2
All-Red Time (s)	0.5	0.5	0.5
Maximum Green (s)	24.3	24.3	24.3
Walk Time (s)	5.0	5.0	5.0
Flash Dont Walk (s)	15.0	15.0	15.0
Walk+ ped. clear (s)	20.0	20.0	20.0
Recall Mode	None	None	None
Dual Entry?	☑	☑	☑
Adjusted Flow Rate (veh/h)	60	40	60
Adjusted No of Lanes	1	1	1
Right Turn on Red Volume (vph)	—	—	0
Ideal Satd. Flow (vphpl)	1900	1900	1900
Percent Heavy Vehicles (%)	2	2	2
Lane Utilization Adj.Factor	—	—	—
Peak Hour Factor	1.00	1.00	1.00
Growth Factor	1.00	1.00	1.00
Lost Time Adjust (s)	-0.7	-0.7	-0.7
Startup Lost Time (s)	2.0	2.0	2.0
Extension of Effect.Green Time (s)	2.7	2.7	2.7
HCM Platoon Ratio	1	1	1

Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Reports

- Methodologies
  - Intersection Capacity Utilization (ICU)
    - v/c-based LOS
    - Planning studies
  - Highway Capacity Manual (HCM)
    - Delay-based LOS
    - Operations and signal timing design
    - HCM 2010 and HCM 6th Edition method limitations

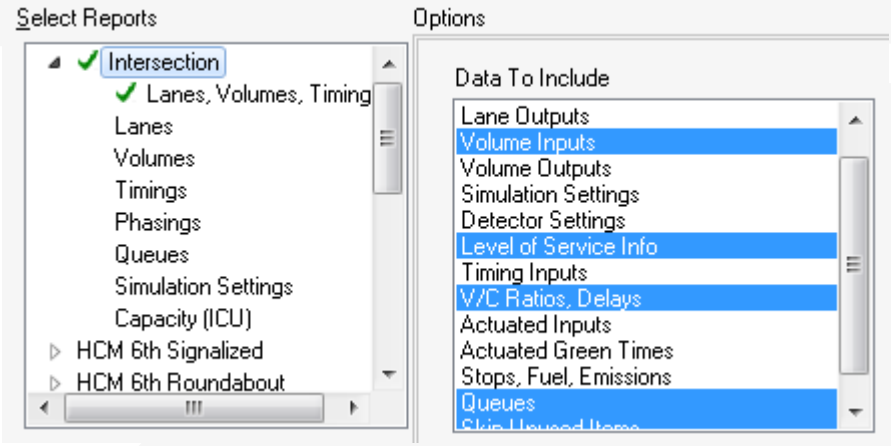


Caltrans

CAMBRIDGE SYSTEMATICS

Synchro Operations – Reports

- Measure of Effectiveness
  - Volume-to-Capacity ratio (v/c)
  - Delay
    - Control Delay: caused by downstream traffic control device
    - Queue Delay: the effects of queues and blockings
    - Total Delay: Control Delay + Queue Delay
  - LOS
  - Queue Length
  - …



Caltrans

CAMBRIDGE SYSTEMATICS

Syr

»

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	200	100	100	60	60	80	70	500	30	60	900	100
Future Volume (vph)	200	100	100	60	60	80	70	500	30	60	900	100
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	12	12	12	12	12	12	12	12	12
Total Lost time (s)	3.0	3.0	3.0		3.0	3.0	2.8	3.0		2.8	3.0	
Lane Util. Factor	0.95	0.95	1.00		1.00	1.00	1.00	0.95		1.00	0.95	
Frt	1.00	1.00	0.85		1.00	0.85	1.00	0.99		1.00	0.98	
Flt Protected	0.95	0.98	1.00		0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1513	1566	1425		1390	1425	1593	2693		1593	2980	
Flt Permitted	0.95	0.98	1.00		0.98	1.00	0.95	1.00		0.95	1.00	
Satd. Flow (perm)	1513	1566	1425		1390	1425	1593	2693		1593	2980	
Peak-hour factor, PHF	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Adj. Flow (vph)	200	100	100	60	60	80	70	500	30	60	900	100
RTOR Reduction (vph)	0	0	84	0	0	69	0	3	0	0	7	0
Lane Group Flow (vph)	148	152	16	0	120	11	70	527	0	60	993	0
Heavy Vehicles (%)	2%	2%	2%	2%	2%	2%	2%	8%	2%	2%	8%	2%
Parking (#/hr)					10			20				
Turn Type	Split	NA	Perm	Split	NA	Perm	Prot	NA		Prot	NA	
Protected Phases	4	4		3	3		5	2		1	6	
Permitted Phases			4			3						
Actuated Green, G (s)	17.2	17.2	17.2		14.9	14.9	6.8	56.3		7.3	56.8	
Effective Green, g (s)	17.9	17.9	17.9		15.6	15.6	7.2	57.0		7.7	57.5	
Actuated g/C Ratio	0.16	0.16	0.16		0.14	0.14	0.07	0.52		0.07	0.52	
Clearance Time (s)	3.7	3.7	3.7		3.7	3.7	3.2	3.7		3.2	3.7	
Vehicle Extension (s)	4.0	4.0	4.0		4.0	4.0	3.0	5.0		3.0	5.0	
Lane Grp Cap (vph)	246	254	231		197	202	104	1395		111	1557	
v/s Ratio Prot	c0.10	0.10			c0.09		c0.04	0.20		0.04	c0.33	
v/s Ratio Perm			0.01			0.01						
v/c Ratio	0.60	0.60	0.07		0.61	0.06	0.67	0.38		0.54	0.64	
Uniform Delay, d1	42.7	42.7	39.0		44.3	40.8	50.2	15.9		49.4	18.8	
Progression Factor	1.00	1.00	1.00		1.00	1.00	1.00	1.00		1.00	1.00	
Incremental Delay, d2	4.8	4.4	0.2		6.1	0.2	16.2	0.8		5.3	2.0	
Delay (s)	47.5	47.1	39.2		50.4	41.0	66.4	16.7		54.8	20.8	
Level of Service	D	D	D		D	D	E	B		D	C	
Approach Delay (s)		45.3			46.7			22.5			22.7	
Approach LOS		D			D			C			C	

Intersection Summary				
HCM 2000 Control Delay	28.8	HCM 2000 Level of Service	C	
HCM 2000 Volume to Capacity ratio	0.63			
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	11.8	
Intersection Capacity Utilization	61.2%	ICU Level of Service	B	
Analysis Period (min)	20			
c Critical Lane Group				

MATICS