TRAFFIC ENGINEERING DESIGN

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INTRODUCTION

Jeff Jasper

Agenda

- Background/Overview
- Prequalification
- Resources

Traffic Engineering

- What is Traffic Engineering Design?
- Size Roadways, Intersections, Interchanges
- Develop Innovative Solutions

Purpose of Traffic Engineering

- Intended Use
  - Purpose and Need identifies Capacity and/or safety concerns
  - May be used in other instances
  - One of many inputs to decision making process

Inform & Document Decision Making Process

Kentucky’s Roadway System

- 4-Lane Roadways < 10,000 ADT
  - 741 miles

- 4-Lane Roadways < 5,000 ADT
  - 116 miles

Traffic Engineering Costs

- Typical Traffic Engineering Cost
  - $5,000-$10,000 per Intersection

- Approximate Cost for 1 Turn Lane
  - $25,000-$50,000

- 2-Lane Facility $7M; 4-Lane Facility $22M

Policies

- Design Memos
  - Design 03-11; Traffic Engineering Analysis
  - Design, Permits, Traffic 03-09; Auxiliary Turn Lane Policy
  - Design 03-10; Roundabout Analysis

Prequalification

Advanced Traffic Engineering Design and Modeling

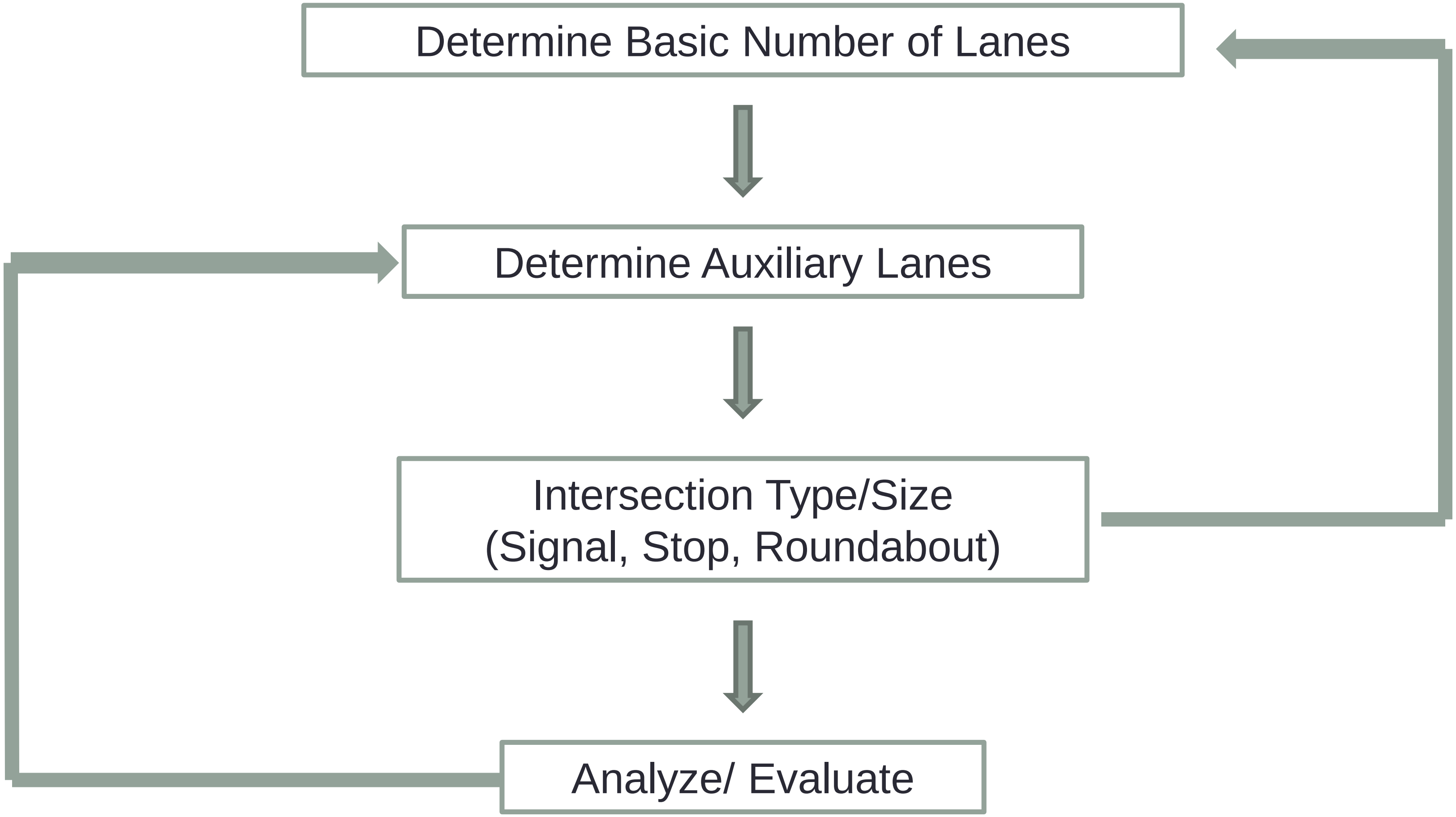
Determine if a firm has the capability to perform advanced traffic engineering analysis for roadway design projects, including microsimulation and corridor signal analysis.

- The firm must have at least one full-time staff member registered as a Professional Traffic Operations Engineer (PTOE) or equivalent experience.
- Demonstrate experience in:
  - Signal Systems Operations
  - Microsimulation Modeling

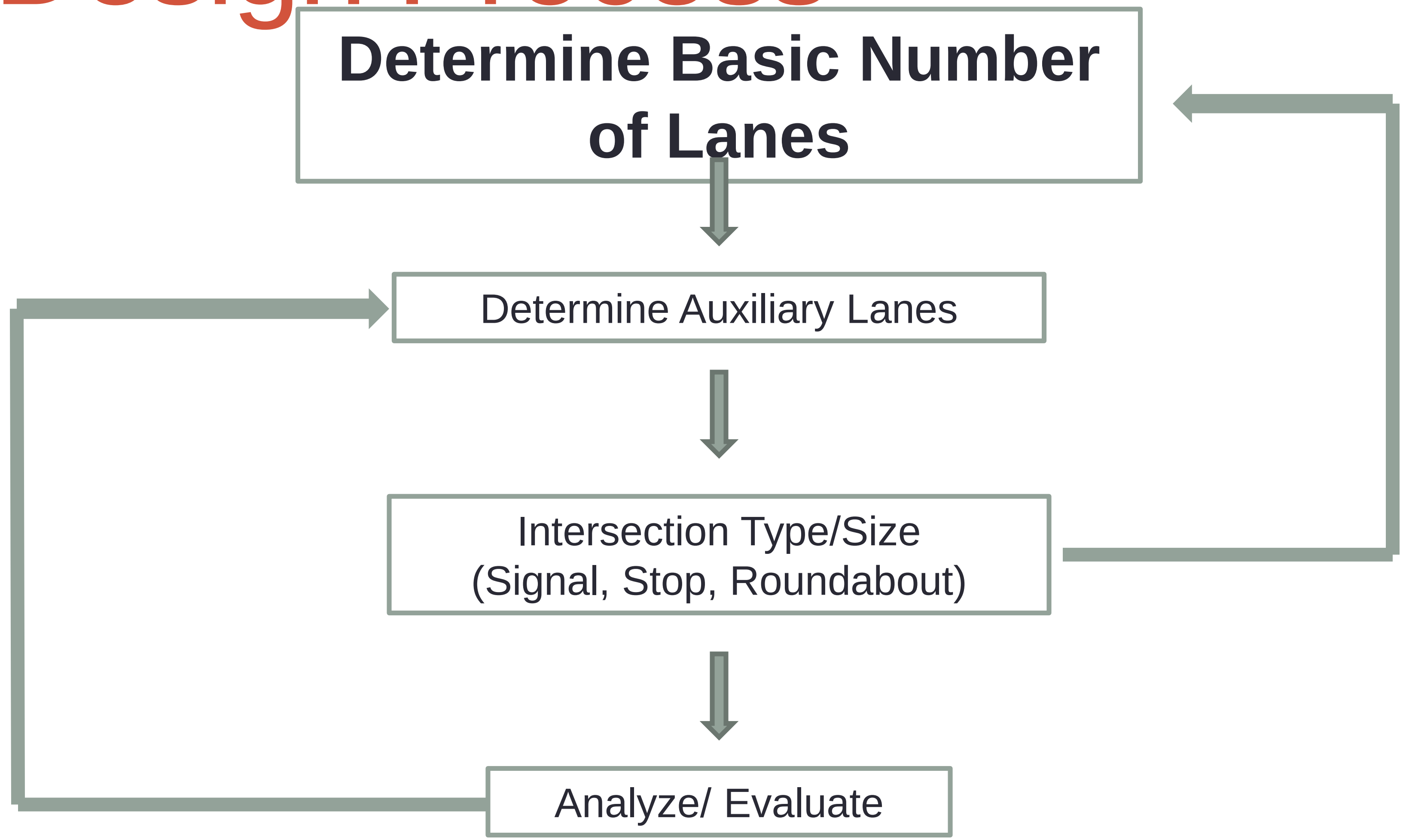
TRAFFIC ENGINEERING DESIGN PROCESS

Adam Kirk

Design Process



Design Process



Basic Number of Lanes

Calculate Volume to Capacity Ratio (V/C)

- **Targeted** V/C
  - 1.0 Urban Areas
  - 0.9 Rural Areas

- Document if V/C less than
  - 0.8 Urban Areas
  - 0.7 Rural Areas

Why V/C Ratio?

Exhibit 2-2
HCM Service Measures by System Element and Mode

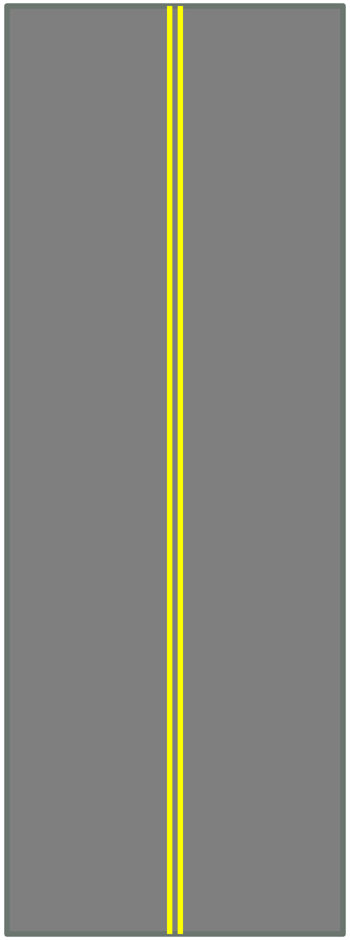
System Element	HCM Chapter	Service Measure(s): Automobile	Pedestrian	Bicycle	Transit	Systems Analysis Measure
Freeway facility	10	Density	--	--	--	Speed
Basic freeway segment	11	Density	--	--	--	Speed
Freeway weaving segment	12	Density	--	--	--	Speed
Freeway merge and diverge segments	13	Density	--	--	--	Speed
Multilane highway	14	Density	--	LOS score[a]	--	Speed
Two-lane highway	15	Percent time-spent-following, speed	--	LOS score[a]	--	Speed
Urban street facility	16	Speed	LOS score[a]	LOS score[a]	LOS score[a]	Speed
Urban street segment	17	Speed	LOS score[a]	LOS score[a]	LOS score[a]	Speed
Signalized intersection	18	Delay	LOS score[a]	LOS score[a]	--	Delay
Two-way stop	19	Delay	Delay	--	--	Delay
All-way stop	20	Delay	--	--	--	Delay
Roundabout	21	Delay	--	--	--	Delay
Interchange ramp terminal	22	Delay	--	--	--	Delay
Off-street pedestrian–bicycle facility	23	--	Space, events[b]	LOS score[a]	--	Speed

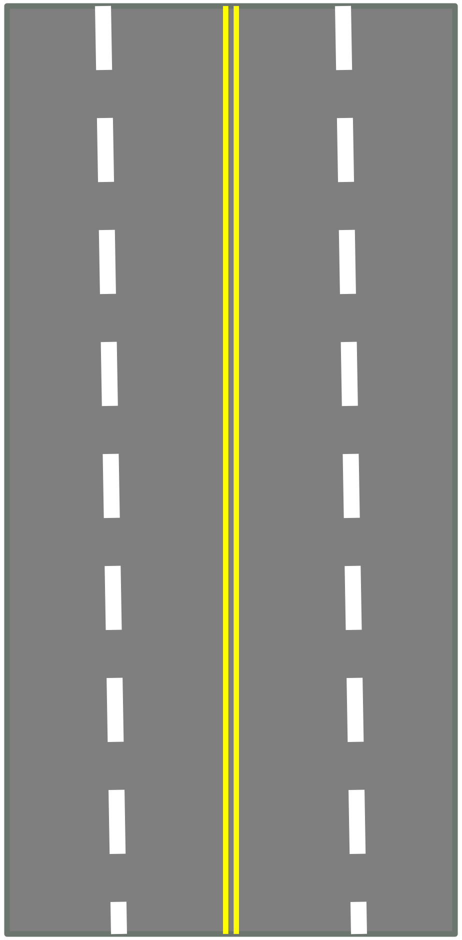
Notes: [a] See Exhibit 2-3 for the LOS score components.
[b] Events are situations where pedestrians meet bicyclists.

Basic Number of Lanes

Determined by Roadway Capacity

- 2-Lane Facility:
  - 1700 vphpl; 3200 vphpl (both directions)
- Multi-lane Facility
  - 2000 vphpl
- Interstate
  - 2300 vphpl
- Signalized Intersection
  - 1900 vphplphg





Analysis Scenarios

- Design Year Analysis (20 Year)
  - Current Year analysis can be used to calibrate models
  - Interim Analysis may be useful (Incremental Improvements)

- AM and PM Peak Hours

- Requires Traffic Forecasting (Division of Planning)

Example

- Suburban Roadway Project
- 30,000 AADT Design Year Volume
- Peak Hour Factor (K) = 0.09
- Directional Factor (D) = 0.6
- PHF = 0.95

- How many lanes??

Example

- 30,000 ADT
- Peak Hour Factor (K) = 0.09
- Peak Hour Volume = 2700 vph
- Directional Factor (D) = 0.6
- Directional Volume = 1620/0.95 = 1705
- V/C (2-Lane) = 1705/1700 = 1.01

- V/C (4-Lane) = 1700/4000 =0.425

AUXILIARY LANES

Design Process

Determine Basic Number of Lanes

Determine Auxiliary Lanes

Intersection Type/Size
(Signal, Stop, Roundabout)

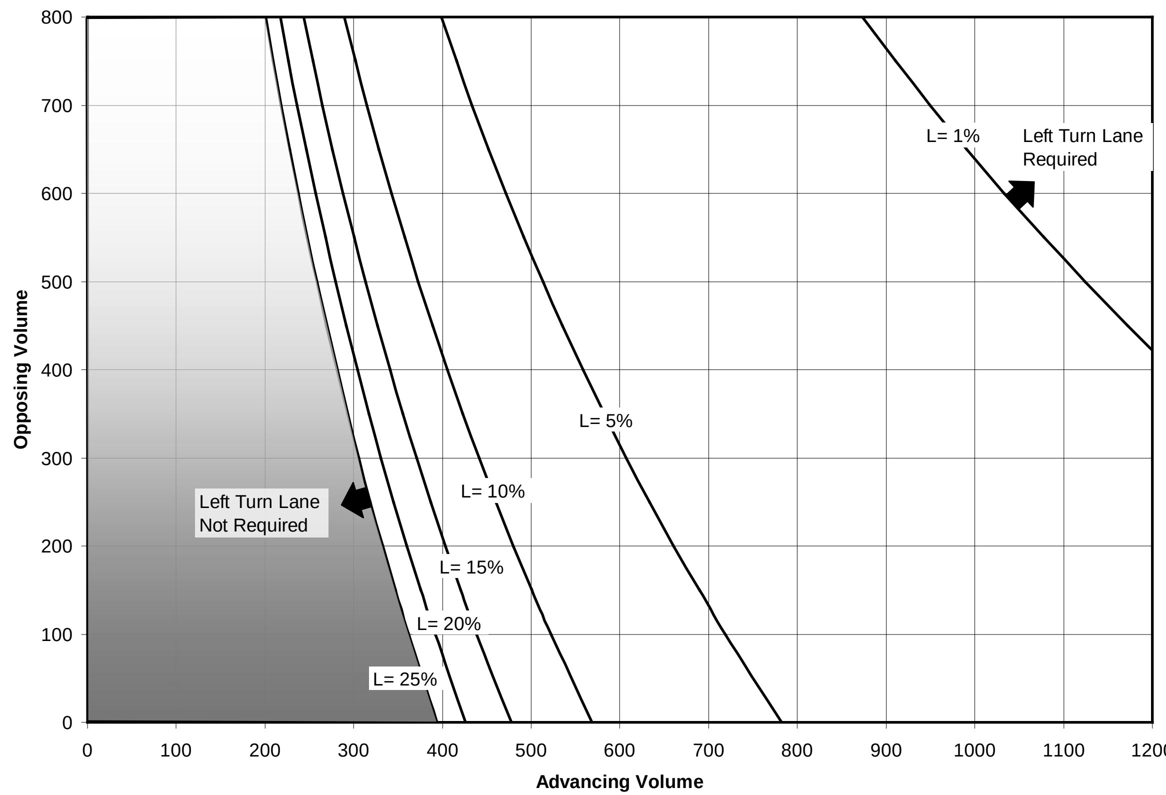
Analyze/ Evaluate

LEFT-TURN LANE WARRANTS

- Uncontrolled Approaches
  - Left-turn lanes shall be provided at median openings on divided roadways
  - Left-turn lanes shall be provided if traffic volumes at the intersection meet the thresholds identified in Figures 1 and 2.
  - Left-turn lanes should be considered as a safety countermeasure, e.g. where sight distance of approaching traffic is limited.

LEFT-TURN LANE WARRANTS

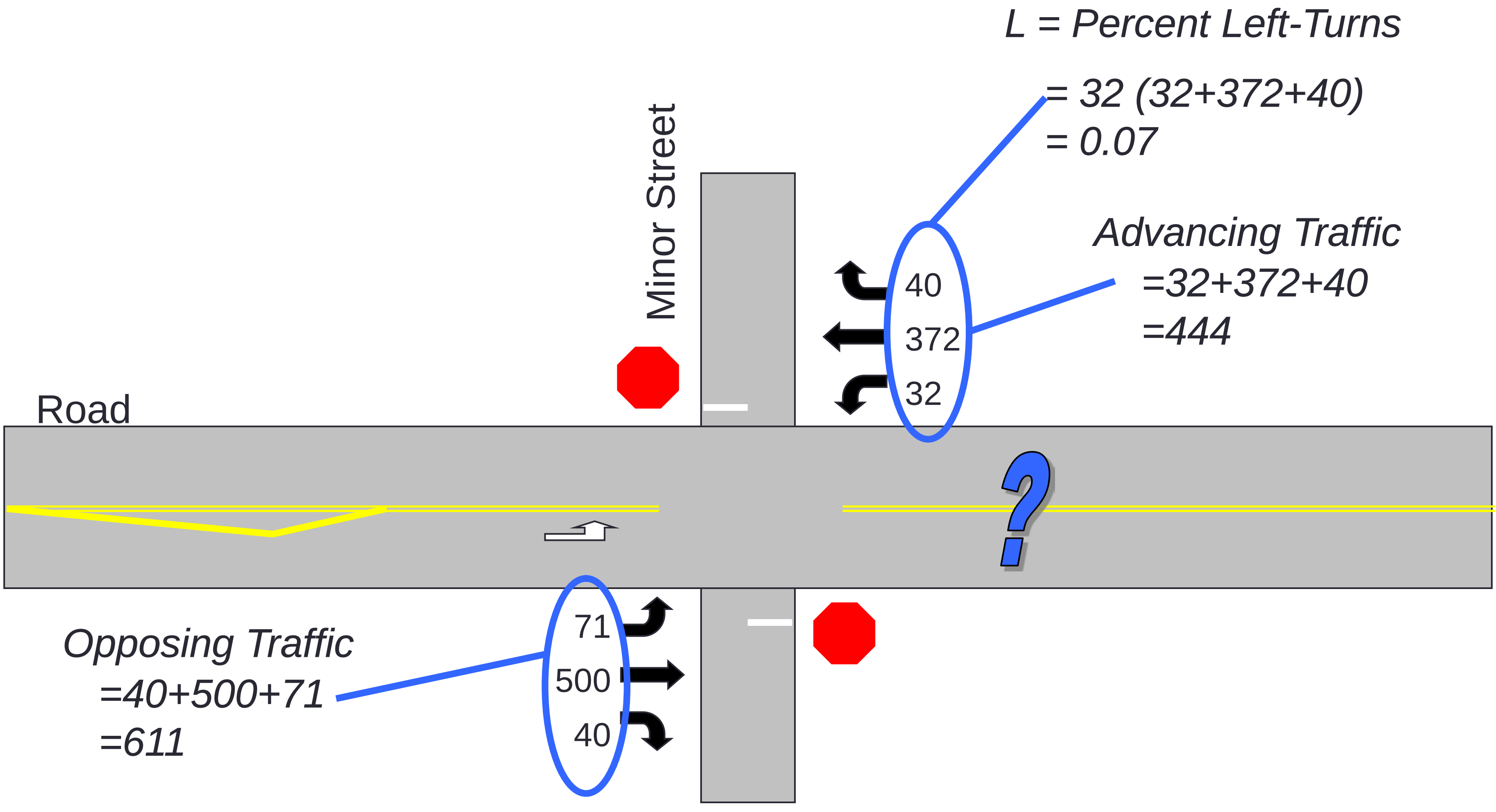
- 2 Graphs measure probability of stopped vehicle blocking lane
  - ≤ 45 MPH (P = 0.02)
  - >45 MPH (P = 0.01)



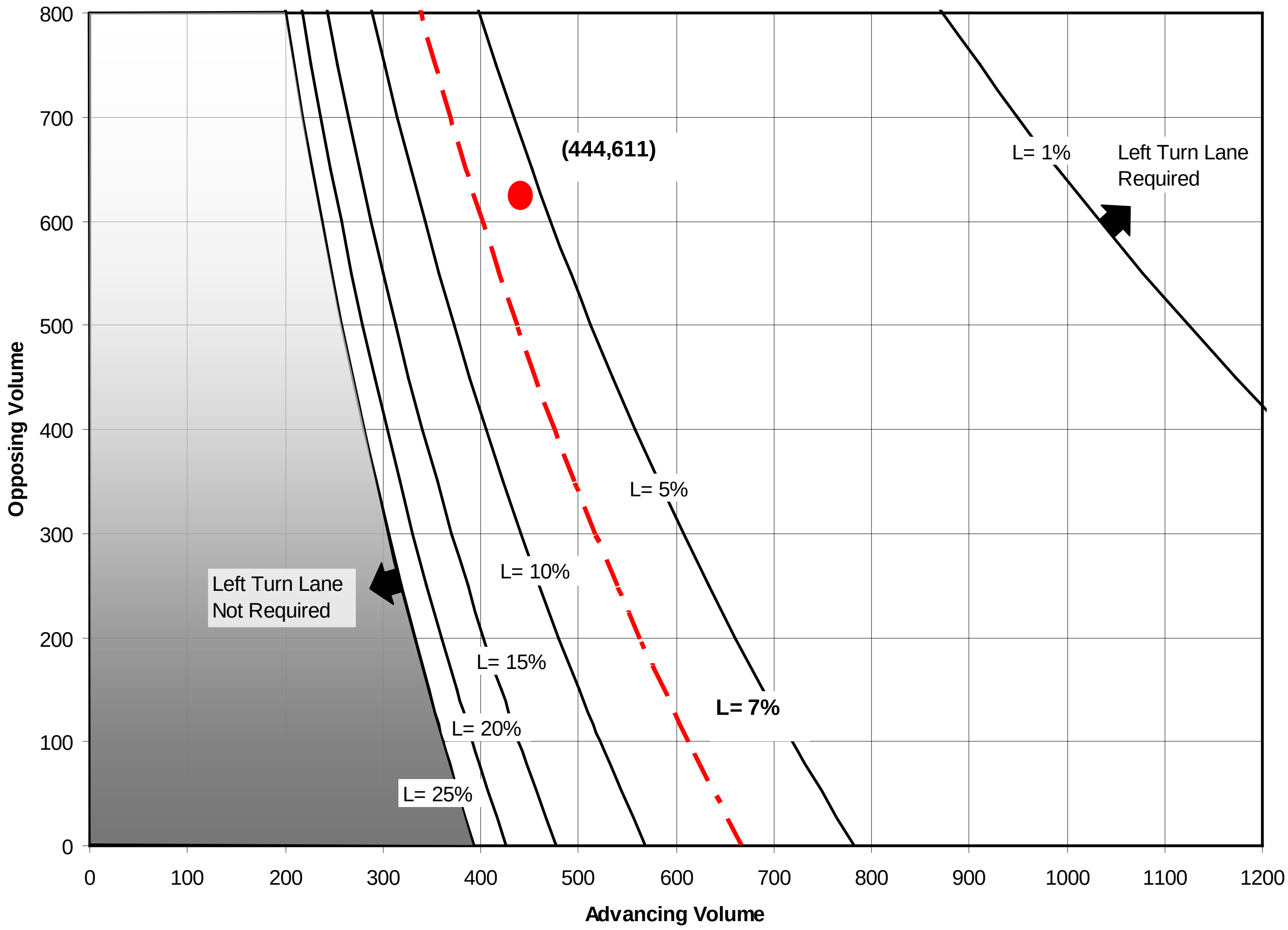
LEFT-TURN LANE WARRANTS

- Inputs
  - *L = Percent Left-Turns*
  - *Advancing Volume = Through + Left + Right-Turn Traffic*
  - *Opposing Volume = Through + Left + Right-Turn Opposing Traffic*

LEFT-TURN LANE WARRANTS

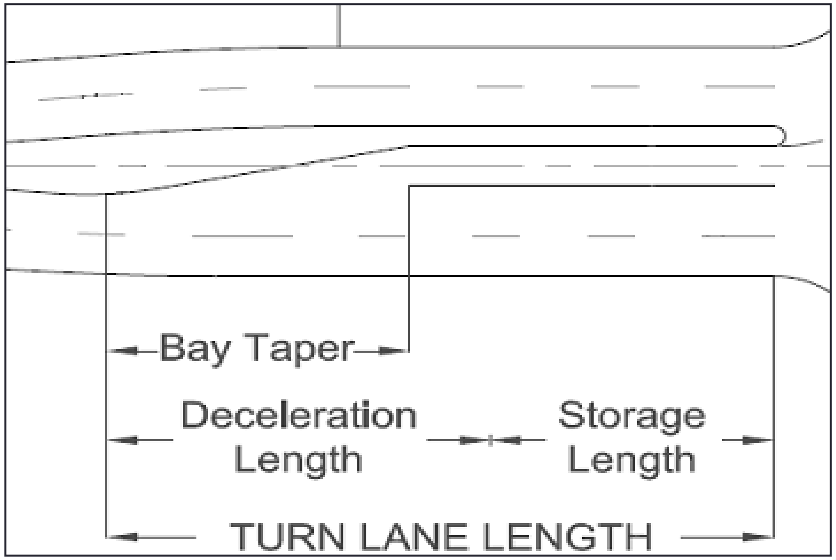


LEFT-TURN LANE WARRANTS



LEFT-TURN LANE DESIGN

- Turn Lane Length
  - Deceleration Length
  - Storage Length



LEFT-TURN LANE DESIGN

- Turn Lane Length

Table 1: Auxiliary Turn Lane Length by Turn Type and Intersection Control

Approach Control	Turn Type	Turn Lane length
Uncontrolled	Left-Turn	Greater of Method 1[A] or Method 2[A]
	[redacted]	
Stop Controlled	Left-Turn	Storage + Bay Taper
	[redacted]	
Signal Control[B]	Left-Turn	Greater of Method 1 or Method 2
	[redacted]	

Notes: A: See Table 2 below.
B: At signalized intersections the length of turn lanes should be extended so that it is not blocked by the queue of adjacent through traffic.

LEFT-TURN LANE DESIGN

- Turn Lane Length

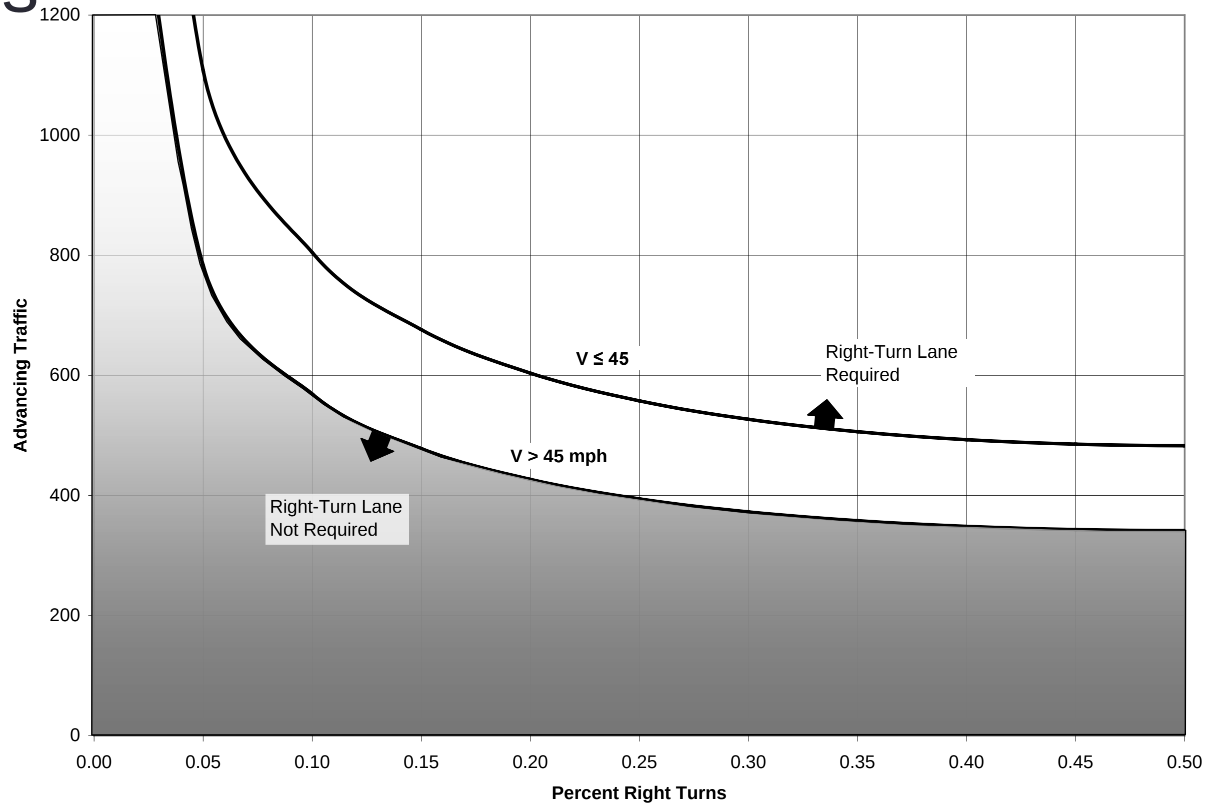
Table 2: Turn Lane Length by Speed

Speed (MPH)	Method 1: Deceleration Only[B]	Method 2: Moderate Deceleration + Storage[B]	Method 3: Full Deceleration + Storage (Rural Arterial ≥45 mph)[B]
20	125 ft	Storage + Bay Taper	N/A
25	125 ft	Storage + Bay Taper	
30	125 ft	Storage +Bay Taper	
35	125 ft	Storage +Bay Taper	
40	170 ft	70 ft + Storage	
45	220 ft	115 ft + Storage	340 ft + Storage
50	275 ft	170 ft + Storage	410 ft + Storage
55	340 ft	220 ft + Storage	485 ft + Storage
60	410 ft	275 ft + Storage	565 ft + Storage
65	485 ft	340 ft + Storage	645 ft + Storage

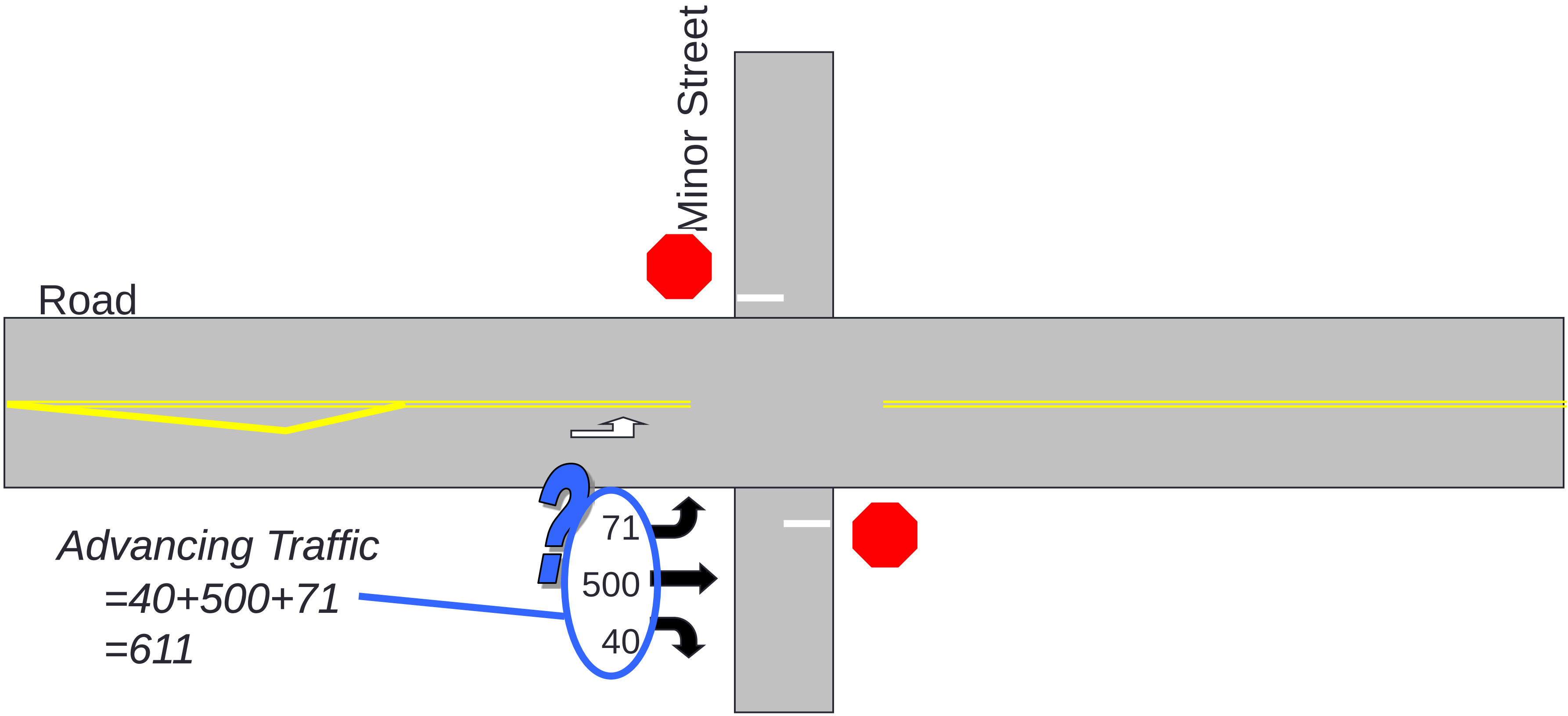
B: At signalized intersections the length of turn lanes should be extended so that it is not blocked by the queue of adjacent through traffic.

RIGHT-TURN LANE WARRANTS

- 1 Graph measures probability of turning vehicle blocking lane
  - ≤ 45 MPH (P = 0.02)
  - >45 MPH (P = 0.01)



RIGHT-TURN LANE WARRANTS



Advancing Traffic

=40+500+71

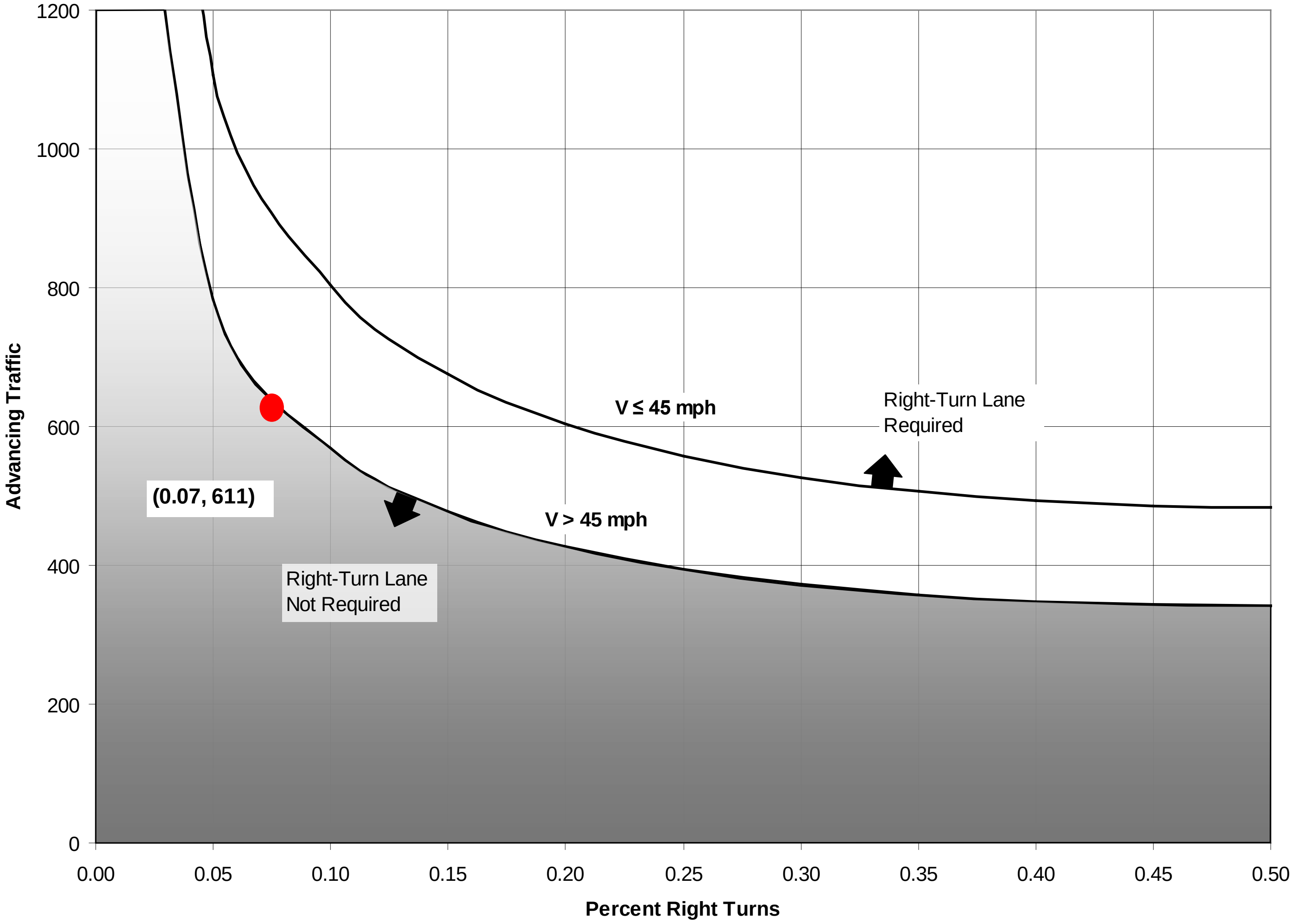
=611

Percent Right Turns

=40 / 611

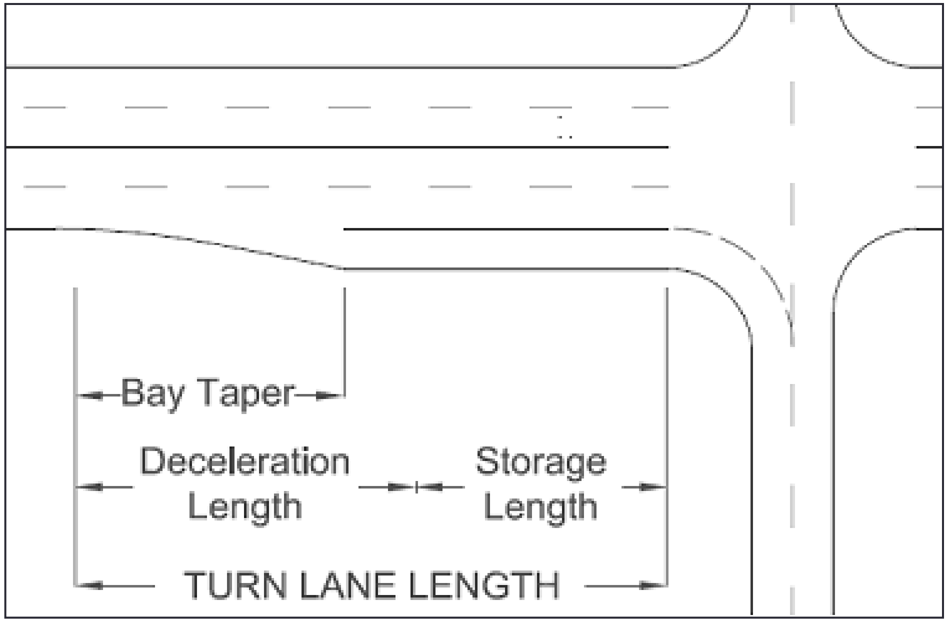
=0.07

RIGHT-TURN LANE WARRANTS



RIGHT-TURN LANE DESIGN

- Turn Lane Length
  - Deceleration Length
  - Storage Length



RIGHT-TURN LANE DESIGN

- Turn Lane Length

Table 1: Auxiliary Turn Lane Length by Turn Type and Intersection Control

Approach Control	Turn Type	Turn Lane length
Uncontrolled	[redacted]	
	Right-Turn	Method 1[A]
Stop Controlled	[redacted]	
	Right-Turn	Storage + Bay taper
Signal Control[B]	[redacted]	
	Right-Turn	Greater of Method 1[A] or Method 2[A]

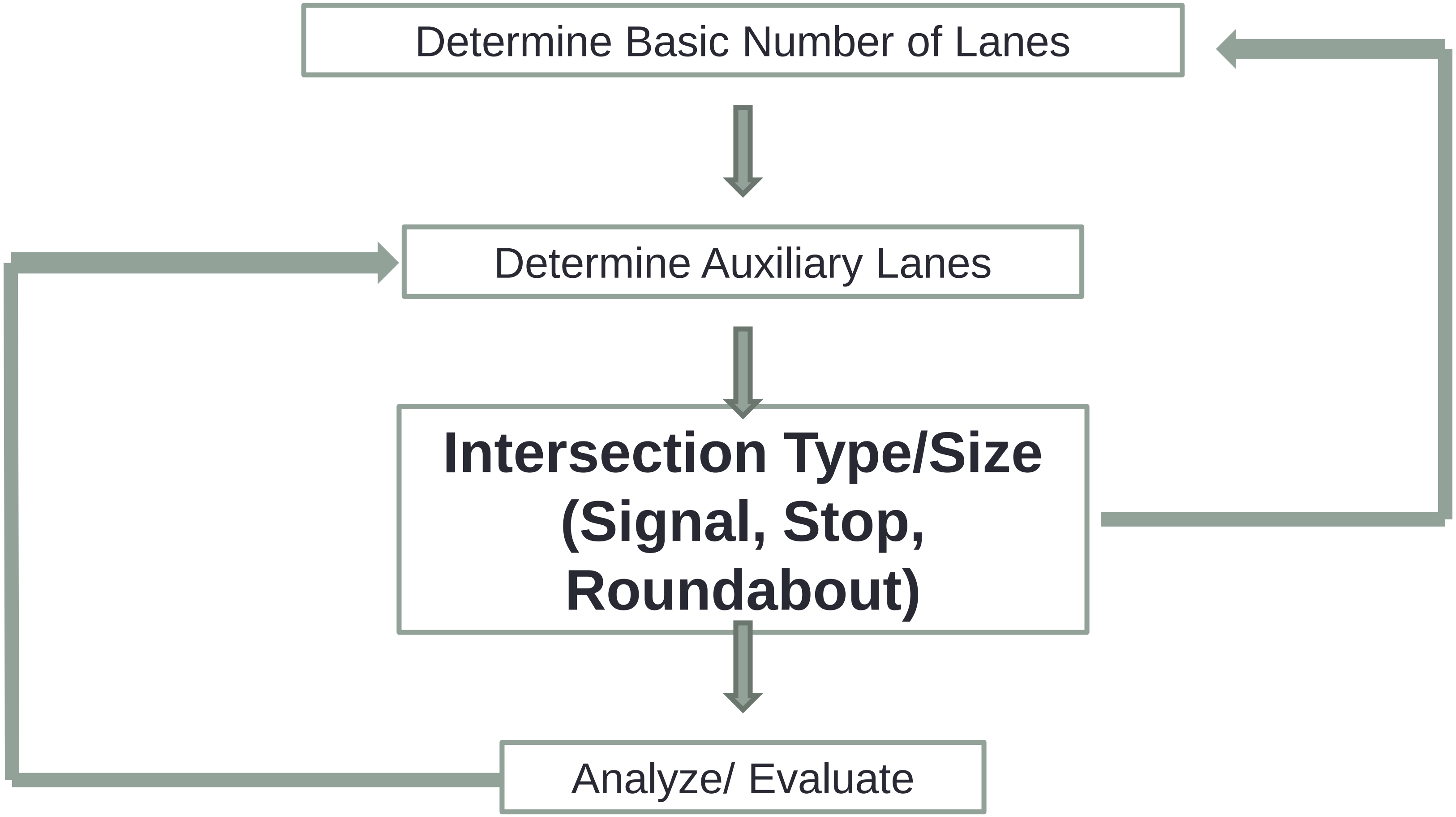
Notes: A: See Table 2 below.
B: At signalized intersections the length of turn lanes should be extended so that it is not blocked by the queue of adjacent through traffic.

Table 2: Turn Lane Length by Speed

Speed (MPH)	Method 1: Deceleration Only	Method 2: Moderate Deceleration + Storage
20	100 ft	Storage + Bay Taper
25	100 ft	Storage + Bay Taper
30	100 ft	Storage +Bay Taper
35	100 ft	Storage +Bay Taper
40	170 ft	70 ft + Storage
45	220 ft	115 ft + Storage
50	275 ft	170 ft + Storage
55	340 ft	220 ft + Storage
60	410 ft	275 ft + Storage
65	485 ft	340 ft + Storage

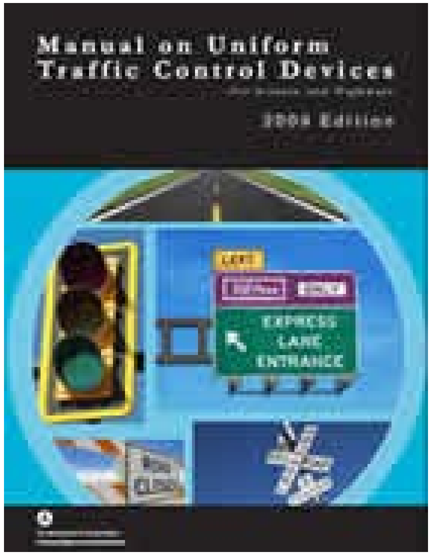
INTERSECTION TYPE & SIZE

Design Process



Determine Intersection Type

- Warrant Analysis – MUTCD
- Alternative Analysis

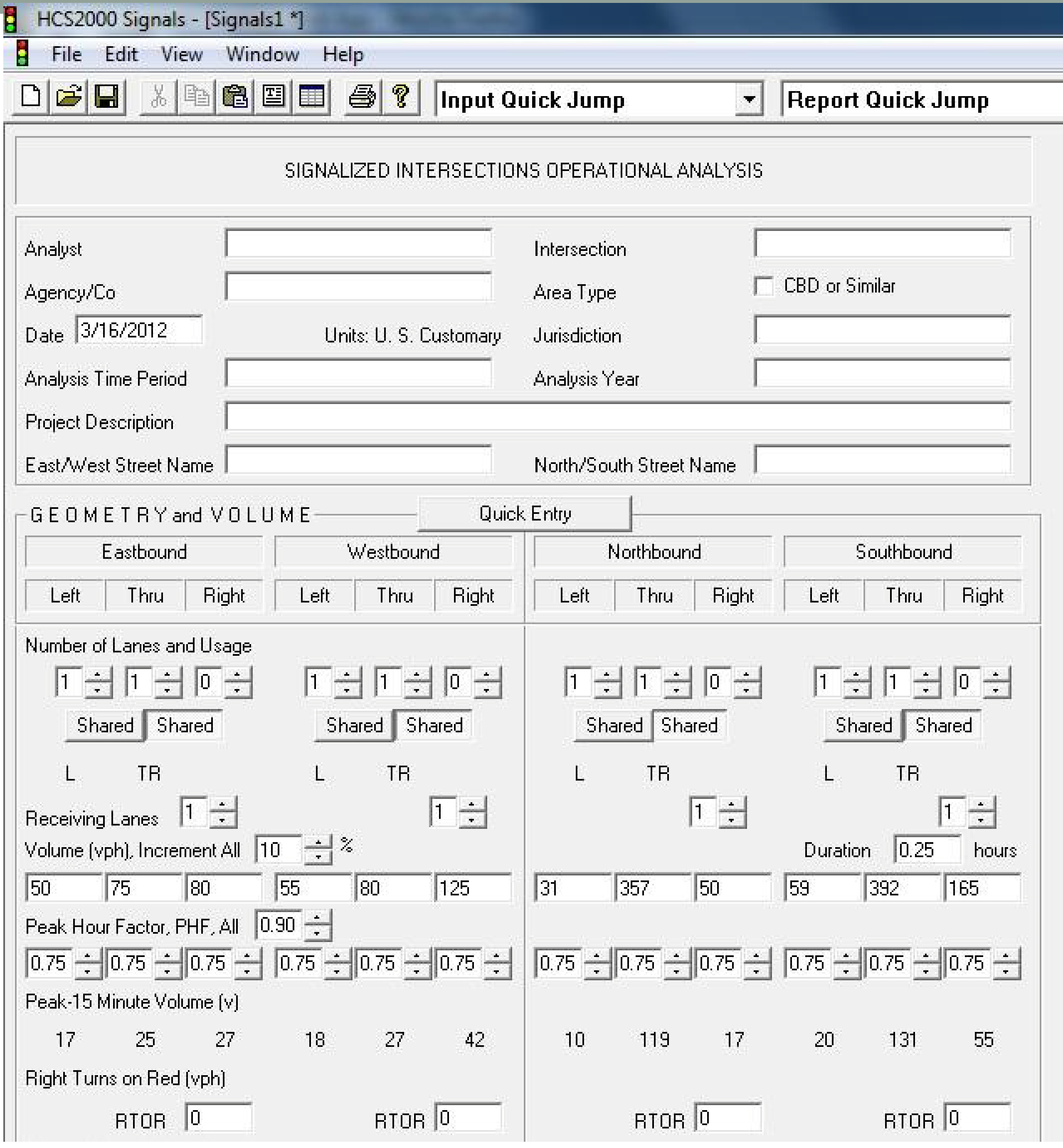


Warrants

- Traffic Signal Control
- 4-Way Stop Control
- Roundabout

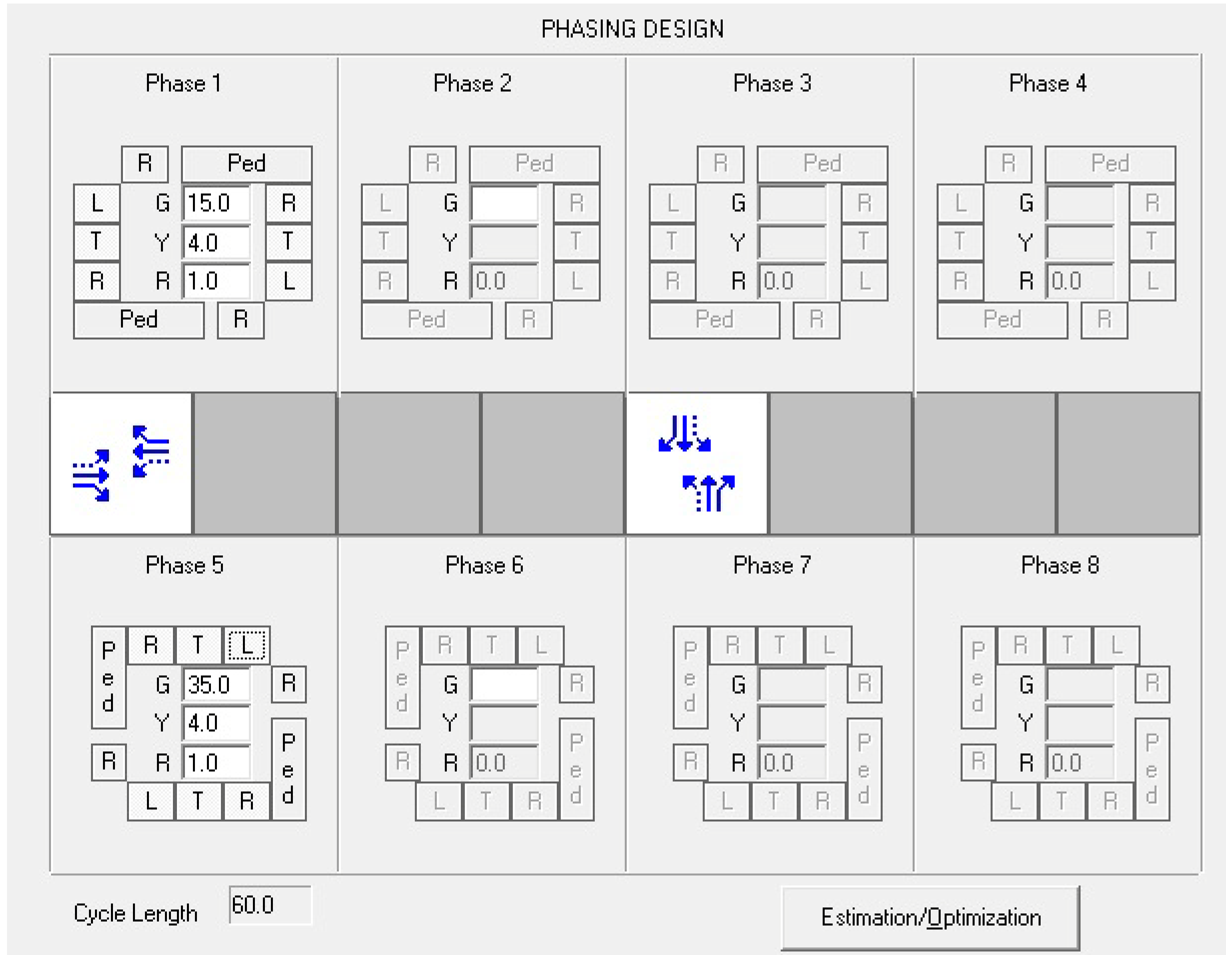
HCS Signals

Input Screen



HCS Signals

Phasing Design



HCS Signals

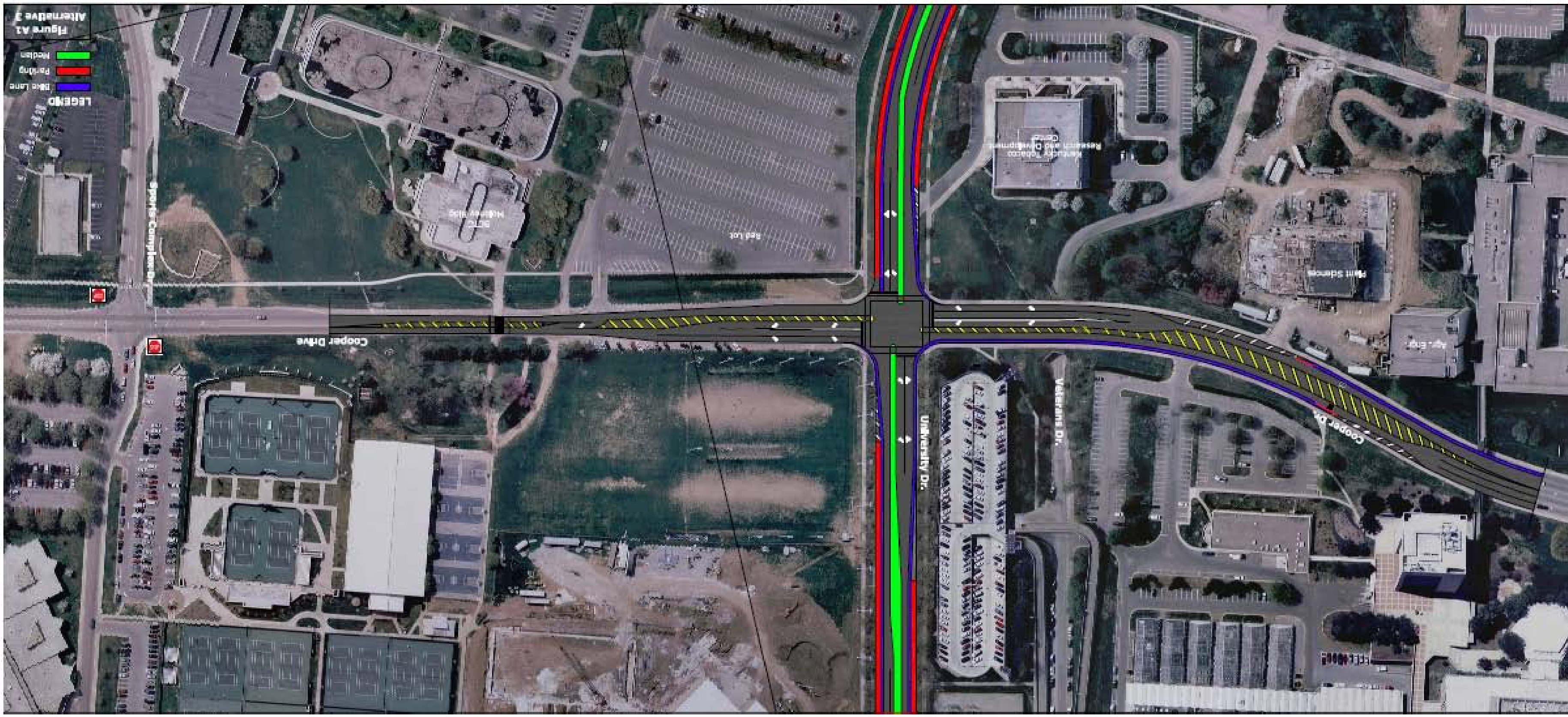
Output

RESULTS

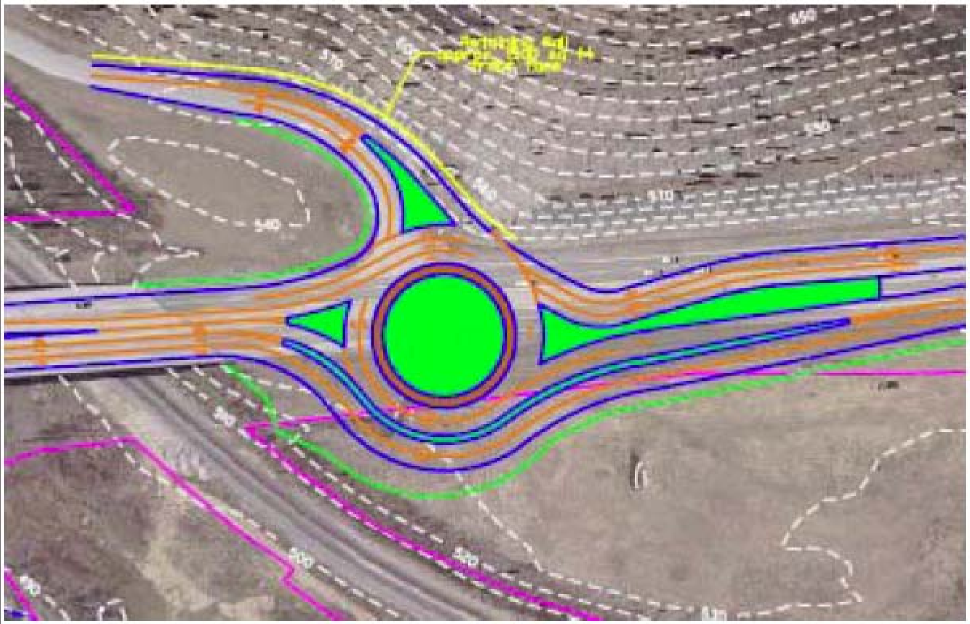
	Eastbound L	Eastbound TR		Westbound L	Westbound TR		Northbound L	Northbound TR		Southbound L	Southbound TR	
Lane Group Adjusted Volume, (vph)	67	207	0	73	274	0	41	543	0	27	743	0
Lane Group Capacity, (vph)	223	438		282	432		272	1088		427	1059	
Lane Group v/c Ratio	0.30	0.47		0.26	0.63		0.15	0.50		0.06	0.70	
Critical Lane Group					#						#	
Lane Group Delay, (sec/veh)	21.7	22.8		20.3	27.0		6.9	9.0		5.7	12.7	
Lane Group Level of Service	C	C		C	C		A	A		A	B	
Final Unmet Demand, (v)	0.0	0.0		0.0	0.0		0.0	0.0		0.0	0.0	
Approach Delay, (sec/veh)		22.5			25.6			8.8			12.5	
Approach Level of Service		C			C			A			B	

Cycle Length 60.0 sec Intersection Delay 15.1 sec/veh Intersection LOS B

Output: Conceptual Layout



Innovative Designs

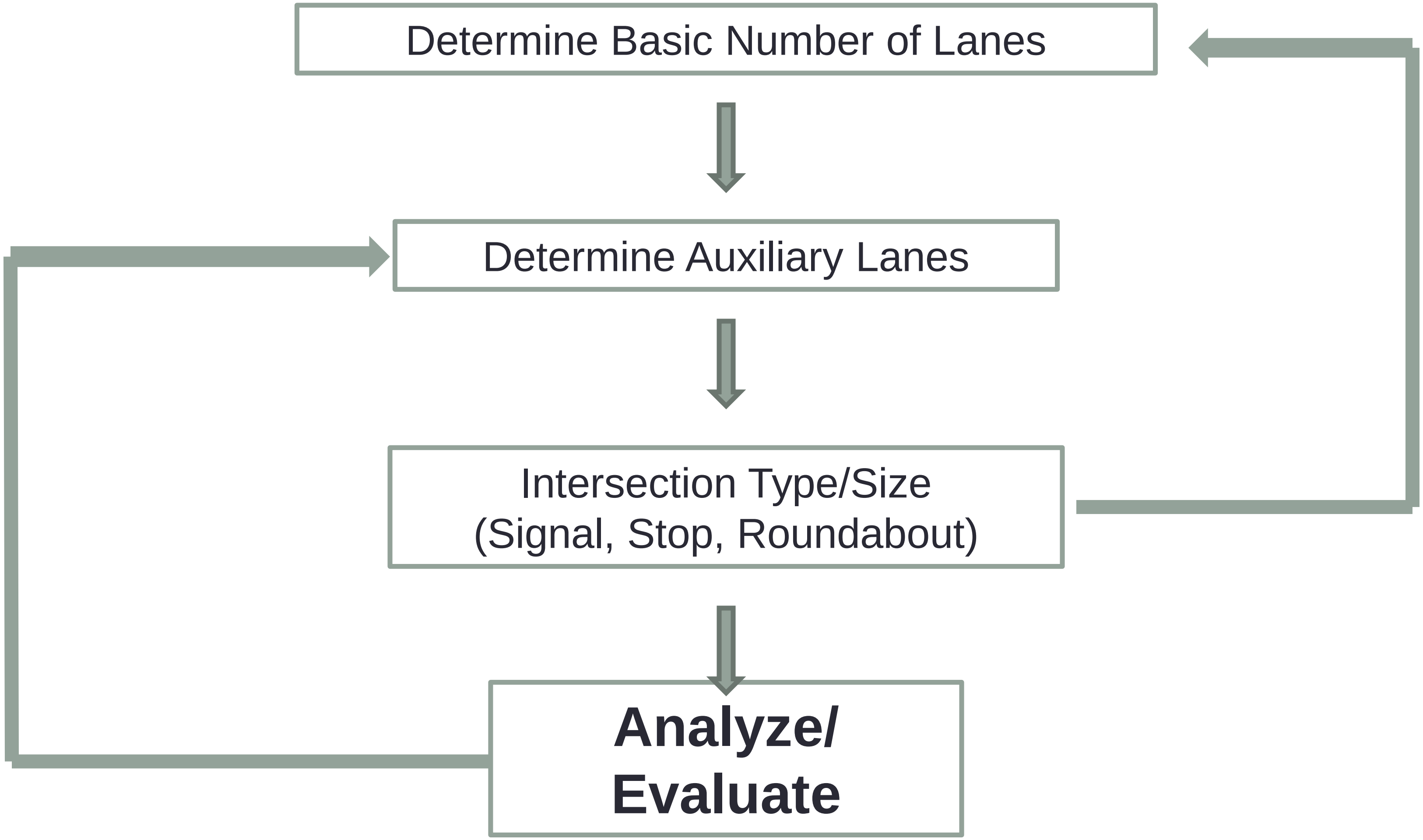


Innovative Designs

- Cost Savings:
  - $4.5M
- LOS B
- Target LOS D/E

ANALYZE / EVALUATE

Design Process



Measures of Effectiveness

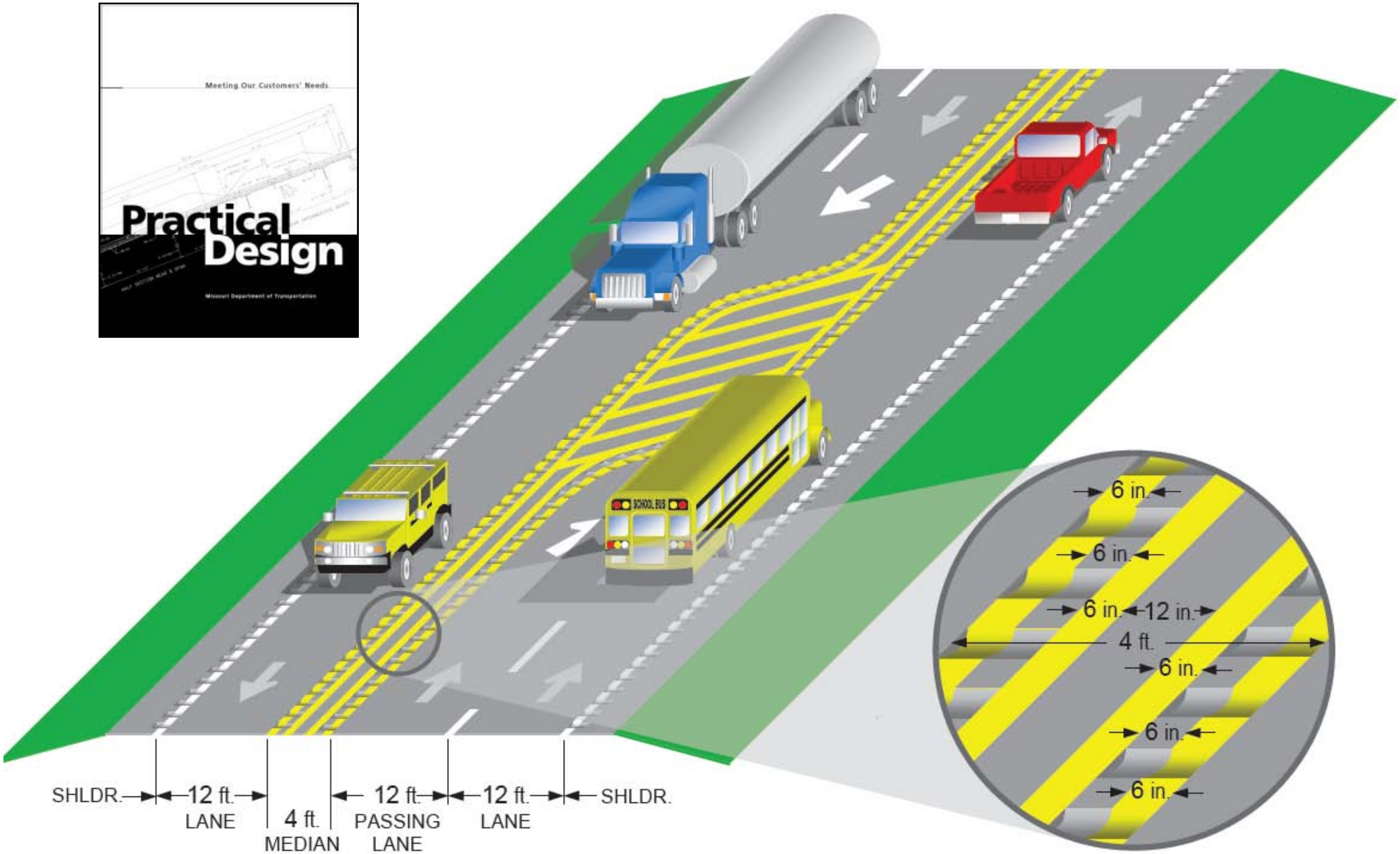
- V/C
- Level of Service (LOS)
- Queuing
- Travel Time
- Delay

Other MOEs. Additional MOEs required by project type, such as interchange justification studies, or defined by the project Purpose and Need Statement, e.g., emissions, queues, etc. for CMAQ projects, may be analyzed, and documented as needed.

Traffic Analysis

- Validates Proposed Design
- Alternative Analysis and Evaluation
- Refine Design
  - Passing Sight Distance
  - Auxiliary Climbing Lanes
  - Additional Turn Lanes
  - Lane Widths/Shoulder Widths

Innovative Approach



Current Design Guidelines

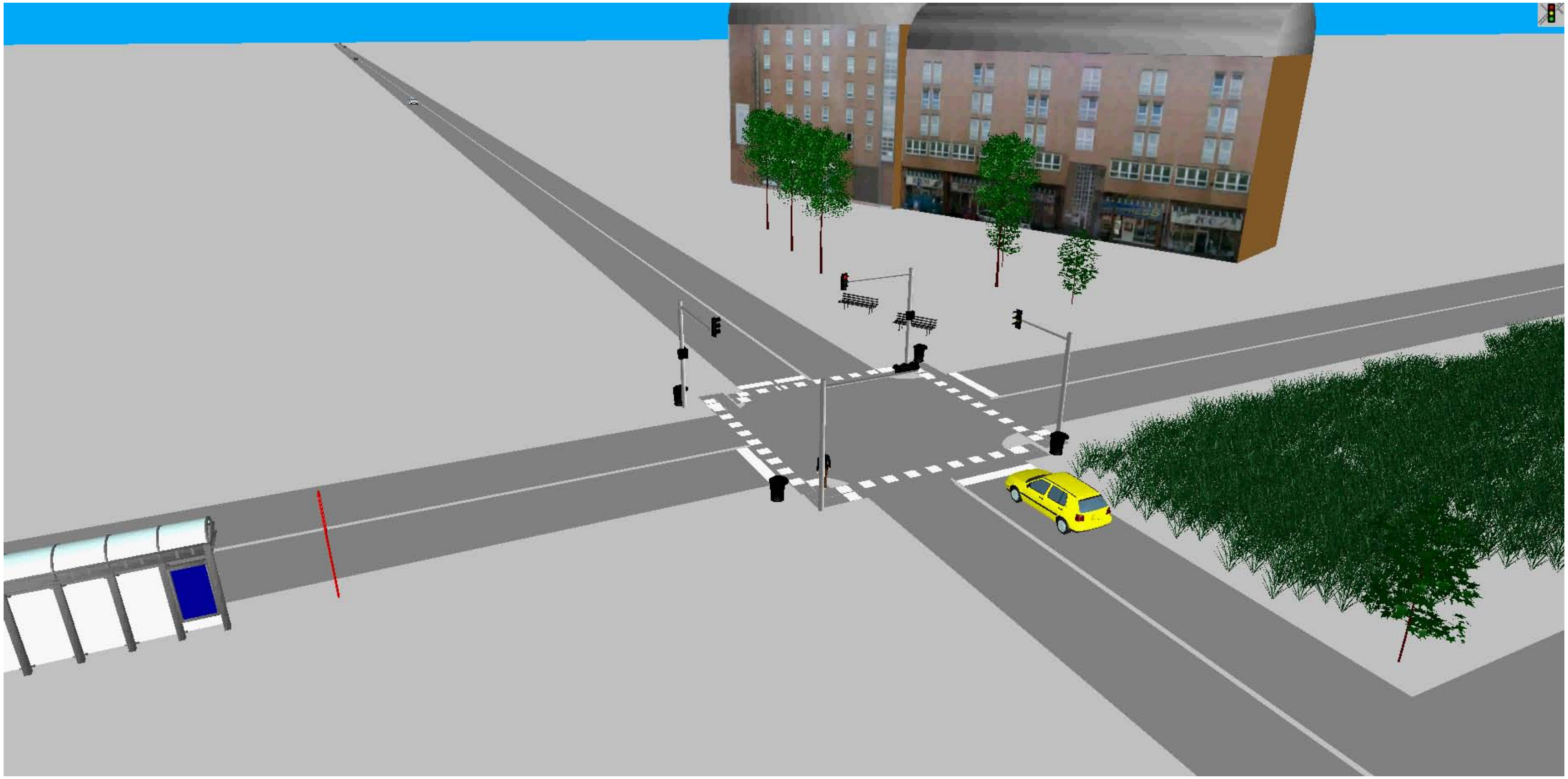
Criteria	Standard
Typical Section	No Cable Barrier. Rumble Strips in 4’ striped median. 4-6ft shoulders, with or without shoulder rumbles
Length of Passing Lanes	0.5 – 1.5 mile spacing (1-2.5km, and 0.8-1.1 mi)
Widen Direction	Symmetrical, Asymmetrical, Non-Continuous
LOS Capacity (C)	Up to 2800pc/hr if one directional 1700pc/hr max.

Traffic Analysis

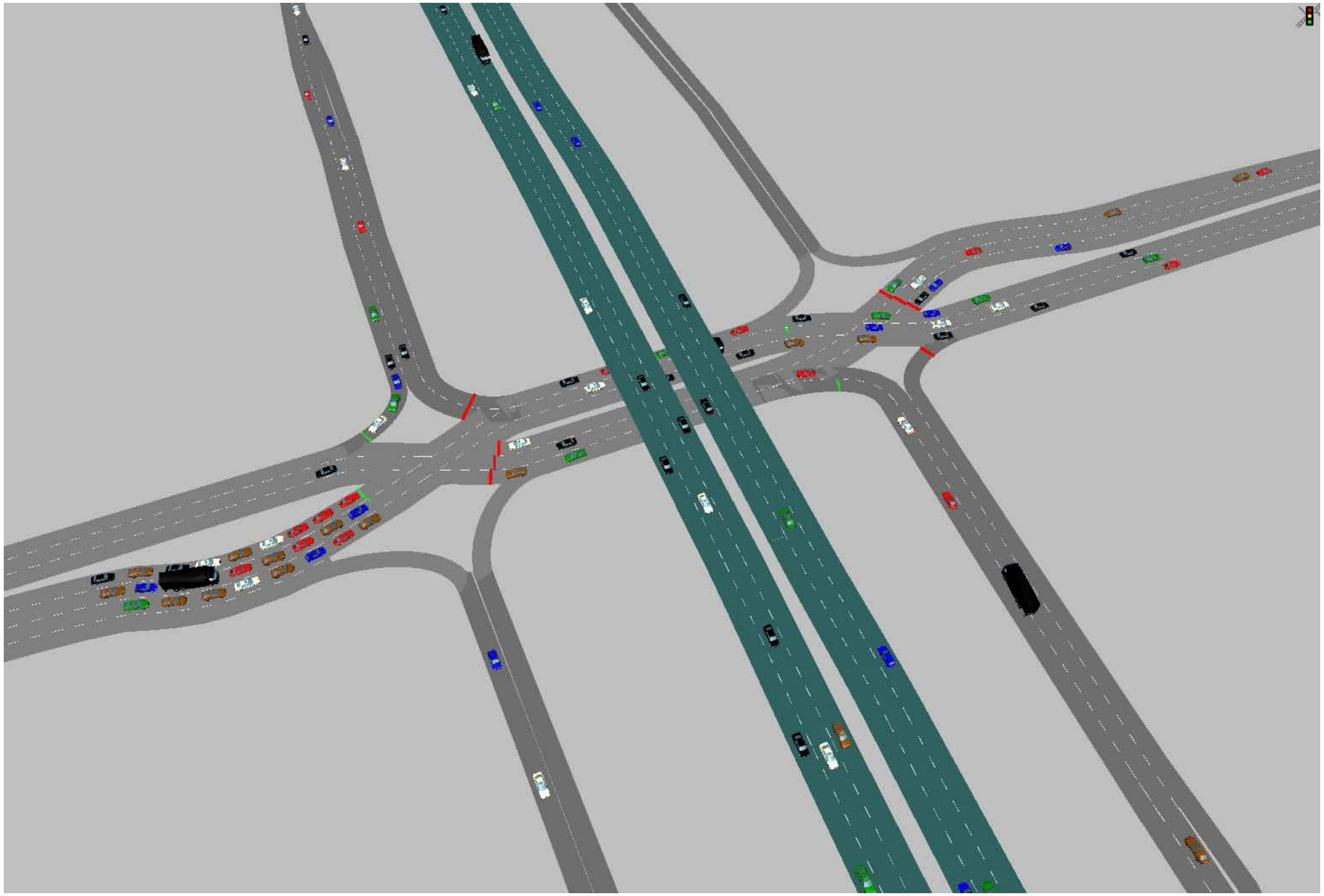
- Highway Capacity Manual/Software (HCM/HCS)

- Microsimulation
  - TSIS/CORSIM
  - VISSIM
  - HCM 2010 Urban Streets??

Micro Simulation



Micro-Simulation



Micro Simulation

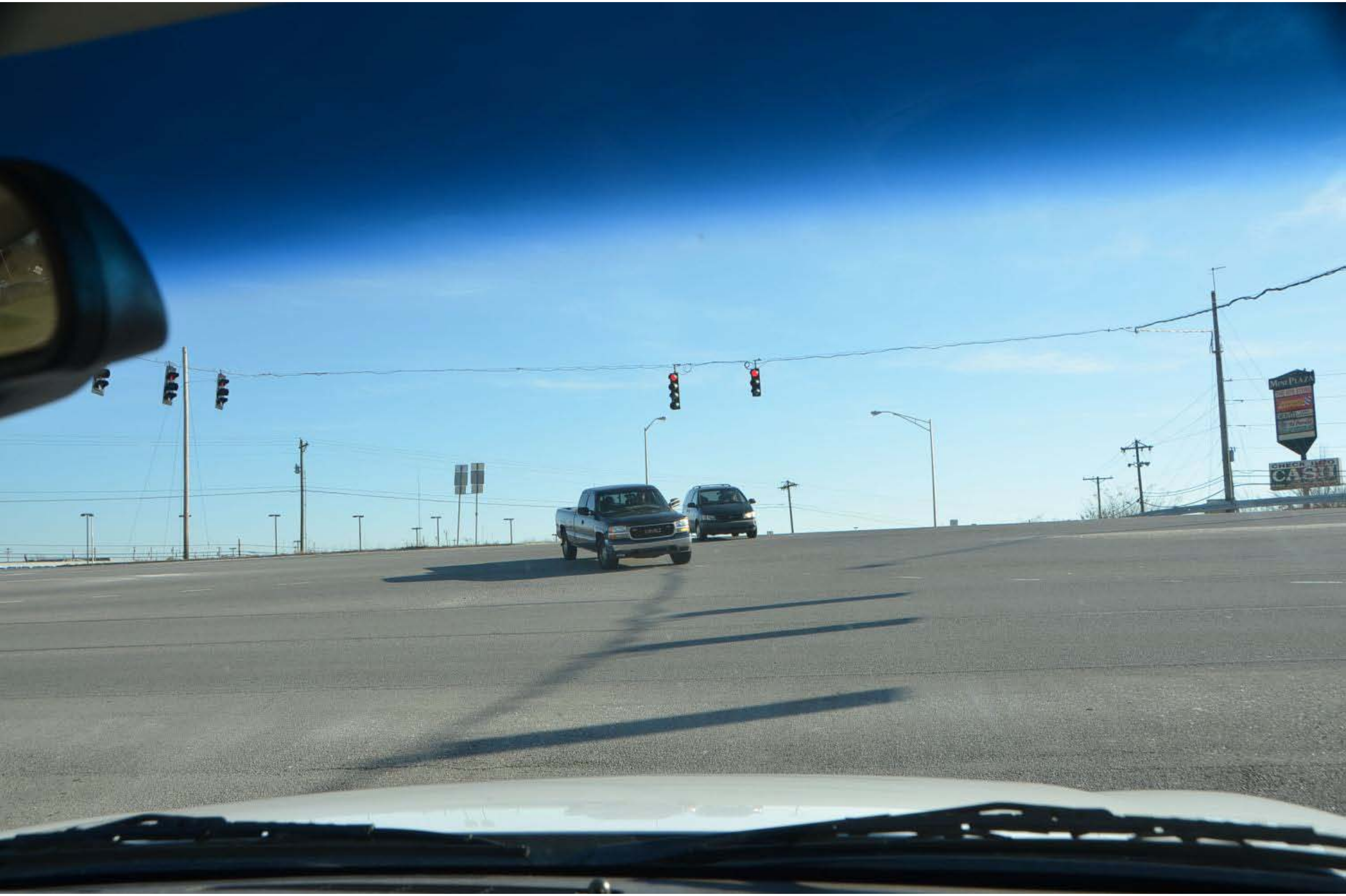
Micro-simulation may be considered on corridors that:

- Operate within coordinated signal systems,
- Have multiple signalized intersections where queuing may impact adjacent intersections,
- Operate interdependently, such as at interchanges, or
- When deemed necessary by the project team for operational or other reasons such as for use in public involvement activities.

DESIGN CONSIDERATIONS

Example 1


245 EXV
27
27



Design Considerations

Critical issues to the proper operation of a facility may be identified and documented in a technical memorandum if deemed necessary by the project team

- Alignment of opposing left turn lanes
- Number of receiving lanes
- Turn restrictions
- Passing sight distance

REVIEW AND APPROVAL

Review and Approval

- Scoping Meeting
  - assumptions
  - description of alternatives
  - modeling limits
  - analysis time periods (AM, PM peak periods)
  - design year
  - calibration factors
  - micro-simulation program

Review and Approval

- Coordination
  - Planning: Traffic Forecast
  - Traffic Operations: Proposed traffic signal or lighting
  - Location Engineers: DES Approval; Other Resources

Documentation

- Documentation
- provide sufficient information to allow a thorough review of the analysis and analytical results,
- document reasoning behind operational assumptions and
- provide enough information to duplicate the results.
- At a minimum this includes:
  - assumptions (input)
  - calibration method and results
  - conceptual layout
  - MOE summary
  - design considerations
  - output
  - electronic input and output files