The National Academies of
SCIENCES • ENGINEERING • MEDICINE

TRANSPORTATION RESEARCH BOARD

Intersection Control Evaluation for Roundabouts and Alternative Intersections

Tuesday, March 20, 2018
2:00-4:00 PM ET

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

Purpose

Discuss how to use Intersection Control Evaluation (ICE) policies and procedures to develop intersection safety and mitigate congestion within roundabouts.

Learning Objectives

At the end of this webinar, you will be able to:

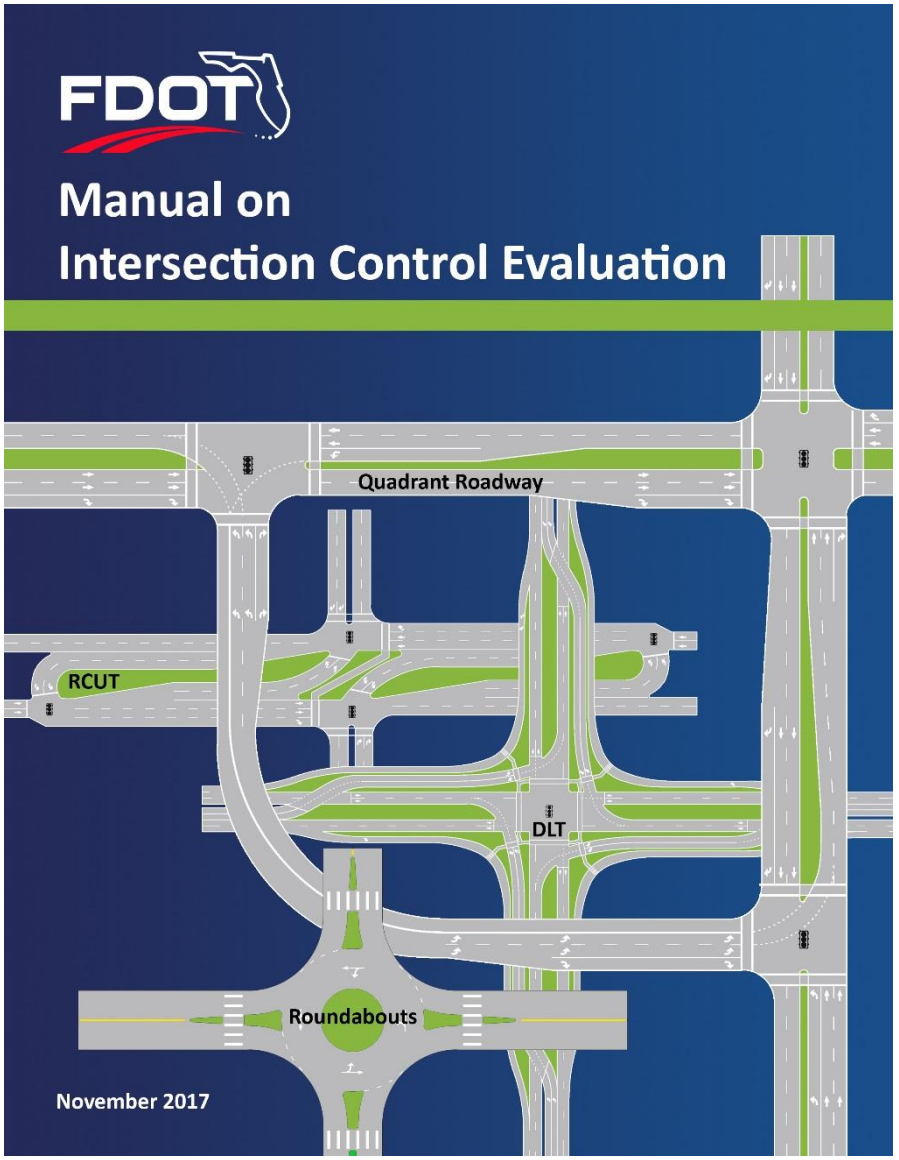
- Understand why the Federal Highway Administration recommends ICE
- Describe the tools available to implement ICE
- Apply ICE implementation from other states to their own agencies

INTERSECTION CONTROL EVALUATION

MARCH 2018

ICE OVERVIEW AGENDA

- Why ICE?
- When ICE is Required?
- Applicability and Process
- Tools and Resources
- Forms



TRAINING OUTCOME GOALS

1. Understand the intent and purpose of ICE procedure

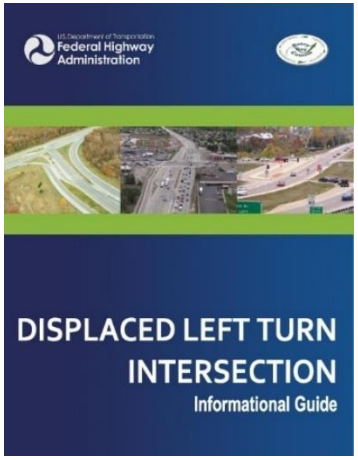
2. Be aware of the readily available resources
   - ICE Forms, CAP-X, SPICE, ICE Tool, Synchro Templates

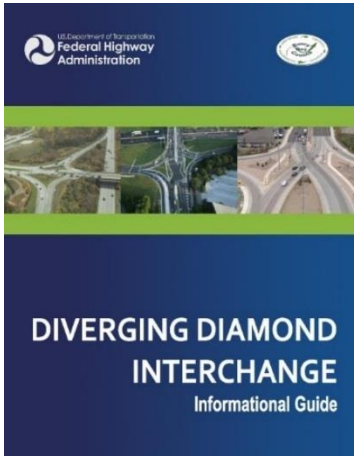
3. Understand the level of effort needed to conduct ICE
   - Data Collection
   - Evaluation
   - Documentation

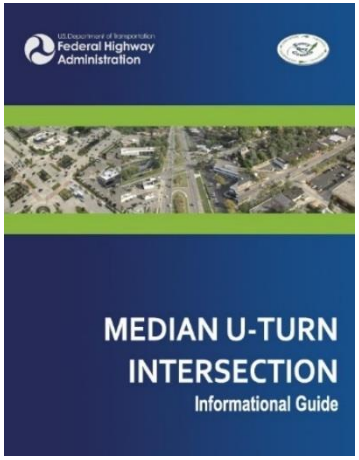
4. Case Study: demonstrate the use of tools

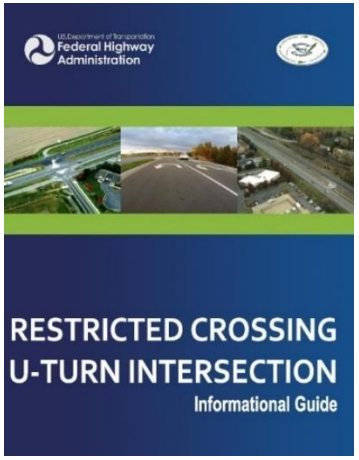
WHY ICE IN FLORIDA?

- Intersection choices have historically been stop control, signalization and recently roundabouts
- Raise awareness and increase use of alternative intersections
- Consider context classifications, safety, and all road users
  - Support SHSP by addressing one of the 13 emphasis areas: Intersection Safety
- Quantitative analysis to select intersection control types
- FDOT Developed ICE Manual and Tools
  - ICE Manual released Nov. 1, 2017
  - Spreadsheet tools developed to support safety, operations and benefit-cost analyses

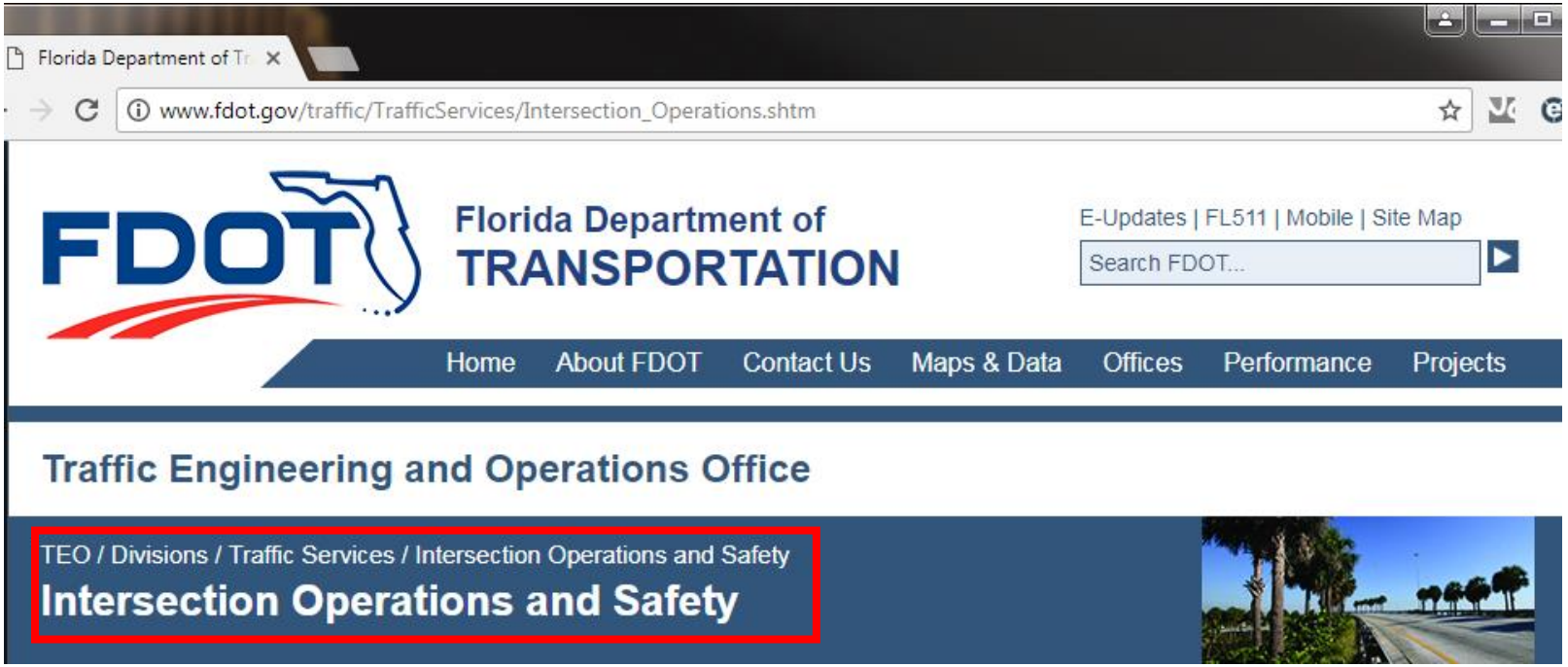








AVAILABLE RESOURCES

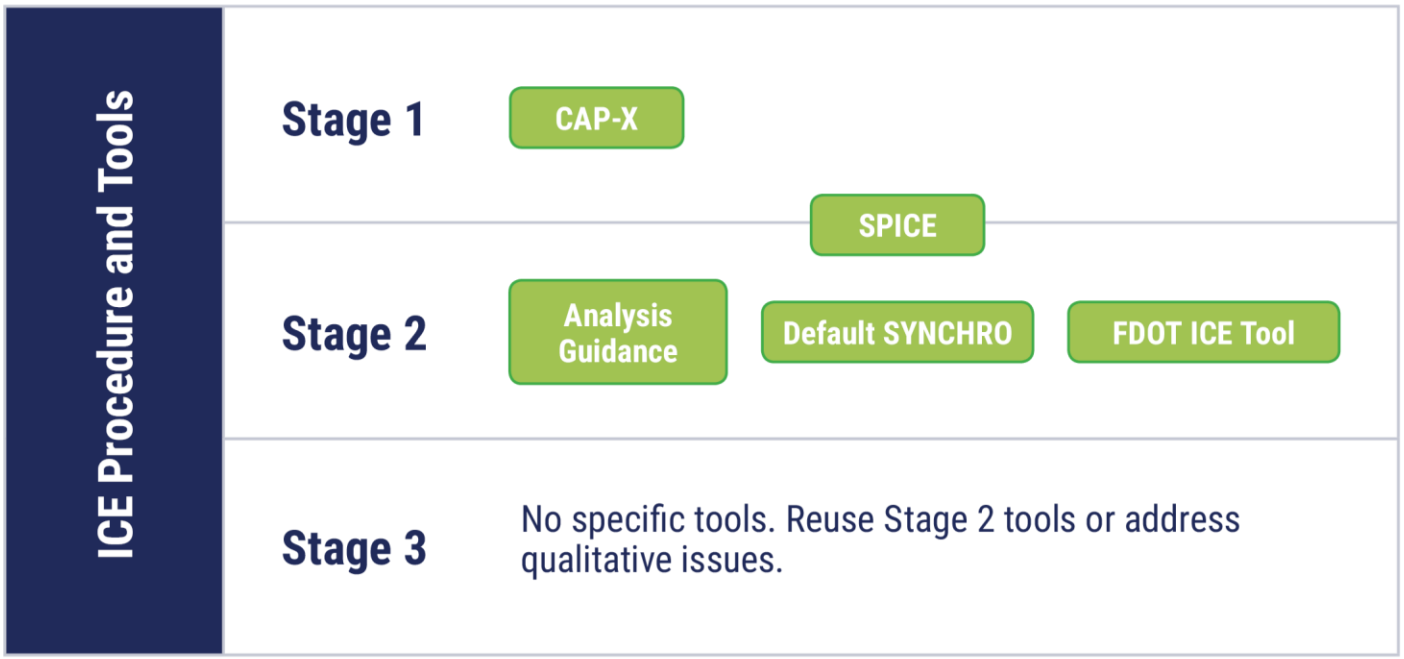


http://www.fdot.gov/traffic/TrafficServices/Intersection_Operations.shtm

ICE PURPOSE

- Consistently consider multiple context-sensitive control strategies when planning a new or modified intersection through…
  - Informed decision-making considering
    - purpose and need, context classification, safe travel facilities for all road users, with the overall best value
  - Select a context-sensitive control strategy considering
    - the goals and needs of the community and all road users
  - Measure the control strategy's value using
    - performance-based criteria
- Promotes thoughtful consideration of alternative intersection types through quantitative analysis

STAGES OF ICE



Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Figure 1; Page 7

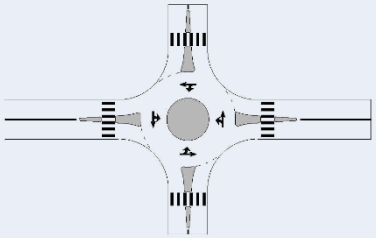
STAGES OF ICE

Is there one viable control strategy or more than one?

If only one control strategy, Stages 2 and 3 are not necessary

Intent - Don't make ICE a burden if the choice is straightforward

- **Procedure includes:**
  - Appendix A with information on intersection forms
  - List of references and tools (*Specifics covered later today*)
  - Recommended Analysis Tools

Intersection Control Type			Mode Accommodations			Reference Material	Recommended Analysis Tool
Intersection Name	Illustration	Description	Vehicles	Pedestrians	Bicycles		
Roundabout							

GUIDANCE FOR ICE EVALUATION – APPENDIX A

	Mode Accommodations		
Description	**Vehicles**	**Pedestrians**	**Bicycles**
A subset of traffic circles that feature yield control of all entering vehicles, channelized approaches, and horizontal curvature and roadway elements to induce desirable vehicle speeds. Advantages: Usually reduced crashes and delay compared to signalized control Disadvantages: Usually higher cost and require more right-of-way than signalized control	Vehicles approaching the intersection must yield to vehicles circulating within the circulatory roadway.	Pedestrian crossings are located only across the legs of the roundabout, typically separated from the circulatory roadway by at least one vehicle length.	Bicyclists may ride in the roadway with vehicles or transition to multi-use paths via bicycle ramps (if present). Bike lanes should not be used at roundabouts

GUIDANCE FOR ICE EVALUATION – APPENDIX B

- Appendix B provides information details to be provided in ICE Forms
- Forms have to be approved by District Traffic Operations Engineer (DTOE) and District Design Engineer (DDE)
- One form available for each Stage
  - Excel Spreadsheet Format
    - Yellow cells provide a dropdown menu
    - White cells require manual input regarding project specific information
    - Auto-populates project information and control strategies to Stage 2 and Stage 3

Florida Department of Transportation

Intersection Control Evaluation (ICE) Form

Stage I: Screening

To fulfill the requirements of Stage 1 (Screening) of FDOT's ICE procedures, complete the following form and append all supporting documentation. Completed forms can be submitted to the District Traffic Operations Engineer (DTOE) and District Design Engineer (DDE) for the project's approval.

Project Information					
Project Name		FDOT Context Classification		FDOT Project #	
Submitted By		Agency/Company		Email	
Project Purpose (*What is the catalyst for this project and why is being undertaken?*)					
Project Setting Description (*Describe the area surrounding the intersection*)					
County		Project Locality (City/Town/Village)			
FDOT District		Project Type (select most appropriate)			
Multimodal Context					

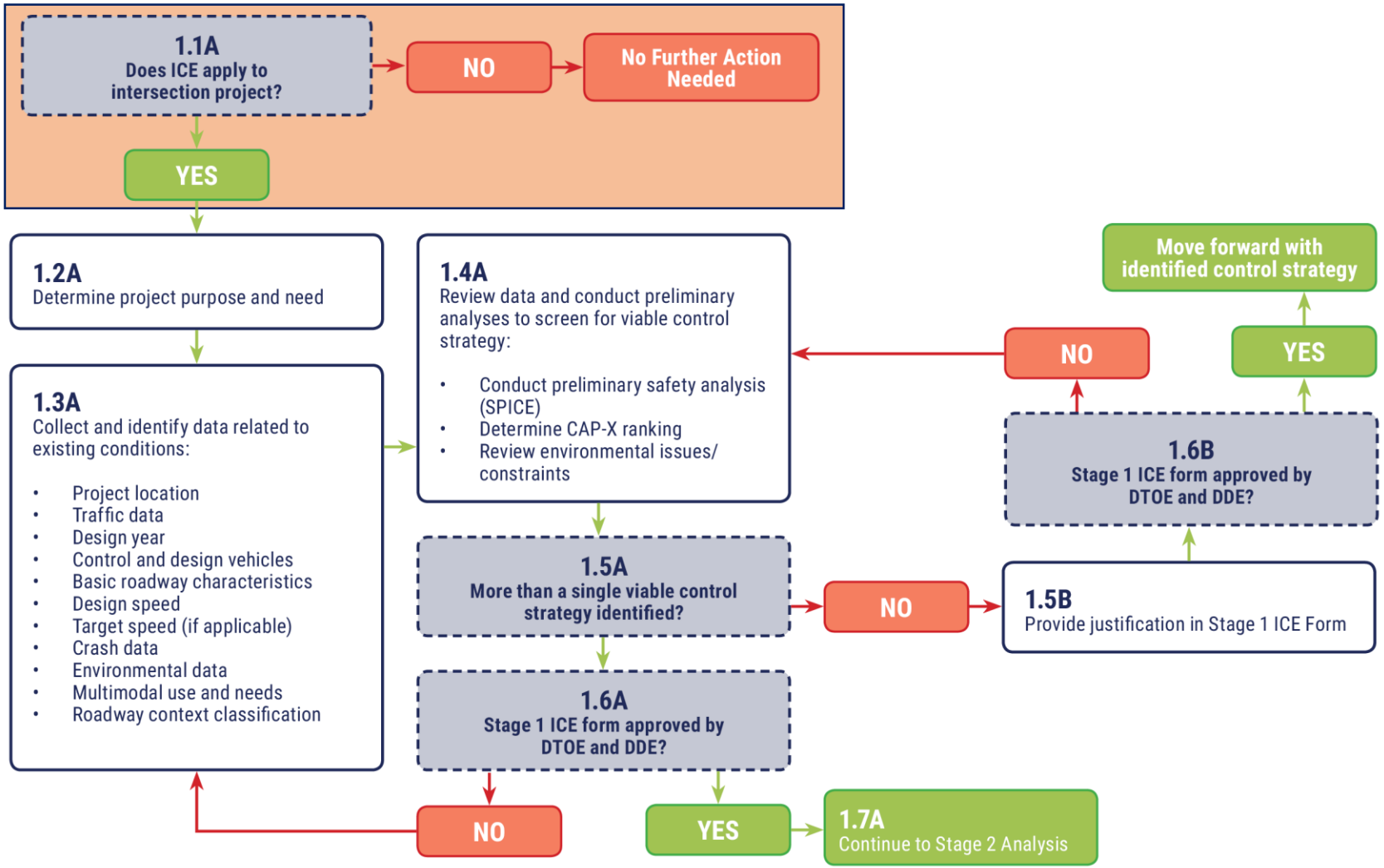
FDOT ICE IMPLEMENTATION PLAN

- 2018: Training and Acclimation
  - Implementation Focus: District Training
    - Two intersections per district
- 2019: Districts Identify & Conduct ICE Analysis for Additional Locations
  - Implementation Focus: Refine ICE Process
    - Evaluate minimum of three projects in these offices/focus areas
      - PD&E
      - Traffic Operations
      - Access Management/Permitting
- 2020: Full ICE Procedure Implementation by Districts
  - Implementation Focus: Mainstream ICE Process
    - ICE Manual Procedures fully effective January 1, 2020
    - Quality Assistance Reviews (QAR) starting in Year 4

PROCESS WALKTHROUGH

STAGE 1

ICE STAGE 1 PROCESS



Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Figure 2; Page 10

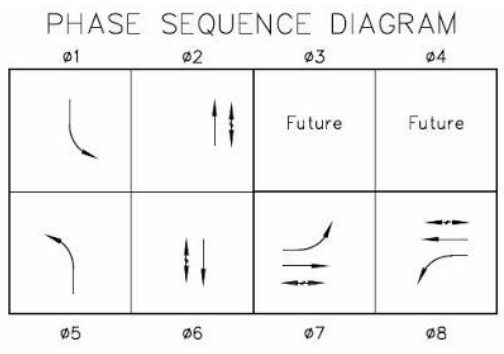
ICE is REQUIRED when

- New signalization is proposed
- Major reconstruction of existing signalized intersection is proposed
  - Adding exclusive left turns, adding intersection legs
- Conversion of a directional or bi-directional median opening to a full median opening is proposed
- Driveway/Connection permit applications for Category E, F, G
- District Design Engineer (DDE) and District Traffic Operations Engineer (DTOE) consider an ICE a good fit for the project

Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Section 2.3; Page 5

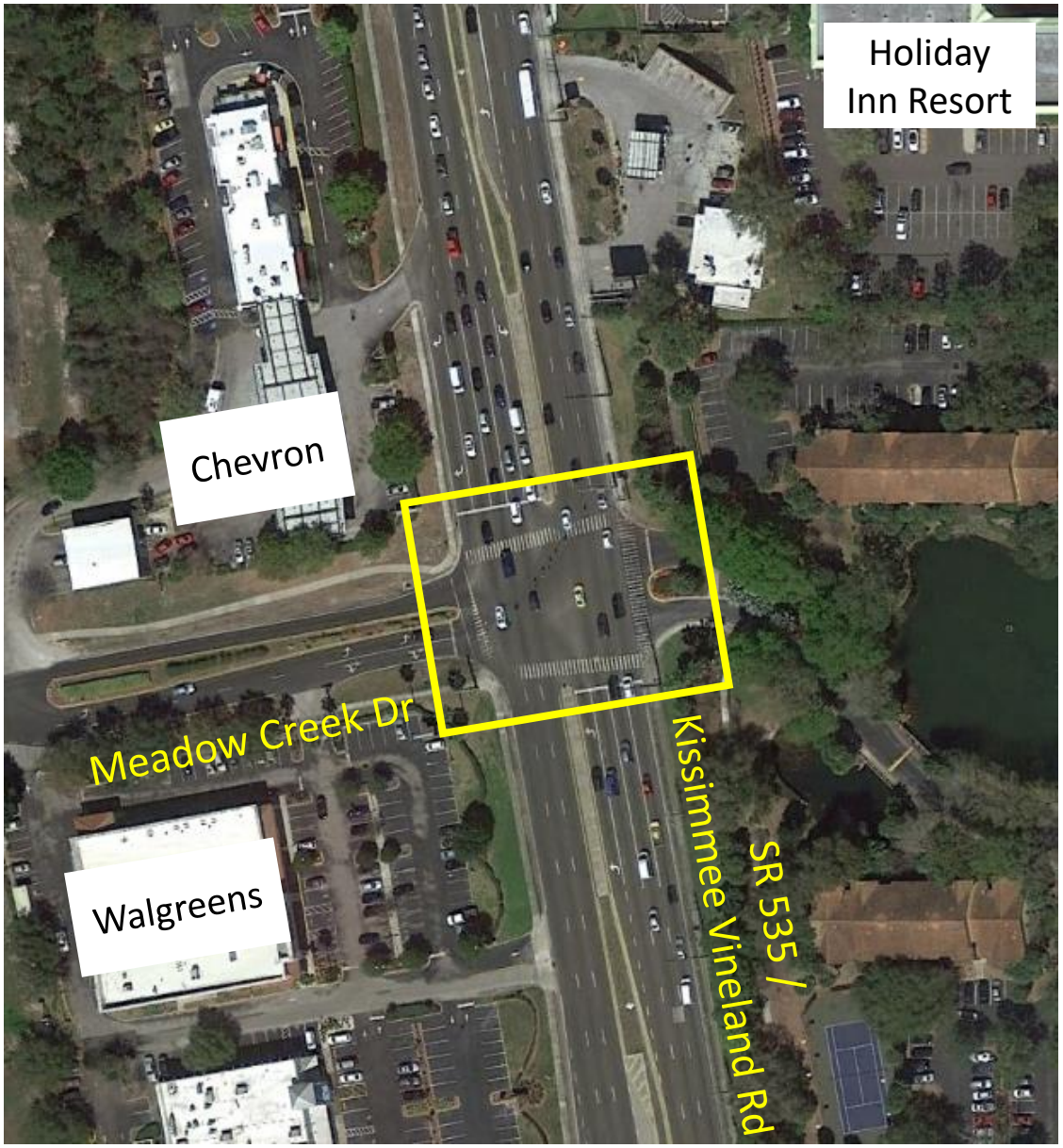
ICE NOT REQUIRED

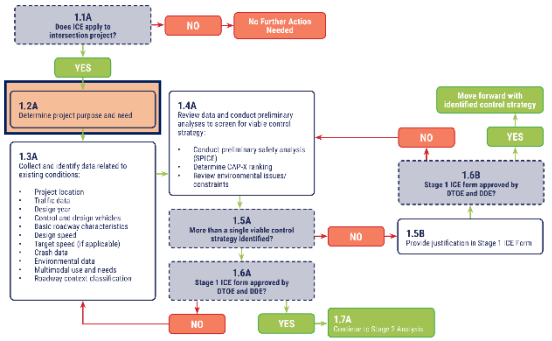
- Work does not include substantive proposed changes to intersection
  - Mill and resurface pavement; changing full median opening to directional median opening
- Minor intersection operational improvements
  - Adding right turn lane or signal phasing changes or equipment upgrades
- Encouraged for local roadways, not required
- Recommended for ramp terminal intersections (stop control, signalized, or yield), not required



Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Section 2.3; Page 5

1.2 A – PROJECT PURPOSE AND NEED

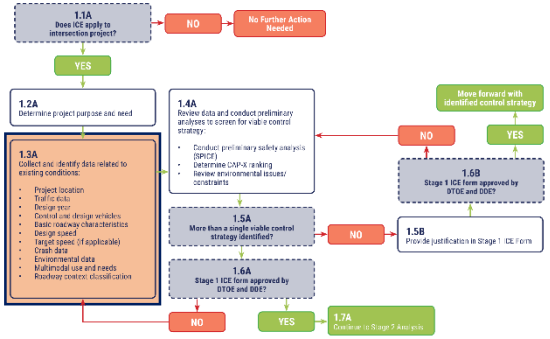




- Increasing throughput capacity along SR 535
- Pedestrian crossing safety
  - 1 marked pedestrian crossing for over a mile south of the I-4 interchange
  - Look for signalized crossing opportunities

1.3 A – DATA COLLECTION FOR EXISTING CONDITIONS

- Analysis Years
  - 2016 – Existing
  - 2020 – Build
  - 2040 – Design
- TMC & AADTs
  - 2015 AM/PM
  - 2020
  - 2040



- Intersection Configuration
- Truck Percentages
- Roadway Context Class
- Design Vehicle
- Posted speeds

Intersection Control Evaluation Form 750-010-003

Florida Department of Transportation
Intersection Control Evaluation (ICE) Form
Stage I: Screening

To fulfill the requirements of Stage 1 (Screening) of FDOT's ICE procedures, complete the following form and append all supporting documentation. Completed forms can be submitted to the District Traffic Operations Engineer (DTOE) and District Design Engineer (DDE) for the project's approval.

Project Information					
Project Name	SR 535 at Meadow Creek Drive	FDOT Context Classification	C3C - Suburban Commercial	FDOT Project #	
Submitted By	KAI	Agency/Company	FDOT Central Office	Email	
Project Purpose (*What is the catalyst for this project and why is being undertaken?*)	The intersection of SR 535 and Meadow Creek Drive is currently a signalized intersection. The area is expected to experience an increase in throughput capacity along SR 535. Pedestrian crossing safety is one of the driving components to find alternative intersections as there is only 1 marked crossing for over a mile south of the I-4 interchange. The evaluation and implementation of alternative intersections at this intersection can help provide more signalized crossing opportunities.				
Project Setting Description (*Describe the area surrounding the intersection*)	SR 535 is classided as an urban minor arterial, 4-lane facility. The immediate land uses surrounding the intersection comprise mostly commercial use.				
County	Orange	Project Locality (City/Town/Village)	Unincorporated Orange County		
FDOT District	District 5	Project Type (select most appropriate)	Multimodal Improvement		
Multimodal Context (*Describe pedestrian, bicycle, and transit activity in the area and the potential for activity based on surrounding land uses and development pattern*)	5' sidewalks are provided on all four legs of the intersection and high emphasis crosswalks are provided an all intersection legs at Meadow Creek Dr. No bicycle lanes are provided, there are 2' curb and gutter on the inner and outside shoulders of SR 535.				

Basic Intersection Information											
Major Street											
Major Street Route Number(s)	SR 535	Major Street Route Name(s)	Kissimmee Vineland Road			Milepost	1.903	Existing AADT	49,700		
Design Year AADT	70,000	Existing Control Type	Signalized	Design Vehicle	Interstate Semitrailer (WB-62)	Control Vehicle	Interstate Semitrailer (WB-62)				
Primary Functional Classification	Minor Arterial	Secondary Functional Class. (if app.)				Design Speed (mph)	50	Target Speed (mph) [if app.]			
Major Street Ownership	FDOT			Sidewalks are present along:		Neither side of the roadway					
Crosswalks? ☑	On-Street Bike Facilities? ☐	Multi-Use Path? ☐		Scheduled Bus Service? ☐		Bus stop at intersection? ☐					
Approach #1 (NB)	Number of Lanes (Count Shared Lanes as Through):	Left-Turn	1	Through	3	Right-Turn	0	Daily Truck %	2.5		
	AM Peak Hour Traffic Volumes:	Left-Turn	41	Through	1710	Right-Turn	6				
	PM Peak Hour Traffic Volumes:	Left-Turn	67	Through	1487	Right-Turn	17				
Approach #2 (SB)	Number of Lanes (Count Shared Lanes as Through):	Left-Turn	1	Through	3	Right-Turn	1	Daily Truck %	3.5		
	AM Peak Hour Traffic Volumes:	Left-Turn	39	Through	1118	Right-Turn	63				
	PM Peak Hour Traffic Volumes:	Left-Turn	101	Through	1647	Right-Turn	154				

1.5 B – FDOT ICE FORMS – STAGE 1

Minor Street	Existing ☑		New ☐							
Minor Street Route Number(s)		Minor Street Route Name(s)		Meadow Creek Drive		Milepost (if app.)		Existing AADT (if		
Design Year AADT	5,000	Existing Control Type	Signalized	Design Vehicle	School Bus (S-BUS-36)	Control Vehicle	School Bus (S-BUS-36)			
Primary Functional Classification	Local Road	Secondary Functional Class. (if app.)				Design Speed (mph)	35	Target Speed (mph) [if app.]		
Minor Street Ownership	Local			Sidewalks are present along:		Neither side of the roadway				
Crosswalks? ☑	On-Street Bike Facilities? ☐		Multi-Use Path? ☐		Scheduled Bus Service? ☐		Bus stop at intersection? ☐			

Approach #1 (EB)	Number of Lanes (Count Shared Lanes as Through):	Left-Turn	1	Through	1	Right-Turn	0	Daily Truck %	9
	AM Peak Hour Traffic Volumes:	Left-Turn	113	Through	2	Right-Turn	43		
	PM Peak Hour Traffic Volumes:	Left-Turn	212	Through	13	Right-Turn	73		
Approach #2 (WB)	Number of Lanes (Count Shared Lanes as Through):	Left-Turn	0	Through	1	Right-Turn	0	Daily Truck %	0
	AM Peak Hour Traffic Volumes:	Left-Turn	21	Through	2	Right-Turn	58		
	PM Peak Hour Traffic Volumes:	Left-Turn	22	Through	3	Right-Turn	39		
Approach #3	Number of Lanes (Count Shared Lanes as Through):	Left-Turn		Through		Right-Turn		Daily Truck %	
	AM Peak Hour Traffic Volumes:	Left-Turn		Through		Right-Turn			
	PM Peak Hour Traffic Volumes:	Left-Turn		Through		Right-Turn			

Crash History (Existing Intersections Only)

Append the most recent five-years of crash data for the intersection from the CAR System. If the crash data evidences any issues relating to safety performance, discuss briefly here:

The most recent five years of crash data on record (2011-2015) was collected for the study intersection. Over the five-year history, 228 total crashes were reported with two involving a fatality and 56 resulting in injury. The two fatalities were bicycle and pedestrian related crashes. The two fatalities occurred at night (11 PM -12 AM).

33 of the injury crashes were rear-end, and 6 were angle or "other" crashes. Rear-end is the most common crash type and sideswipe and "other" are next with 19 crashes each. Right-turn and angle were next with 14 and 12 crashes, respectively.

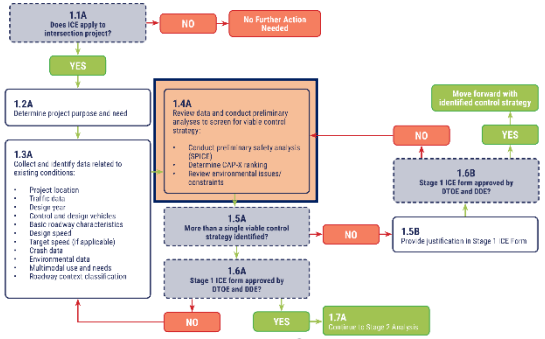
1.5 B – FDOT ICE FORMS – STAGE 1

Screening Evaluation

Provide a brief justification as to why each of the following control strategies should be advanced or not. Justification should consider potential environmental impa

Control Strategy	CAP-X Outputs			SPICE Ranking	Strategy to be Advanced ?	
	V/C Ratio		Multimodal Score			
	Select time periods analyzed in CAP-X:					
	Weekday AM Peak	Weekday PM Peak				
Two-way Stop-Controlled						
All-way Stop-Controlled						
Signalized Control						
Roundabout						
Median U-Turn						
Restricted Crossing U-Turn (RCUT) Signalized						
Restricted Crossing U-Turn (RCUT) Unsignalized						
Jughandle						
Displaced Left-Turn						
Continuous Green Tee						
Quadrant Roadway						

1.4 A – CONDUCT CAP-X



ICE Procedure and Tools

Stage 1	CAP-X			
Stage 2	SPICE	Analysis Guidance	Default SYNCHRO	FDOT ICE Tool
Stage 3	No specific tools. Reuse Stage 2 tools or address qualitative issues.			

TOOLS

CAP-X

1.4 A – VISION AND NEED FOR THE CAP-X TOOL

- Capacity Analysis for Planning of Junctions (CAP-X)
- FHWA tool for planning-level capacity assessment
- Stage 1 tool for Intersection Control Evaluation
- Initial operational screening of intersection control alternatives
  - Can be used during project's scoping stage
- Simple tool for efficient comparisons
  - User-friendly
  - Only requires readily available inputs
- FDOT updates
  - Incorporation of multimodal considerations
  - Improved input sheets and output comparisons
  - Updated inputs to reflect FDOT default values
  - HCM 6th Edition roundabout capacity analysis
  - Added stop controlled intersections
  - Additional intersection alternatives

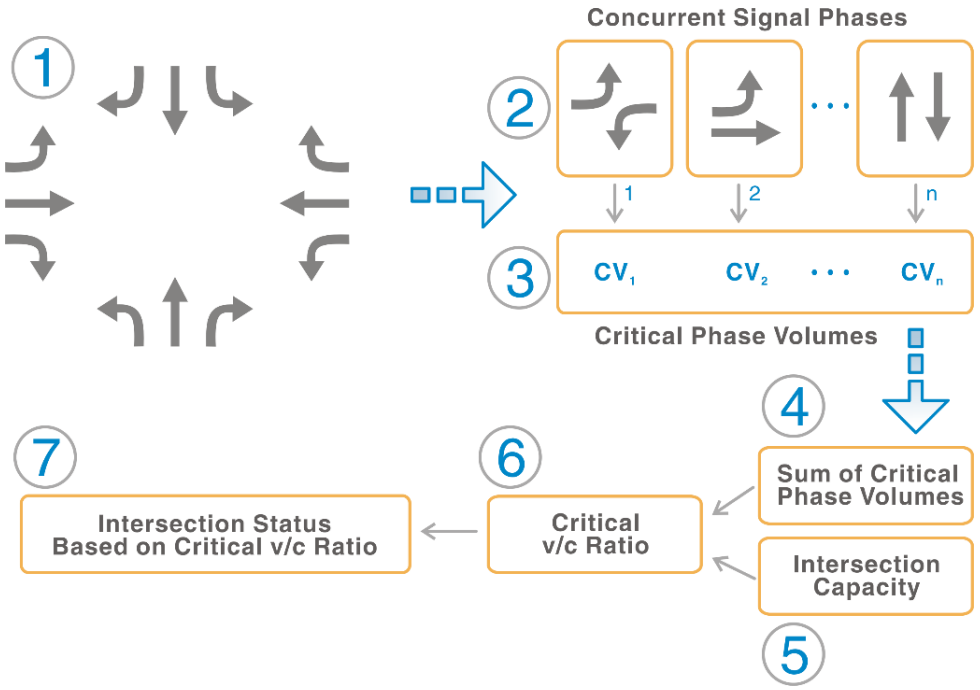
1.4 A – CAP-X TOOL OVERVIEW

- Conducts critical movement analysis (CMA) to gauge the potential performance of intersection and interchange types
- CMA identifies the critical movements at an intersection and estimates whether the intersection is operating below, near, at, or over capacity;
- Includes vast majority of intersections and interchange types

- At-Grade Intersections
  - All Way Stop Control
  - Two Way Stop Control
  - Traffic Signal
  - Continuous Green T
  - Quadrant Roadway
  - Displaced Left Turn
  - Median U-Turn
  - Restricted Crossing U-Turn
- Roundabouts
  - 50 and 75 ICD Mini-roundabouts
  - 1-Lane Roundabouts
  - 2-Lane Roundabouts
  - Hybrid 1x2 lane configurations
- Grade-Separated Interchanges
  - Traditional Diamond
  - Partial Cloverleaf
  - Displaced Left Turn
  - Diverging Diamond Interchange
  - Single Point Diamond

WHAT IS CRITICAL MOVEMENT ANALYSIS?

Included in the 1985 HCM and NCHRP Report 812: Signal Timing Manual, 1st Edition



Source: Traffic Signal Timing Manual – 1st Edition

1) Identify movements served, # lanes and volumes per lane
2) Arrange in desired sequence of phases
3) Determine critical volume per lane to be accommodated
4) Sum the critical volumes
5) Determine maximum critical volume for intersection – CAP-X
6) Determine volume to capacity ratio

1.4 A – WHEN TO CHANGE THE DEFAULTS?

Cap-X Default Values

Critical Lane Volume Threshold	2-phase signal	**Suggested = 1800**	**1800**
	3-phase signal	**Suggested = 1750**	**1750**
	4-phase signal	**Suggested = 1700**	**1700**

Assumptions:

- *Base Sat Flow = 1,950 pc/h/ln*
- *120-second cycle length*
- *4 seconds lost time/phase*
- *2/3/4 critical phases*

- Consider changing default values, when assumptions are not met
- Saturation Flow Rate is likely lower for rural intersections!
- Recommend to keep defaults to extent possible
- Note that v/c ratios close to 1.0 will always be re-evaluated in ICE Stage 2

ANALYSIS FOR UNSIGNALIZED INTERSECTIONS

- All-Way Stop Controlled Intersection
  - Critical Movement Analysis applies directly
- Two-Way Stop Controlled (TWSC) Intersection
  - Capacity of Rank 2 through 4 movements are function of gap acceptance parameters and relative flow rates
  - Cap-X uses HCM Planning and Preliminary Engineering Applications Guide (PPEAG) planning-level methods
- Unsignalized RCUT
  - Similar to TWSC with different gap acceptance values
  - Cap-X uses modified PPEAG planning-level methods
- Roundabouts
  - Entry capacity defined by gap acceptance and conflicting flow rate (more straightforward than others)
  - Cap-X uses HCM 6th Edition capacity model directly

1.4 A – CAP-X INPUTS

Traffic Volume Demand						
	Volume (Veh/hr)				Percent (%)	
	U-Turn	Left	Thru	Right	Heavy Vehicles	Volume Growth
Eastbound	0	113	2	43	14.00%	0.00%
Westbound	0	21	2	58	0.00%	0.00%
Southbound	0	39	1118	63	5.00%	0.00%
Northbound	0	41	1710	6	3.00%	0.00%
Adjustment Factor	0.80	0.95		0.85		
Suggested	**0.80**	**0.95**		**0.85**		
Truck to PCE Factor				**Suggested = 2.00**	2.00	
FDOT Context Zone			**C3C-Suburban Commercial**			
Critical Lane Volume Threshold	2-phase signal			**Suggested = 1800**	**1800**	
	3-phase signal			**Suggested = 1750**	**1750**	
	4-phase signal			**Suggested = 1700**	**1700**	

Equivalent Passenger Car Volume				
	Volume (Veh/hr)			
	U-Turn	Left	Thru	Right
Eastbound	0	113	2	43
Westbound	0	21	2	58
Southbound	0	41	1174	66
Northbound	0	42	1761	6

- Movement Volumes
- Multimodal level of activity (FDOT addition)
- Additional planning-level values
- Individual analysis spreadsheets required for each study period (AM, Midday, PM Peak)

1.4 A – CAP-X INPUTS

Step 2A: Base Conditions Analysis

Project Name:	*SR 535 at MeadowCreek Drive ICE Training*
Project Number:	*XXXXX.XX*
Location:	*Orlando, FL*
Date:	2016 AM
Major Street Direction	North-South

Existing Intersection Configuration	*Traffic Signal*

Number of Lanes for Existing Configuration
(Can be edited in "3- Alt Num Lanes Input" as needed)

TYPE OF INTERSECTION	Sheet	Northbound				Southbound				Eastbound				Westbound			
		U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Traffic Signal	FULL		1	3	0		1	3	1		1	1	0		0	1	0

Results for Existing Configuration

TYPE OF INTERSECTION	Sheet	Zone 1 (North)		Zone 2 (South)		Zone 3 (East)		Zone 4 (West)		Zone 5 (Center)			
		CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C		
Traffic Signal	FULL	--	--	--	--	--	--	--	--	834	*0.55*	--	--

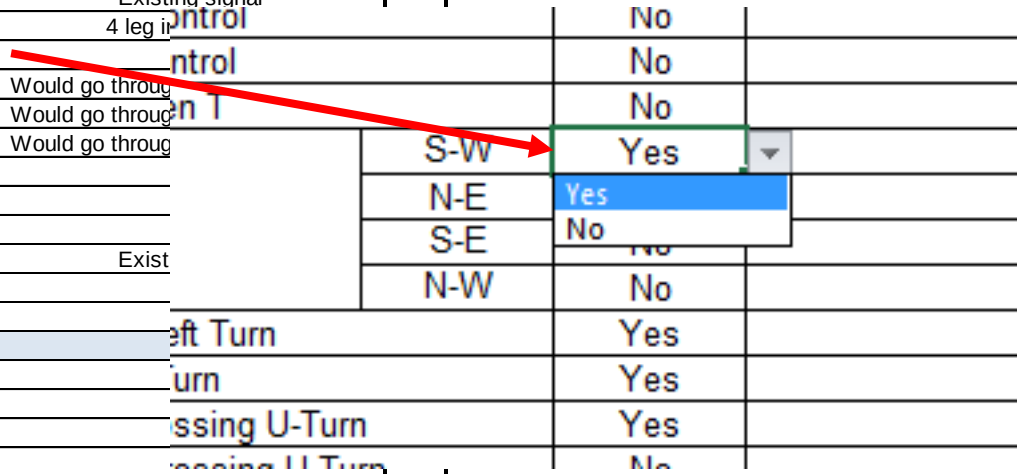
Existing Configuration Results

Overall v/c Ratio	0.55	Pedestrian Accommodation	Fair	Bicycle Accommodation	Fair	Transit Accommodation	Good

1.4 A – CAP-X INPUTS

Step 2B: Alternative Selection

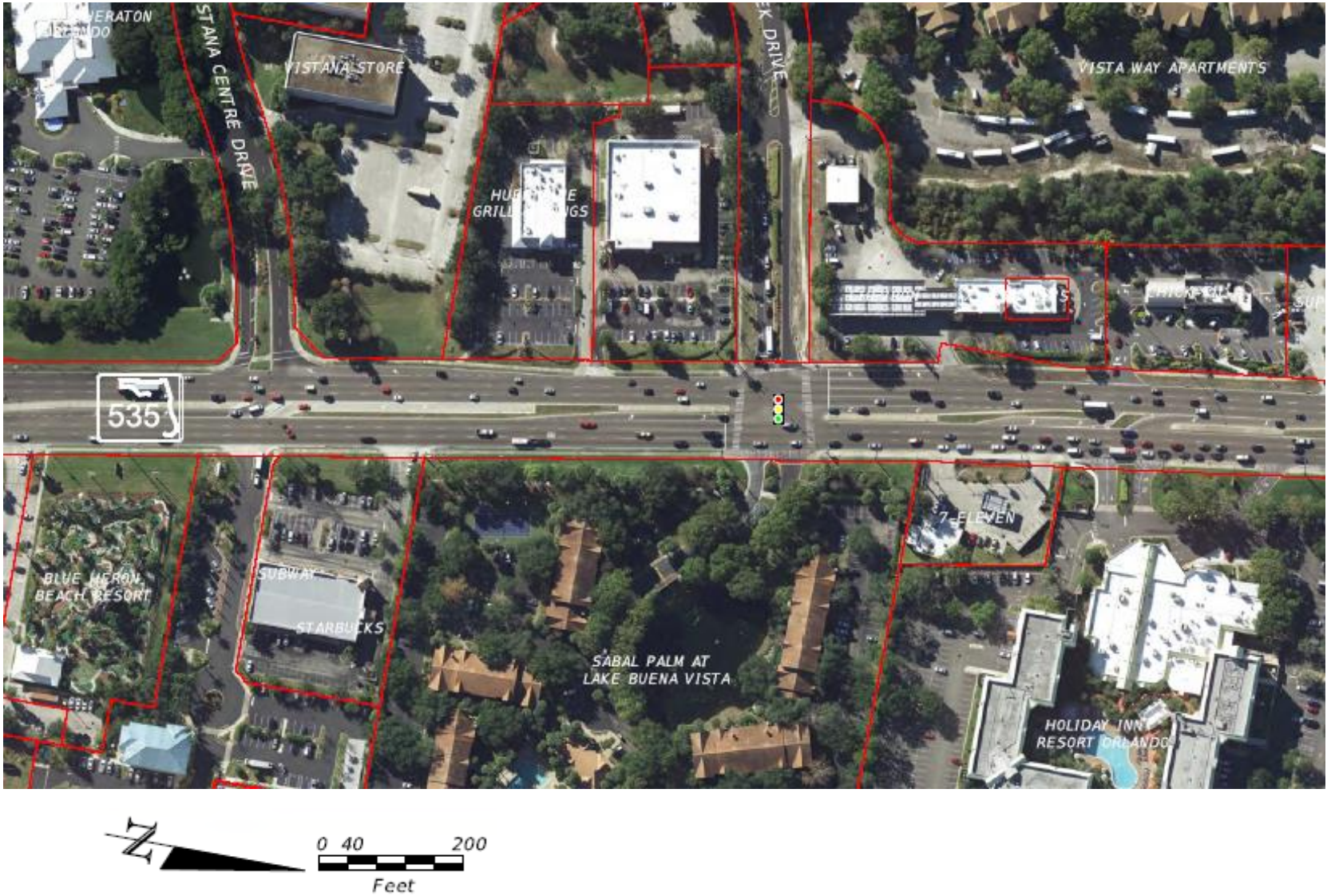
Rankings Inclusion		Yes/No	Comment
At-Grade Non-Roundabout Intersections?		Yes	
Traffic Signal		Yes	
Two-Way Stop Control		No	Existing signal
All-Way Stop Control		No	Existing signal
Continuous Green T		No	4 leg i
Quadrant Roadway	S-W	Yes	
	N-E	No	Would go throug
	S-E	No	Would go throug
	N-W	No	Would go throug
Partial Displaced Left Turn		Yes	
Displaced Left Turn		Yes	
Signalized Restricted Crossing U-Turn		Yes	
Unsignalized Restricted Crossing U-Turn		No	Exist
Median U-Turn		Yes	
Partial Median U-Turn		Yes	
Roundabouts?		No	
50 ICD Miniroundabout			
75 ICD Miniroundaobut			
1x1			
1x2			
2x1			
2x2			
Grade Separated Interchanges?		No	
Diamond			
Partial Cloverleaf A			
Partial Cloverleaf B			
Displaced Left Turn Interchange			
Diverging Diamond Interchange			
Single Point			



Continue to Step 3

Step 3

1.4 A – CAP-X INPUTS



1.4 A – CAP-X INPUTS

- New and revised input sheets to facilitate more efficient analysis
- Number of lanes inputs consolidated to a single worksheet
- Quadrant use respective intersection tabs.
- R-CUT and DLT, MUT (Full and Partial) require input for major street direction alternative

Number of Lanes for Non-roundabout Intersections																
TYPE OF INTERSECTION	Sheet	Northbound				Southbound				Eastbound				Westbound			
		U	L	T	R	U	L	T	R	U	L	T	R	U	L	T	R
Traffic Signal	FULL		1	3	0		1	3	1		1	1	0		0	1	0
Quadrant Roadway	S-W	Use the respective intersection tab(s) to specify the # of lanes inputs.															
Partial Displaced Left Turn	N-S		1	2	1		1	2	1		1	2	1		1	2	1
Displaced Left Turn	FULL		1	2	1		1	2	1		1	2	1		1	2	1
Signalized Restricted Crossing U-Turn	N-S	1	1	2	1	1	1	2	1				1				1
Median U-Turn	N-S	1		2	1	1		2	1			2	1			2	1
Partial Median U-Turn	N-S	1		2	1	1		2	1		1	2	1		1	2	1

For shared lanes, enter "0" in L or R

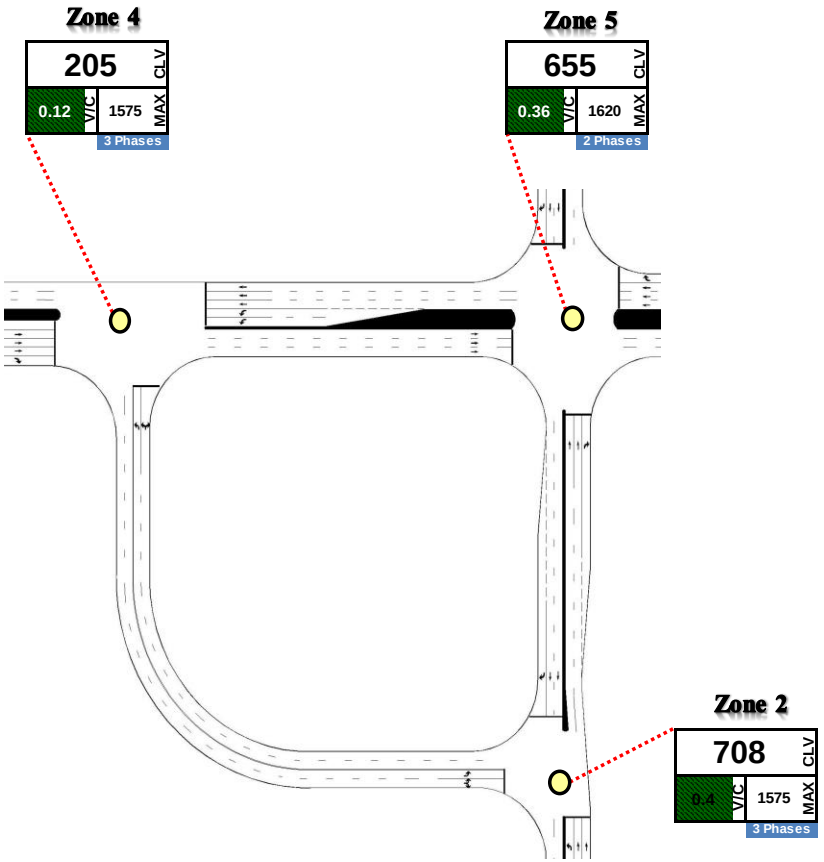
1.4 A – CAP-X INPUTS: QUADRANT ROADWAY INTERSECTION

Quadrant Roadway Intersection (S-W)

Design and Results

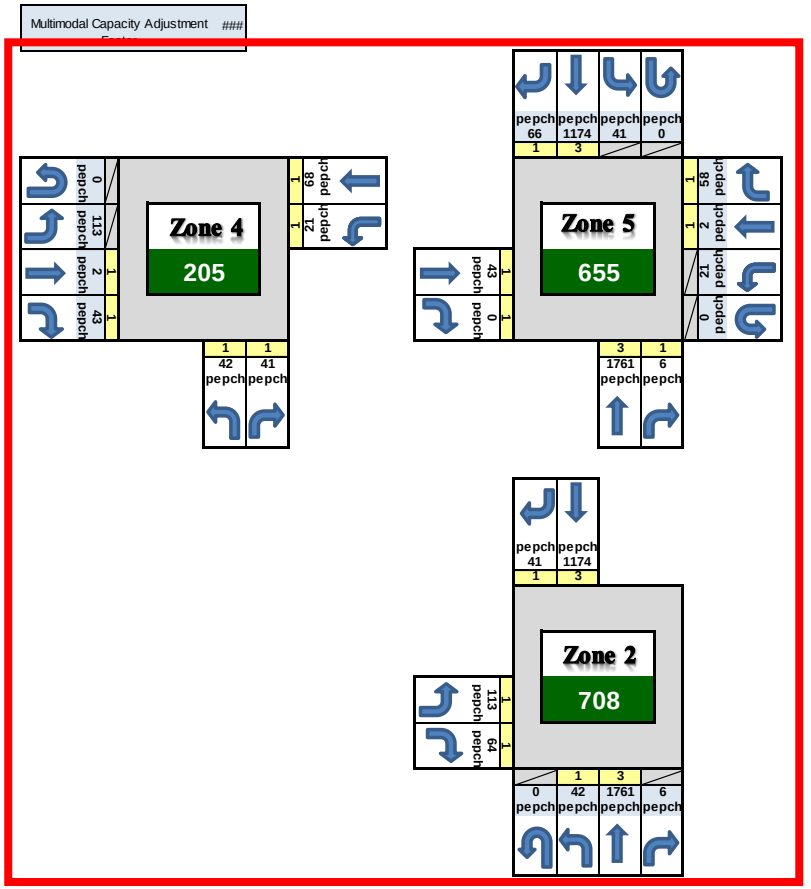
Project Name:	SR 535 at MeadowCreek Drive ICE Training
Project Number:	XXXXX.XX
Location	Orlando, FL
Date	2016 AM

Volume-to-Capacity Ratio			
< 0.750	0.750 - 0.875	0.875 - 1.00	≥ 1.00
VOLUME / CAPACITY RATIO:		0.4	



Quadrant Roadway Intersection (S-W)

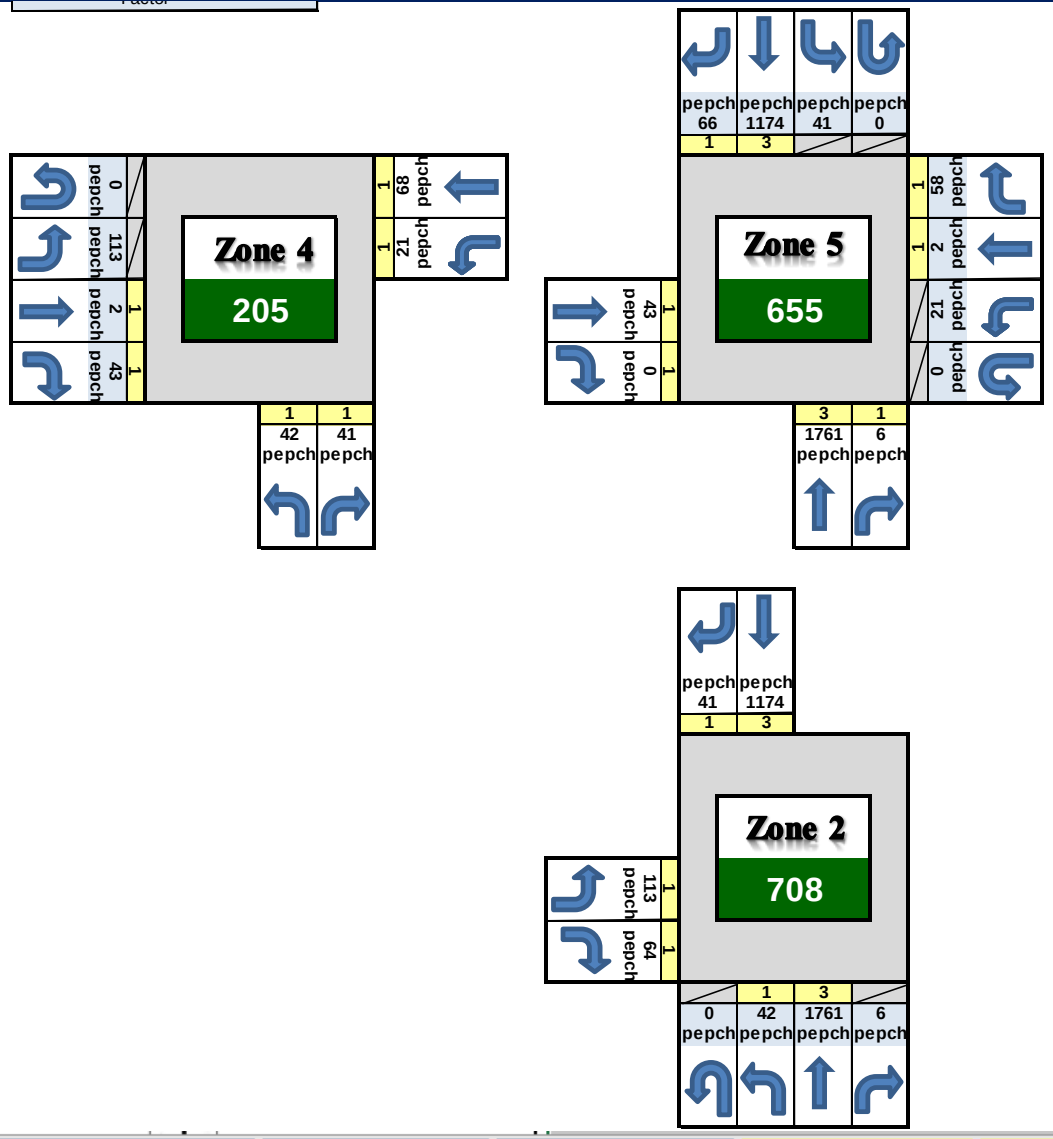
Data Input and Configuration



Back to Results

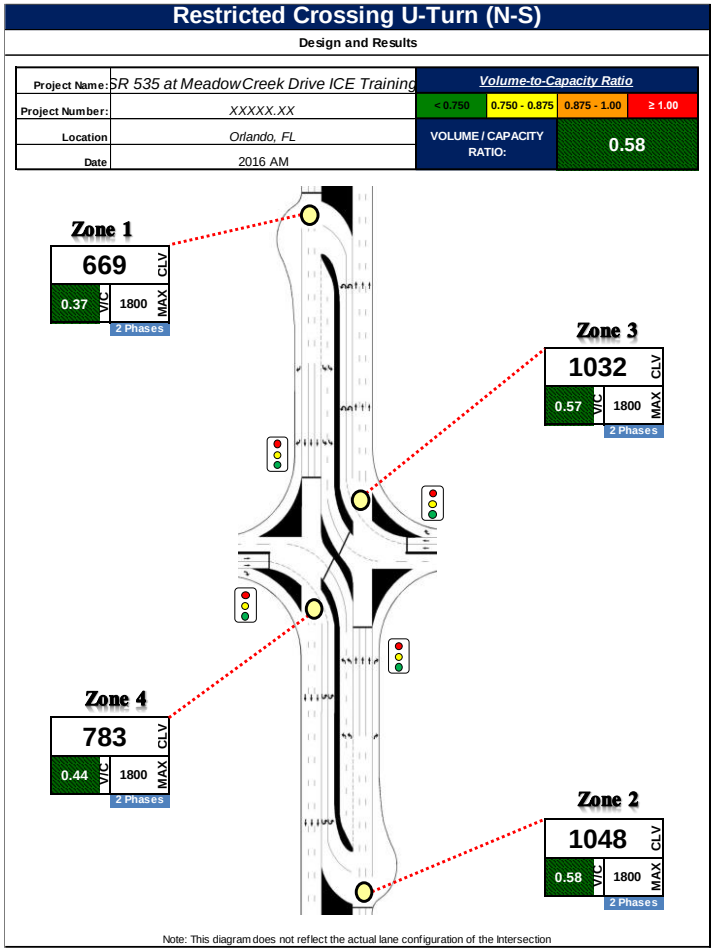
1 - Volume Input | 2 - Base and Alt Sel | 3 - Alt Num Lanes Input | 4a - Detailed Results | 4b - Summary Results | 5a - Summary Report | 5b - Detailed Report | Traffic Signal | QR S-W

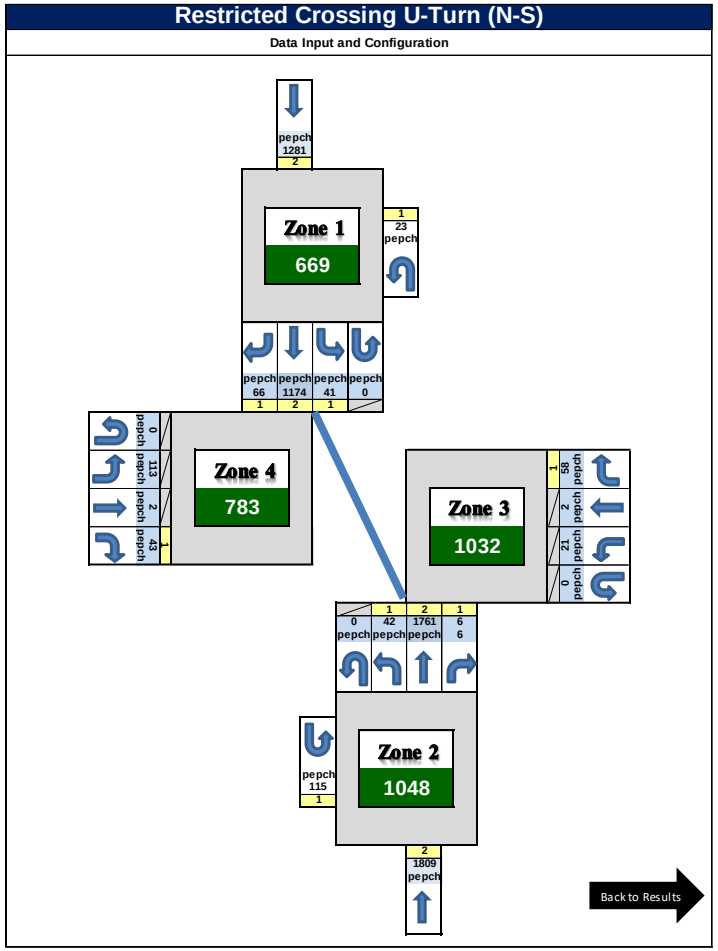
1.4 A – CAP-X INPUTS: QUADRANT ROADWAY



1.4 A – CAP-X INTERSECTION OUTPUT

- Evaluation for each intersection alternative is presented using CMA
- Graphical intersection representation does not update with no. of lanes input





1.4 A – CAP-X MULTIMODAL ACCOMMODATIONS CONSIDERATIONS

- Multi-Modal Accommodation Framework custom-developed for FDOT
- Not true safety prediction, but more qualitative assessment
- Framework considers range of factors:
  - crossing control (signal vs. uncontrolled)
  - crossing width (short vs. long)
  - vehicle speed (slow vs. fast)
  - volume (high vs. low)
  - out-of-direction travel
- Factors evaluated for each crossing at each of the intersections
- Score aggregated across modes for entire intersection
- Weighting Factors: Pedestrians (x3), Bicycles (x2), Transit (x1)

1.4 A – CAP-X MM CONSIDERATIONS AND SCORING EXAMPLES

Multimodal Scoring Framework (1 - poor; 2 - adequate; 3 - good)					
Control Type	**Speed**	**Exposure**	**Ped**	**Bike**	**Transit**
Yield/Uncontrolled	Slow	Short	3	3	-
	Slow	Long	2	3	-
	Fast	Short	2	2	-
	Fast	Long	1	2	-
Signalized	Slow	Short	3	3	-
	Slow	Long	2	3	-
	Fast	Short	3	3	-
	Fast	Long	2	2	-
No accommodations	N/A		1	1	1
Out of direction travel			-	-	2
Same As Signal			-	-	3

	Major Street Scores			Minor Street Scores		
Type	**Ped**	**Bike**	**Transit**	**Ped**	**Bike**	**Transit**
	Scoring Results			Scoring Results		
Conventional Traffic Signal	2	2	3	3	3	3
Conventional Signal Shared RTLT	2	2	3	3	3	3
Two-Way Stop Control	1	2	3	3	3	3
All-Way Stop Control	3	3	3	3	3	3
Partial Displaced Left Turn	2	2	3	2	2	3
Displaced Left Turn	2	2	3	2	2	3
RCUT	3	3	3	3	3	2
Unsignalized RCUT	2	2	3	3	3	2
MUT	3	3	3	3	3	2

1.4 A – CAP-X FULL OUTPUT

- Full results provided for each zone of each alternative
- Includes multimodal details based on specified level of activity

		Estimated Volume-to-Capacity Ratio			
Project Name:	SR 535 at Meadow Creek Drive ICE Training	Number of Configurations			
Project Number:	XXXXX.XX	< 0.750	0.750 - 0.875	0.875 - 1.00	≥ 1.00
Location	Orlando, FL	7	0	0	0
Date	2016 AM				

Results for Non-roundabout Intersections

TYPE OF INTERSECTION	Sheet	Zone 1 (North)		Zone 2 (South)		Zone 3 (East)		Zone 4 (West)		Zone 5 (Center)		Overall v/c Ratio	Pedestrian Accommodations	Bicycle Accommodations	Transit Accommodations
		CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C	CLV	V/C				
Traffic Signal	FULL									834	0.55	0.55	Fair	Fair	Good
Quadrant Roadway	S-W			708	0.40			205	0.12	655	0.36	0.40	Fair	Fair	Fair
Partial Displaced Left Turn	N-S	980	0.54	642	0.36					1024	0.59	0.59	Fair	Fair	Good
Displaced Left Turn	FULL	980	0.54	642	0.36	44	0.02	141	0.08	999	0.56	0.56	Fair	Fair	Good
Signalized Restricted Crossing U-Turn	N-S	669	0.37	1048	0.58	1032	0.57	783	0.44			0.58	Good	Good	Fair
Median U-Turn	N-S	719	0.40	1097	0.61					1085	0.60	0.61	Good	Good	Fair
Partial Median U-Turn	N-S	693	0.39	956	0.53					1089	0.62	0.62	Good	Good	Fair

1.4 A – CAP-X SUMMARY OUTPUTS

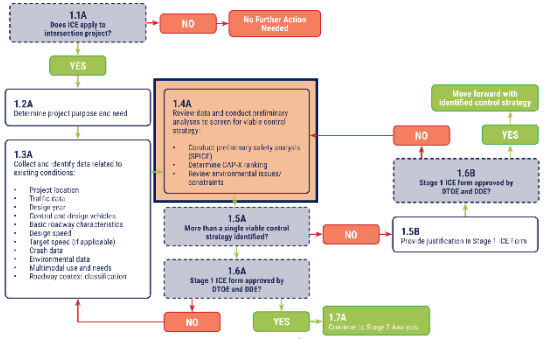
- Summary with dynamic rankings based on V/C
- Includes multimodal details based on level of activity (based purely on intersection control)

TYPE OF INTERSECTION	Overall V/C Ratio	V/C Ranking	Multimodal Score	Pedestrian Accommodations	Bicycle Accommodations	Transit Accommodations
Quadrant Roadway S-W	0.40	1	4.4	Fair	Fair	Fair
Traffic Signal	0.55	2	4.8	Fair	Fair	Good
Displaced Left Turn	0.56	3	4.8	Fair	Fair	Good
Signalized Restricted Crossing U-Turn N-S	0.58	4	6.3	Good	Good	Fair
Partial Displaced Left Turn N-S	0.59	5	4.8	Fair	Fair	Good
Median U-Turn N-S	0.61	6	6.3	Good	Good	Fair
Partial Median U-Turn N-S	0.62	7	6.3	Good	Good	Fair

1.4 A – CAP-X IN FDOT ICE FORMS – STAGE 1

Screening Evaluation						
Provide a brief justification as to why each of the following control strategies should be advanced or not. Justification should consider potential environmental						
Control Strategy	**CAP-X Outputs**			**SPICE Ranking**	**Strategy to be Advanced ?**	
	V/C Ratio		**Multimoda Score**			
	Select time periods analyzed in CAP-X:					
	Weekday AM Peak	Weekday PM Peak				
Two-way Stop-Controlled	-	-	-			
All-way Stop-Controlled	-	-	-			
Signalized Control	0.55	0.67	4.8			
Roundabout	-	-	-			
Median U-Turn	0.44 (Full) 0.46 (Partial)	0.77 (Full) 0.75 (Partial)	6.3 (Both)			
Restricted Crossing U-Turn (RCUT) Signalized	0.41	0.75	6.3			
Restricted Crossing U-Turn (RCUT) Unsignalized	-	-	-			
Jughandle						
Displaced Left-Turn	0.56 (Full) 0.59 (Partial)	0.68 (Full) 0.70 (Partial)	4.8 (Both)			
Continuous Green Tee	-	-	-			
Quadrant Roadway	0.40	0.55	4.4			

1.4 A – CONDUCT SPICE



ICE Procedure and Tools		
Stage 1	CAP-X	SPICE
Stage 2	Analysis Guidance	Default SYNCHRO, FDOT ICE Tool
Stage 3	No specific tools. Reuse Stage 2 tools or address qualitative issues.	

SPICE is used in both: Stage 1 and Stage 2 analyses

TOOLS

SPICE – STAGE 1

1.4 A – VISION AND NEED FOR THE SPICE TOOL

- Safety Performance Intersection Control Evaluations (SPICE)

- Safety comparisons of intersections becoming more common – ICE, increased use of HSM in general, etc.

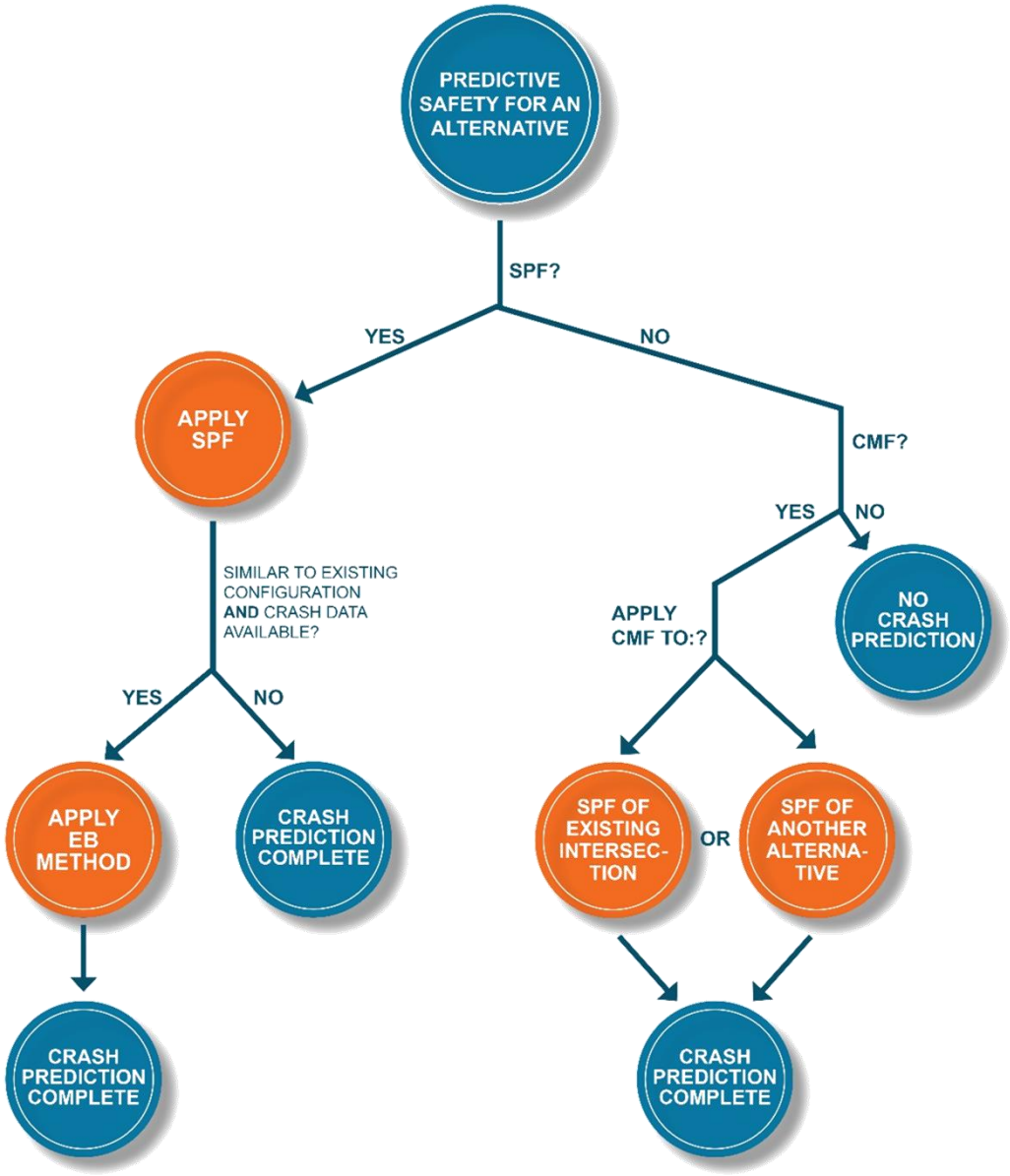
- Challenges with HSM Implementation
  - Which Crash Modification Factor (CMF) is *right*?
  - What should the CMF be applied to (existing, another alt, etc.)?
  - New Safety Performance Functions (SPFs) being produced through NCHRP (such as 6 and 8 lane arterials/roundabouts)

- Simple tool needed for safety comparisons only
  - Same level of effort as CAP-X

1.4 A – SPICE TOOL OVERVIEW

- Performs predictive safety analysis of at-grade intersection alternatives/control types and ramp terminal intersections
  - Implements the methodologies of the Highway Safety Manual (HSM)
  - For interchanges, only analyzes ramp terminals for diamond (D4)
- Developed with goal to be user-friendly
  - Only requires data inputs readily available to the analyst
  - Option to conduct planning level analysis
- Allows simultaneous evaluation of multiple alternatives and control types
- Tool will work for vast majority of intersections
- Development of FHWA SPICE tool ongoing
- Preliminary FDOT version now available

1.4 A – SPICE TOOL OVERVIEW



1.4 A – SPICE – INTRODUCTION

Federal Highway Administration (FHWA)

Safety Performance for Intersection Control Evaluation Tool

Introduction	Overview
The Safety Performance for Intersection Control Evaluation (SPICE) Tool was developed to provide an easy-to-use tool that automates the predictive safety analysis of intersections. This tool will allow analysts conducting Intersection Control Evaluations (ICE) to be equipped with necessary safety information during the decision-making process, without having to research a myriad of crash modification factors (CMFs) and Safety Performance Functions (SPFs) in multiple sources. The SPICE tool will perform a comparative predictive safety analysis of different intersection control strategies. The results – crash frequency and severity for each alternative – will then enable safety performance of alternatives to be considered quantitatively like traffic operations, construction cost, maintenance cost, or other factors.	The SPICE Tool performs safety analysis of at-grade intersection forms/control types and ramp terminal intersections of diamond interchanges. This user-friendly tool requires only data inputs that are readily available to the analyst. In addition, the SPICE tool has an option to conduct planning level analysis, where the tool assumes default values for data inputs that are challenging to obtain in the early stages of a project and/or have a very minor impact on the results. The SPICE tool assumes that certain attributes of the intersection – AADT, facility type, and number of legs – are the same for all alternatives. If they are not, users will be required to use the tool twice to get results. The tool will not allow simultaneous evaluation of at-grade intersections and ramp terminal intersections. For projects where analysis of both intersections and interchanges is needed, users are required use the tool twice to get results.

Worksheets

Project Information: Provide general project information for reference purposes only.
Definitions: Reference sheet with additional information related to inputs for the SPICE tool.
Control Strategy Selection: Choose between At-Grade or Ramp Terminal intersection types to be included in the SPICE analysis.
At-Grade Inputs: SPF and Part C CMF inputs for At-Grade intersections (hidden if Ramp Terminals are being analyzed).
Ramp Terminal Inputs: SPF and Part C CMF inputs for Ramp Terminal intersections (hidden if At-Grade intersections are being analyzed).
Calibration: Input optional override values for SPF calibration factors from locally-developed or updated information.
Results: Summary of opening year and (if applicable) design year and total project life cycle crash frequency and crash severity.
Additional Worksheets: Additional worksheets to support the underlying Macros. Not to be updated by users unless updating future tool versions.

Maintenance	Input Legend	
Version: SPICE Tool 1.0		Required data entry field
Maintained By: TBD		Optional data entry field
Contact Information: TBD		Planning-Level Default Input
Disclaimer		Data entry field not used

Disclaimers may be added, if needed.

1.4 A – SPICE: INPUTS AND CONTROL STRATEGY SELECTION

Control Strategy Selection and Inputs

Specify the Facility Level Inputs and the Control Strategies to be included in the SPICE Analysis.

Intersection Type	At-Grade Intersections
Analysis Year	Opening and Design Year
Opening Year	2020
Design Year	2040
Facility Type	On Urban and Suburban Arterial
Number of Legs	4-leg
1-Way/2-Way	2-way Intersecting 2-way
# of Major Street Lanes (both directions)	6 or more
Major Street Approach Speed	Less than 55 mph
Opening Year - Major Road AADT	50,000
Opening Year - Minor Road AADT	3,500
Design Year - Major Road AADT	70,000
Design Year - Minor Road AADT	5,000

For more information on how to determine these values, see the "Definitions" worksheet

Control Strategy	Include	Base Intersection		
Traffic Signal	Yes	--		
Traffic Signal (Alternative Configuration)	No	--		
Minor Road Stop	No	--		Design Year AADT Outside of SPF Development Range
All Way Stop	No	--		
1-Lane Roundabout	No	--	Opening Year AADT Outside of SPF Development Range	Design Year AADT Outside of SPF Development Range
2-Lane Roundabout	No	--	Opening Year AADT Outside of SPF Development Range	Design Year AADT Outside of SPF Development Range
Displaced Left Turn (DLT)	Yes	Traffic Signal		
Median U-Turn (MUT)	Yes	Traffic Signal		
Signalized Restricted Crossing U-Turn (RCUT)	Yes	Traffic Signal		
Unsignalized Restricted Crossing U-Turn (RCUT)	No	Minor Road Stop		
Continuous Green-T Intersection	No	Traffic Signal		
Jughandle	No	Traffic Signal		
Other 1	No	Traffic Signal	*Please Select	
Other 2	No	Minor Road Stop	*Please Select	

1.4 A – SPICE TOOL OVERVIEW

At-Grade Intersection to include in SPICE Tool

Traffic Signal	On Rural Two Lane Highway	3 leg	-	-	1	SPF under development in 17-68
	On Rural Multilane Highway	3 leg	-	-	3	SPF under development in 17-68
		3 leg	2x2	6 or more	7	SPF from 17-58
		4 leg	2x2	6 or more	8	SPF from 17-58
		3 leg	1x2	-	9	SPF from 17-58
		4 leg	1x2	-	10	SPF from 17-58
		3 leg	1x1	-	11	SPF from 17-58
		4 leg	1x1	-	12	SPF from 17-58
		5 leg	-		13	SPF under development in 17-68
	On High Speed (50+ MPH) Urban and Suburban Arterial	3 leg	-	-	14	SPF under development in 17-68
		4 leg	-	-	15	SPF under development in 17-68
		5 leg	-	-	18	SPF under development in 17-68
		3 leg	2x2	6 or more	23	SPF from 17-58
		4 leg	2x2	6 or more	24	SPF from 17-58
		3 leg	1x2	-	25	SPF from 17-58
		4 leg	1x2	-	26	SPF from 17-58
		3 leg	1x1	-	27	SPF from 17-58
		4 leg	1x1	-	28	SPF from 17-58
	On High Speed (50+ MPH) Urban and Suburban Arterial	3 leg	-	-	29	SPF under development in 17-68
		4 leg	-	-	30	SPF under development in 17-68
All-Way Stop	On Rural Two Lane Highway	4 leg	-	-	31	SPF under development in 17-68
	On Urban and Suburban Arterial	3 leg	-	-	32	SPF under development in 17-68
	On Urban and Suburban Arterial	4 leg	-	-	33	SPF under development in 17-68

Legend

Completed SPF - include in SPICE Tool
SPF Under Development - Include in SPICE Tool
CMF - Include in SPICE Tool
Exclude from SPICE Tool

1.4 A – SPICE: AT-GRADE INTERSECTION INPUTS

Required

Input		Control Strategy: Traffic Signal	Displaced Left Turn (DLT)	Median U-Turn (MUT)
Opening Year Major Road AADT	Optional AADT Overrides	50000	50000	50000
Opening Year Minor Road AADT		3500	3500	3500
Design Year Major Road AADT		70000	70000	70000
Design Year Minor Road AADT		5000	5000	5000
Number of Approaches with Left-Turn Lanes	Additional Required Control Strategy Inputs	3		
Number of Approaches with Right-Turn Lanes		1		
Number of Uncontrolled Approaches with Left-Turn Lanes				
Number of Uncontrolled Approaches with Right-Turn Lanes				

Optional for Stage 1, Required for Stage 2

Keep default values below here for planning-level analysis, override with actual val

Reset Planning Inputs to Defaults	Part C CMFS Optional For Stage 1 ICE, Required for Stage 2 ICE			
Skew Angle	A yellow cell indicates the value may be used in the SPF computation	N/A	CMF - No Inputs Required	CMF - No Inputs Required
Lighting Present		Yes		
# of Approaches Permissive LT Signal Phasing		0		
# of Approaches Perm/Prot LT Signal Phasing		0		
# of Approaches Protected LT Signal Phasing		0		
Number of Approaches with Right-Turn-on-Red Prohibited		0		
Red Light Cameras Present		No		
Number of Major Street Through Lanes		0		
Number of Minor Street Lanes		0		
# of Major St Approaches w/ Right-Turn Channelization		0		
Number of Approaches with U-Turn Prohibited		0		
Pedestrian Volume by Activity Level		Low (50)		
User Specified Sum of all daily pedestrian crossing volumes		50		
Max # of Lanes Crossed by Pedestrians		5		
Number of Bus Stops within 1000' of Intersection		0		
Schools within 1000' of intersection		No		
Number of Alcohol Sales Establishments within 1000' of Intersection		0		

- AADT Volumes for major/minor roads for the opening and design years
- Number of major approaches with left-turn or right-turn lanes
- Stage 1 - Pre-filled planning-level defaults
  - Can be overridden by analyst
- Stage 2 - Detailed information for CMF Analysis

1.4 A – SPICE: CRASH PREDICTION OUTPUTS

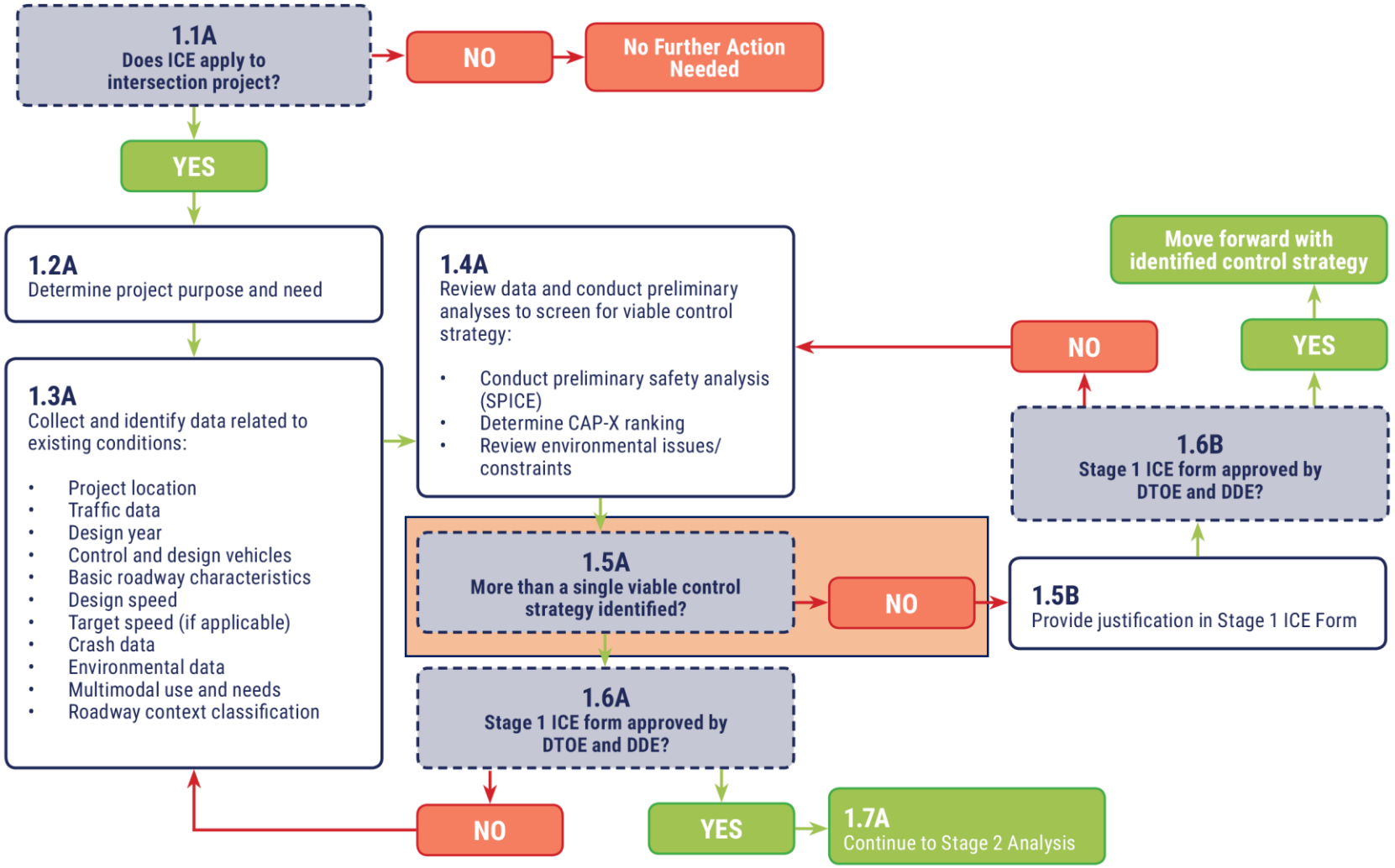
- Computes predicted crashes for all selected control strategy types
- Predicted crashes are broken into “Total” and “Fatal & Injury” groups
- Ranking is based on “Fatal & Injury” crashes.

Crash Prediction Summary							
Control Strategy	**Crash Type**	**Opening Year**	**Design Year**	**Total Project Life Cycle**	**Rank**	**AADT Within Prediction Range?**	**Source of Prediction**
Traffic Signal	Total	7.65	9.37	179.06	5	Yes	Uncalibrated SPF
	Fatal & Injury	4.12	5.11	97.12			
Displaced Left Turn (DLT)	Total	6.73	8.24	157.58	4	N/A	CMF
	Fatal & Injury	3.62	4.50	85.47			
Median U-Turn (MUT)	Total	6.50	7.96	152.20	1	N/A	CMF
	Fatal & Injury	2.88	3.58	67.99			
Signalized RCUT	Total	6.50	7.96	152.20	3	N/A	CMF
	Fatal & Injury	3.21	3.99	75.76			
Jughandle	Total	5.66	6.93	132.51	2	N/A	CMF
	Fatal & Injury	3.05	3.78	71.87			

1.4 A – SPICE IN FDOT ICE FORMS – STAGE 1

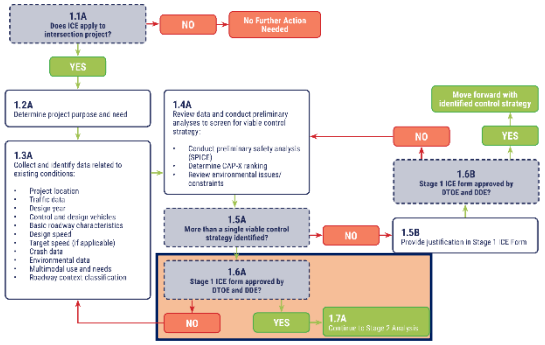
Screening Evaluation					
Provide a brief justification as to why each of the following control strategies should be advanced or not. Justification should consider potential environmenta					
Control Strategy	**CAP-X Outputs**			**SPICE Ranking**	**Strategy to be Advanced ?**
	V/C Ratio		**Multimodal Score**		
	Select time periods analyzed in CAP-X:				
	Weekday AM Peak	Weekday PM Peak			
Two-way Stop-Controlled	-	-	-	-	
All-way Stop-Controlled	-	-	-	-	
Signalized Control	0.55	0.67	4.8	5	
Roundabout	-	-	-	-	
Median U-Turn	0.44 (Full) 0.46 (Partial)	0.77 (Full) 0.75 (Partial)	6.3 (Both)	1	
Restricted Crossing U-Turn (RCUT) Signalized	0.41	0.75	6.3	3	
Restricted Crossing U-Turn (RCUT) Unsignalized	-	-	-	-	
Jughandle				2	
Displaced Left-Turn	0.56 (Full) 0.59 (Partial)	0.68 (Full) 0.70 (Partial)	4.8 (Both)	4	
Continuous Green Tee	-	-	-	-	
Quadrant Roadway	0.40	0.55	4.4		

ICE STAGE 1 PROCESS



Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Figure 2; Page 10

1.6 A – ICE FORM APPROVAL

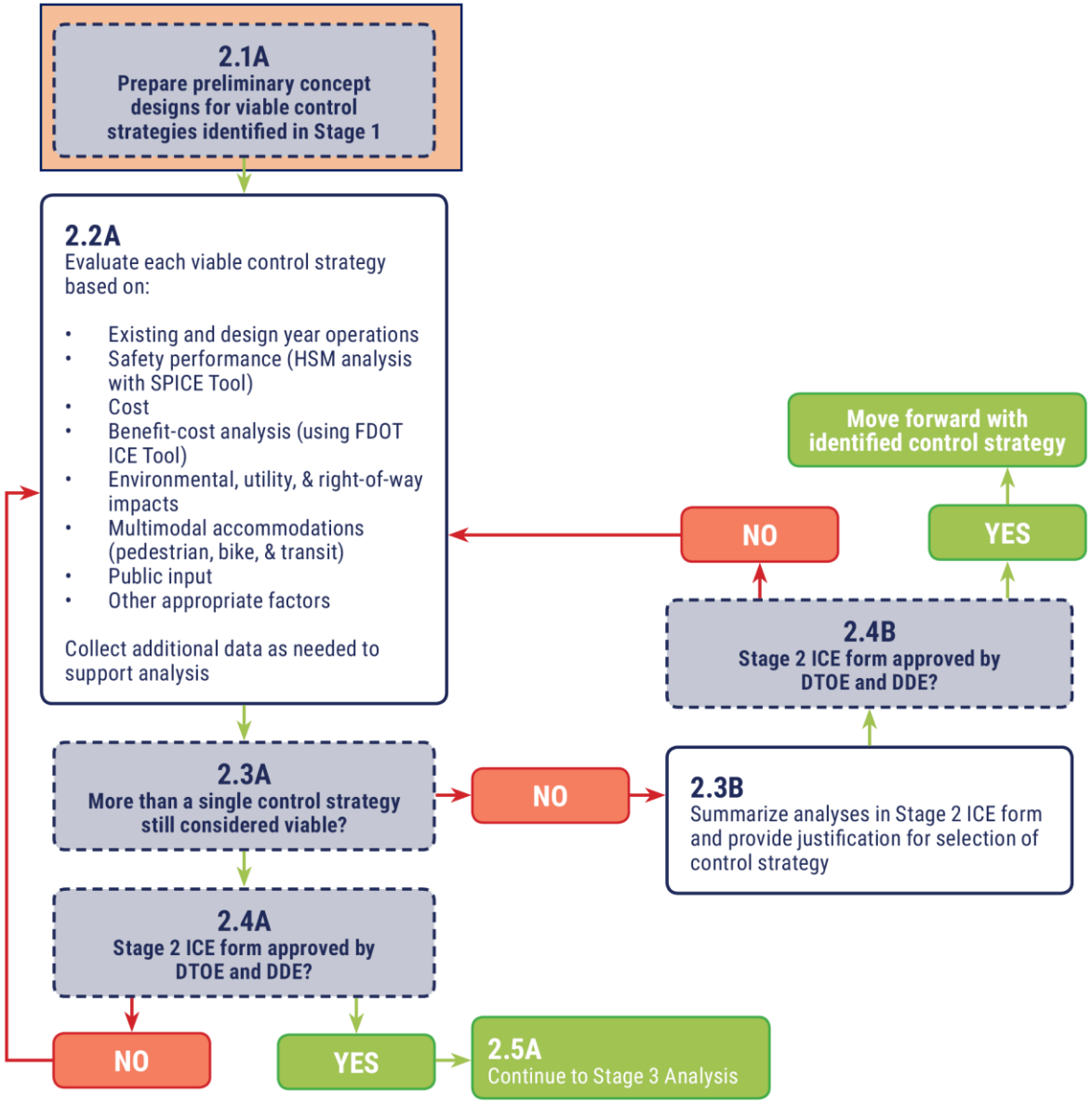


Resolution					
To be filled out by FDOT District Traffic Operations Engineer and District Design Engineer					
Project Determination					
Comments					
DTOE Name *(Type)*		Signature		Date	
DDE Name *(Type)*		Signature		Date	

PROCESS WALKTHROUGH

STAGE 2

ICE STAGE 2 PROCESS



Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Figure 3; Page 14

Signalized Restricted Crossing U-Turn N-S

Construction - $1,300,000

Design Cost - $400,000

ROW Cost - $400,000

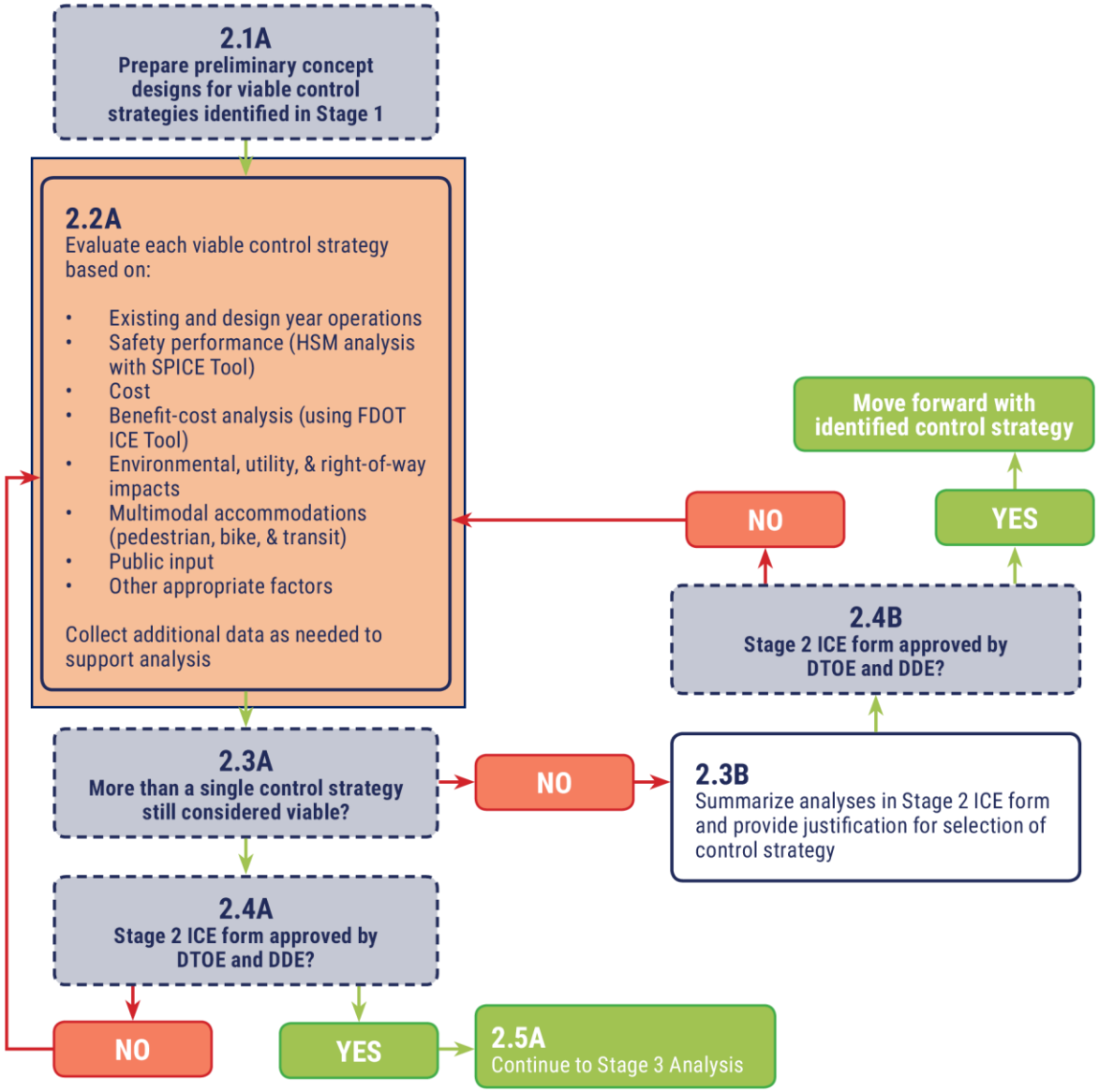
Median U-Turn N-S

Construction - $1,220,000

Design Cost - $300,000

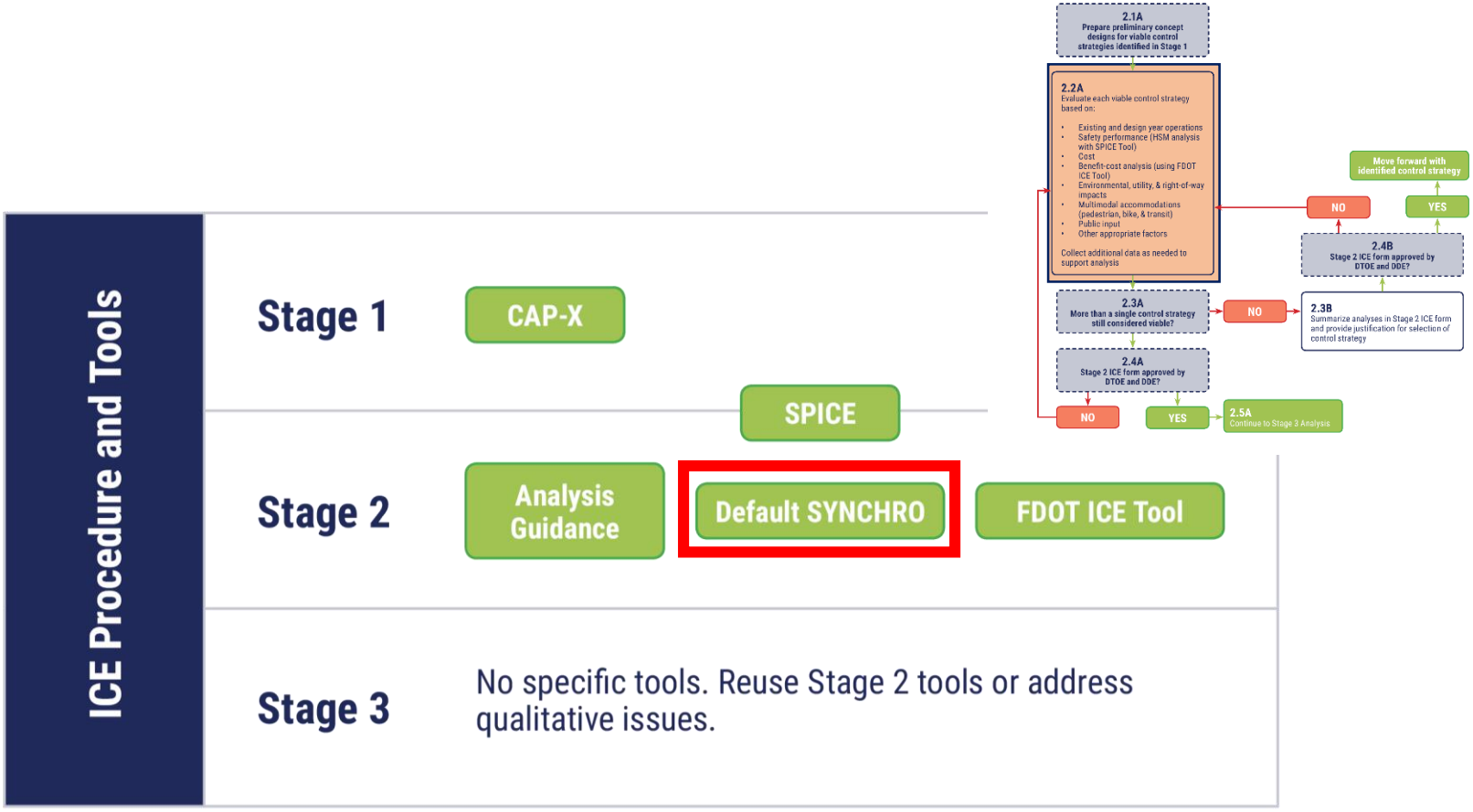
ROW Cost - $400,000

ICE STAGE 2 PROCESS



Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Figure 3; Page 14

ICE PROCEDURE

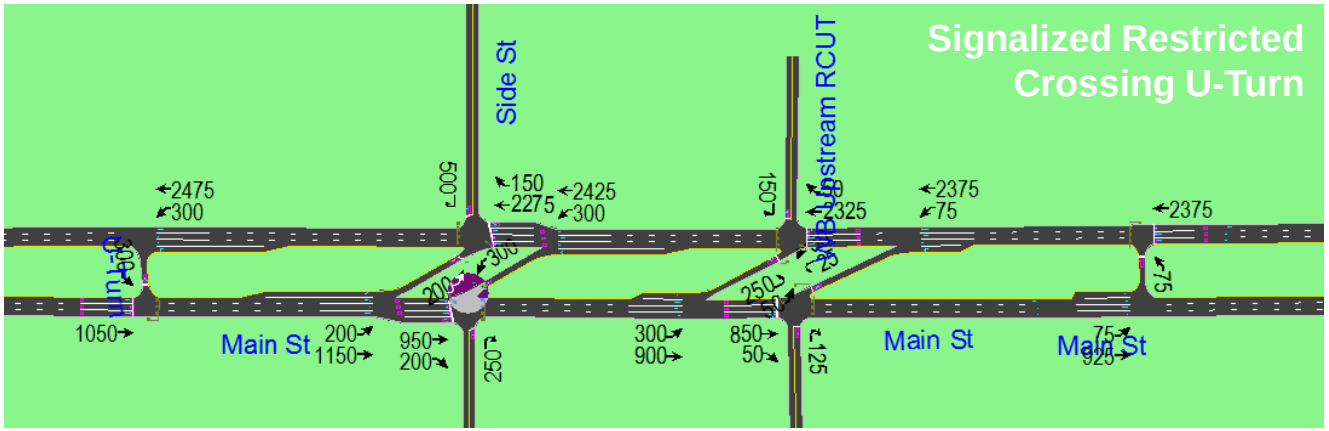


TOOLS

SYNCHRO

2.2 A – SYNCHRO DEFAULT VALUES

- Library of SYNCHRO default files
  - Include proper default signal phasing and saturation flow
- Review of documents for Florida SYNCHRO practice:
  - FDOT Traffic Analysis Handbook (March 2014)
  - FDOT 2013 Quality/Level of Service Handbook



LANE SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBR	NBR2	SWL2	SWL	SWR
Lanes and Sharing (#RL)												
Traffic Volume (vph)	0	950	200	0	0	0	0	0	250	0	300	0
Future Volume (vph)	0	950	200	0	0	0	0	0	250	0	300	0
Street Name							Side St					
Link Distance (ft)	—	150	—	—	426	—	671	—	—	—	167	—
Link Speed (mph)	—	30	—	—	30	—	30	—	—	—	30	—
Set Arterial Name and Speed	—	EB	—	—	WB	—	NB	—	—	—	SW	—
Travel Time (s)	—	3.4	—	—	9.7	—	15.3	—	—	—	3.8	—
Ideal Satd. Flow (vphpl)	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950

2.2 A – ADJUSTED SYNCHRO DEFAULT VALUES

Model Parameter	Default SYNCHRO Value	FDOT Recommended Value	Value Used in SYNCHRO
Peak Hour Factor (PHF)	0.92	Conceptual planning and preliminary engineering levels of analyses may use a PHF of 1.0	1.0 per Quality/Level of Service Handbook – also consistent with the CAP-X assumptions
Base Saturation Flow Rate (passenger cars per hour per lane, pcphpl)	1,900 pcphpl	1,950 pcphpl on arterials and other interrupted flow facilities	1,950 pcphpl per Quality/Level of Service Handbook
Lane Utilization Factor	Varies depending on the number of lanes and lane type	Default lane utilization factors should be overridden with field measurements when more vehicles use one lane group than the other As demand approaches capacity, lane utilization factors that are closer to 1.0 may be used	Default factors were used in the model
Heavy Vehicle Proportion	2%	Heavy vehicle percentages should be calculated based on the existing turning movement counts data. In absence of counts data, guidelines provided in the HCM-based Tools should be used	Default 2% was used

SYNCHRO INNOVATIVE INTERSECTION TEMPLATES: VISION AND NEED

- Stage 2 tool for more detailed operational analysis of alternative intersections

- Need for SYNCHRO templates
  - Modeling alternative intersections in SYNCHRO can be challenging
  - Developing SYNCHRO files on a case-by-case basis is time consuming and prone to error
  - Need for a consistent modeling approach for fair comparisons

- Designed to be quick and easy to use tool
  - Default SYNCHRO files requiring limited data inputs
  - Parameters consistent with HCM 6th Edition and FDOT recommendations

- Flexible enough to accommodate all intersection alternatives and various geometries

2.2 A – ALTERNATIVE INTERSECTION ANALYSIS IN HCS

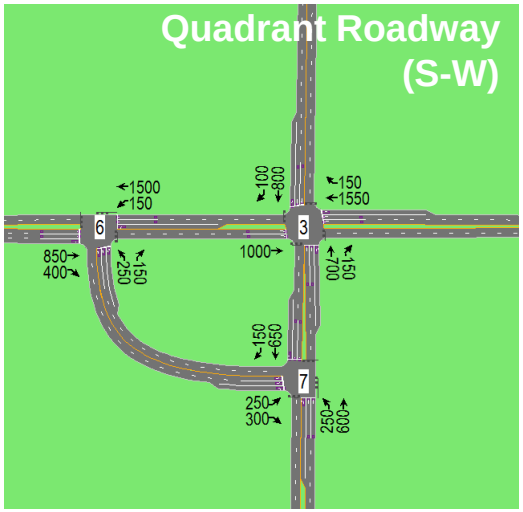
- The latest release of HCS (Release 7.2.1) includes only MUT, RCUT, and DLT, not all the alternative intersections

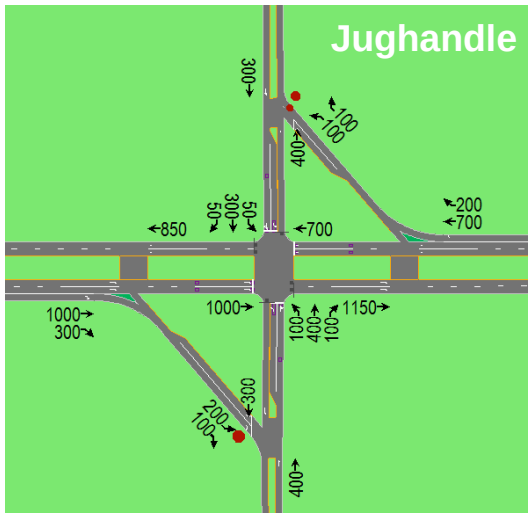
- Modeling everything in one platform (e.g., SYNCHRO) provides consistency across results
  - The ICE tool has worksheets for computing MUT and Signalized RCUT delay from SYNCHRO outputs in manner consistent with HCM 6th Edition

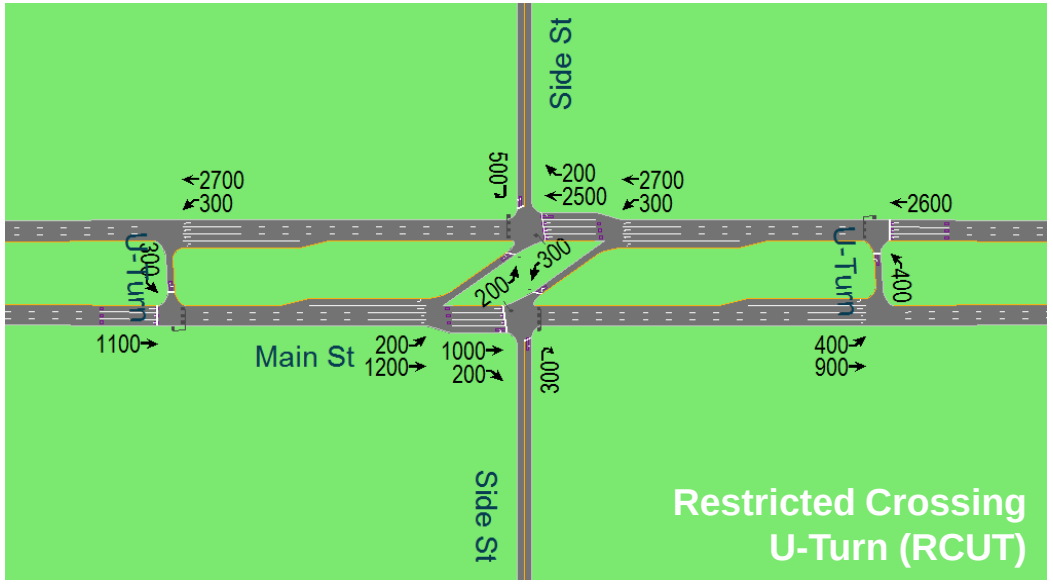
- Modeling alternative intersections in HCS is complicated and creates challenges

2.2 A – SYNCHRO TEMPLATES OVERVIEW

- Median U-Turn (MUT)
- Restricted Crossing U-Turn (RCUT)
  - Unsignalized
  - Signalized
  - Expanded to corridors
- RCUT
- Jug-handle
- Displaced Left Turn (DLT)
- Continuous Green T
- Quadrant Roadway
- Diverging Diamond Interchange (DDI)





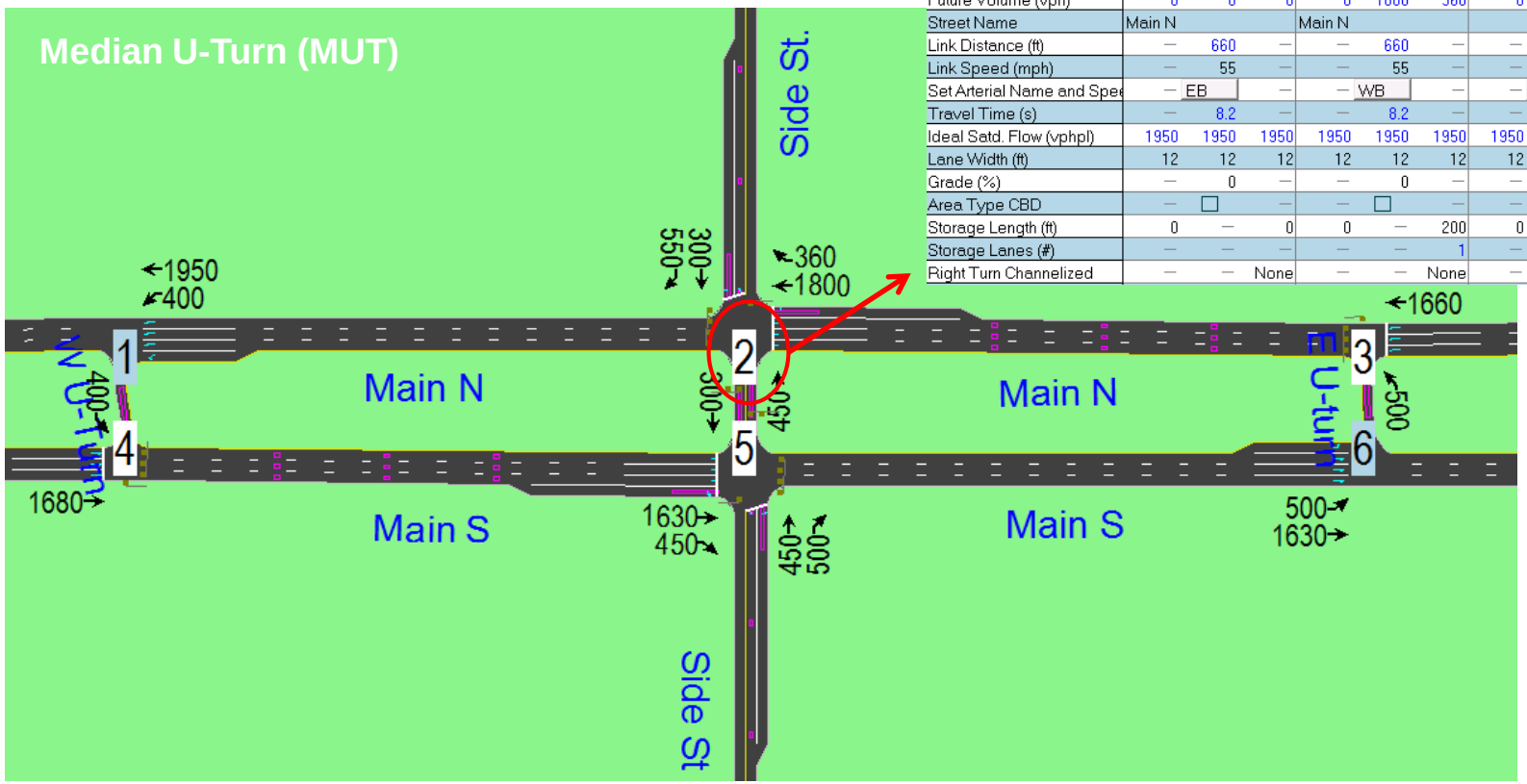


2.2 A – SYNCHRO TEMPLATES: BASIC REQUIRED INPUTS

(LANE CONFIGURATIONS)

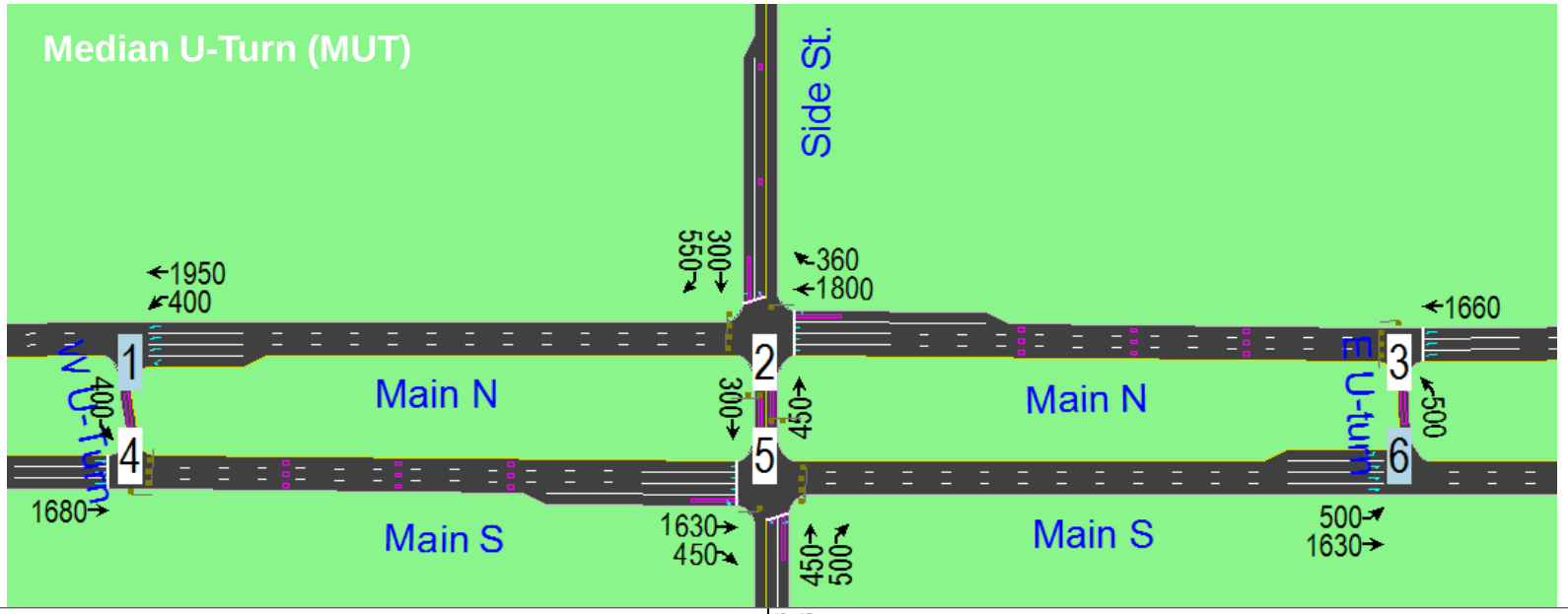
- Lane configurations
  - Number of lanes, storage length, link speed, channelized right turn, etc.

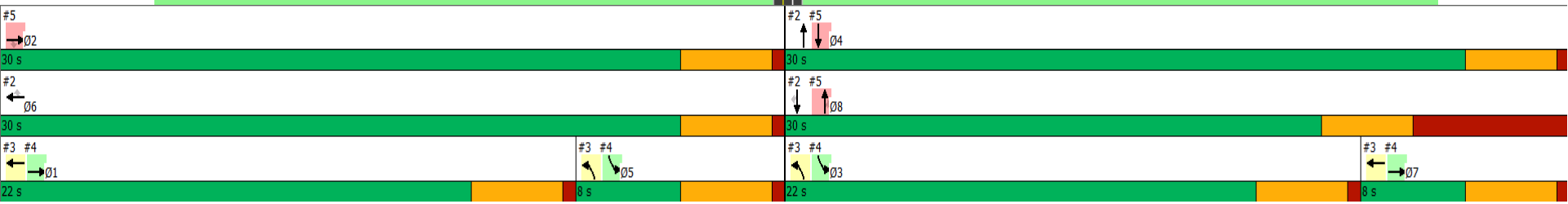
LANE SETTINGS	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lanes and Sharing (#RL)												
Traffic Volume (vph)	0	0	0	0	1800	360	0	450	0	0	300	550
Future Volume (vph)	0	0	0	0	1800	360	0	450	0	0	300	550
Street Name	Main N			Main N						Side St.		
Link Distance (ft)	–	660	–	–	660	–	–	100	–	–	500	–
Link Speed (mph)	–	55	–	–	55	–	–	40	–	–	40	–
Set Arterial Name and Spee	–	EB	–	–	WB	–	–	NB	–	–	SB	–
Travel Time (s)	–	8.2	–	–	8.2	–	–	1.7	–	–	8.5	–
Ideal Satd. Flow (vphpl)	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950	1950
Lane Width (ft)	12	12	12	12	12	12	12	12	12	12	12	12
Grade (%)	–	0	–	–	0	–	–	0	–	–	0	–
Area Type CBD	–	☐	–	–	☐	–	–	☐	–	–	☐	–
Storage Length (ft)	0	–	0	0	–	200	0	–	0	0	–	250
Storage Lanes (#)	–	–	–	–	–	1	–	–	–	–	–	1
Right Turn Channelized	–	–	None	–	–	None	–	–	None	–	–	None



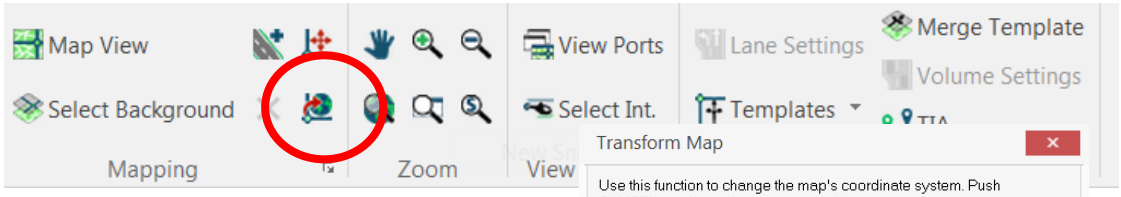
2.2 A – SYNCHRO TEMPLATES: BASIC REQUIRED INPUTS (SIGNAL TIMING)

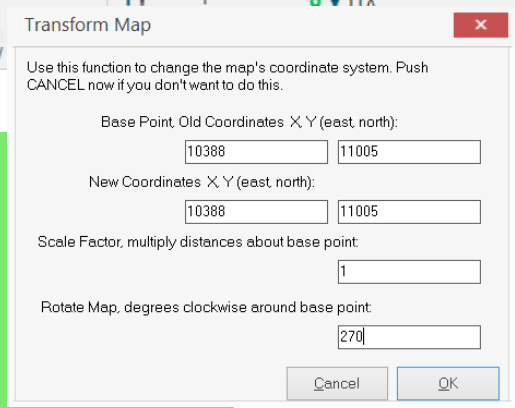
- Signal Timing (modeled as clustered or stand-alone intersections)
  - Splits, yellow and all-red times, pedestrian intervals, right-turn-on-red, minimum and maximum green intervals, etc.

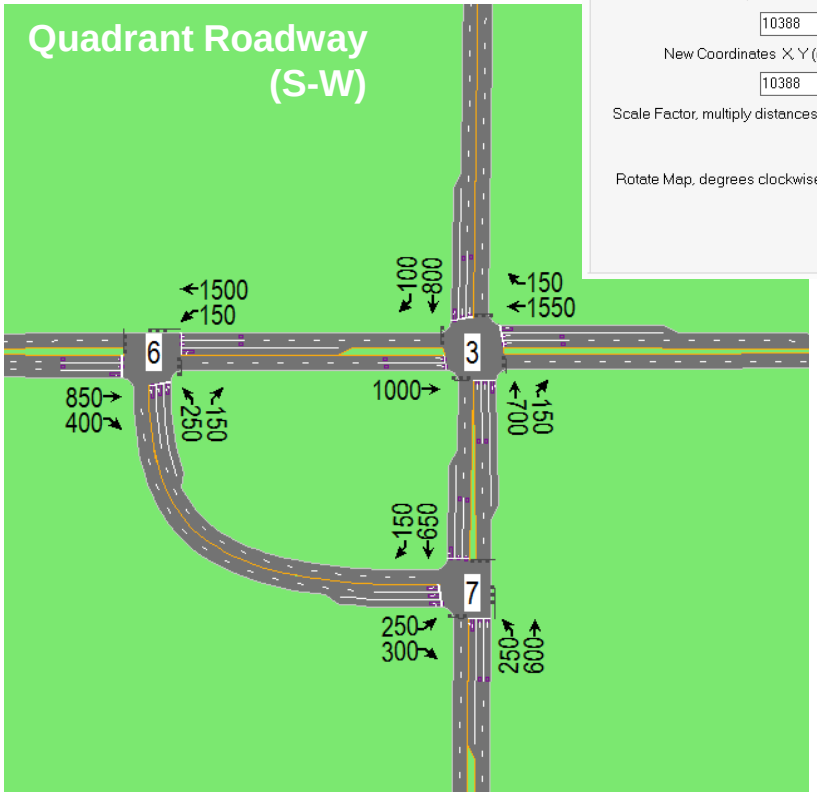


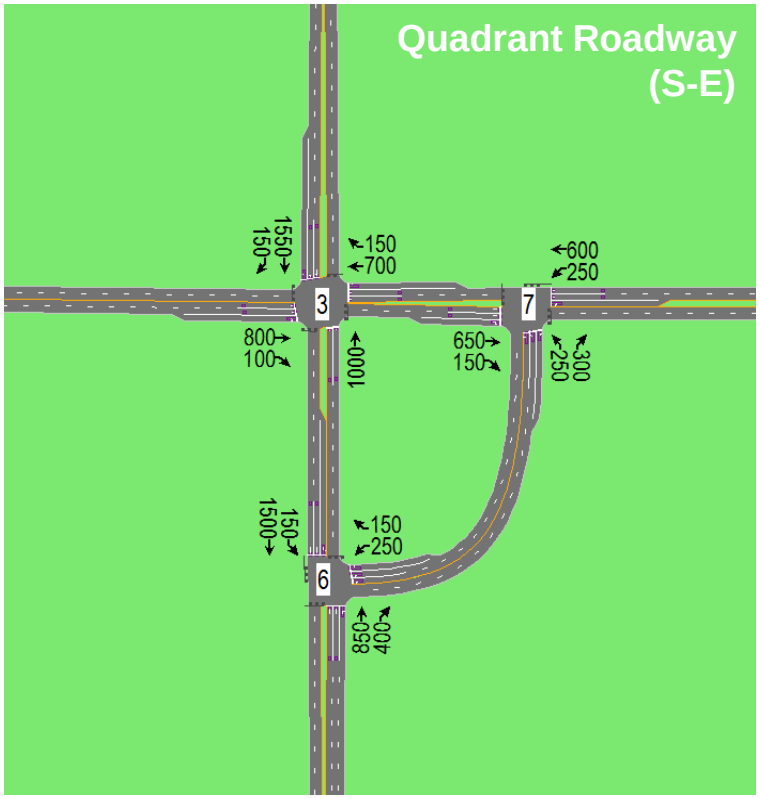


2.2 A – DEALING WITH INTERSECTION ORIENTATION





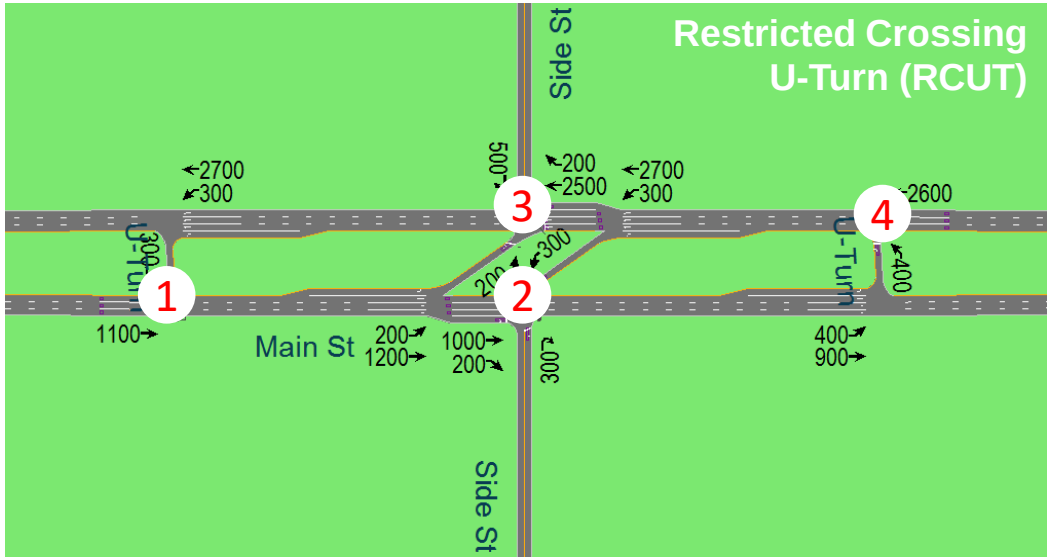




2.2 A – RCUT DELAY OVERVIEW

- Signalized Restricted Crossing U-Turns (RCUTs) can be analyzed in SYNCHRO
  - Limitations: SYNCHRO doesn't know you're modeling an RCUT
  - Assumes it is a network of 4 separate signals

- FDOT ICE tool provides a worksheet to overcome this limitation
  - User enters lane group delay outputs from each intersection's SYNCHRO report
  - User enters travel speed and distance to crossovers to account for out of direction travel
  - FDOT ICE tool computes single delay value for signalized RCUT consistent with HCM 6th Edition (with assumed coordination of signals)

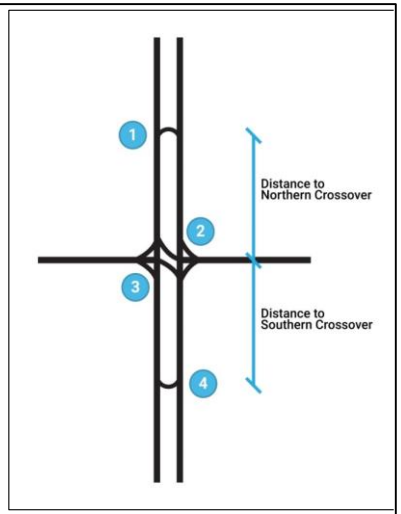


2.2 A – SYNCHRO INNOVATIVE INTERSECTION TEMPLATES: RESULTS

- Custom delay input sheets from SYNCHRO to ICE tool
  - Converts movement delays (e.g., from SYNCHRO) to a single intersection delay
  - Optional specification of weekend peak delays

RCUT N-S

Use this sheet to enter the delay information for a Signalized RCUT with the major street running North-South. (Requires turning movement count demand inputs)



User must enter value on this sheet

	Southern Crossover	Northern Crossover
Distance from main intersection to:	700	900
Free-flow speed on major street:	45	

*Volumes are computed based on values entered in DemandCounts and Exhibit 6-2 of FHWA RCUT Guide

Opening Year AM Peak				
Intersection 1	SB Thru	NB U-Turn		
Volume	1316	23		
Delay	2.4	16.7		
Intersection 2	NB Left	NB Thru	NB Right	WB Right
Volume	41	1976	8	81
Delay	35.1	6.1	2.7	25
Intersection 3	SB Left	SB Thru	SB Right	EB Right
Volume	39	1235	65	158
Delay	23.7	4.7	2.5	24.2
Intersection 4	NB Thru	SB U-Turn		
Volume	1910	115		
Delay	6.8	24.2		

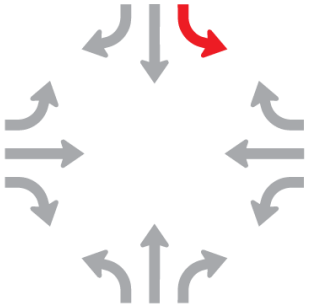
Opening Year PM Peak				
Intersection 1	SB Thru	NB U-Turn		
Volume	2379	25		
Delay	5.3	34.2		
Intersection 2	NB Left	NB Thru	NB Right	WB Right
Volume	68	1834	30	64
Delay	22.4	2.4	0.1	37.7
Intersection 3	SB Left	SB Thru	SB Right	EB Right
Volume	101	2146	157	299
Delay	53.2	9.7	3.8	47.9
Intersection 4	NB Thru	SB U-Turn		
Volume	1707	225		
Delay	9.2	32.6		

Opening Year Weekend Peak				
Intersection 1	SB Thru	NB U-Turn		
Volume	0	0		
Delay				
Intersection 2	NB Left	NB Thru	NB Right	WB Right
Volume	0	0	0	0
Delay				
Intersection 3	SB Left	SB Thru	SB Right	EB Right
Volume	0	0	0	0
Delay				
Intersection 4	NB Thru	SB U-Turn		
Volume	0	0		
Delay				

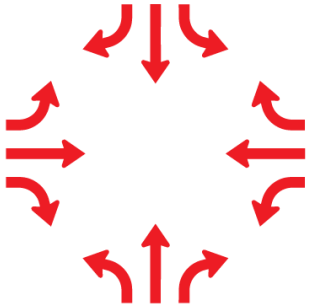
2.2 A – TWSC DELAY

- In a typical traffic study, delay of the critical movement is reported
  - Critical movement = lane group with highest delay
  - Prevents major street through movements with zero delay from “hiding” a low volume, high delay movement in an average

- For life cycle cost analysis considering every vehicle, average delay is needed
  - FDOT ICE tool has a feature for computing this in cases when software does not provide it



Used in typical traffic study (assumes southbound left has highest delay)



Used in life cycle cost analysis

2.2 A – ICE FORM STAGE 2

Operational Analysis

Summarize the results of the peak hour analysis performed for each control strategy. Select analysis year based on guidance in the ICE procedures document.

Design Vehicle	Interstate Semitrailer (WB-62)	Control Vehicle	Interstate Semitrailer (WB-62)

Overall Intersection Performance

Opening Year

Control Strategy	Analysis Year	2020		Analysis Year	2020	
	Peak Hour Analyzed	7:30 - 8:30 AM		Peak Hour Analyzed	4:30-5:30 PM	
	LOS	Delay (sec.)	All queues accommodated?	LOS	Delay (sec.)	All queues accommodated
Signalized Control	C	20.1	YES	C	28.9	YES
Median U-Turn	A	12	YES	A	14.5	YES
Restricted Crossing U-	A	14	YES	A	20.5	YES

Design Year

Control Strategy	Analysis Year	2040		Analysis Year	2040	
	Peak Hour Analyzed	7:30 - 8:30 AM		Peak Hour Analyzed	4:30-5:30 PM	
	LOS	Delay (sec.)	All queues accommodated?	LOS	Delay (sec.)	All queues accommodated
Signalized Control	C	22.2	YES	D	35.4	YES
Median U-Turn	A	12.1	YES	A	23.2	YES
Restricted Crossing U-	A	21.8	YES	B	49.4	NO

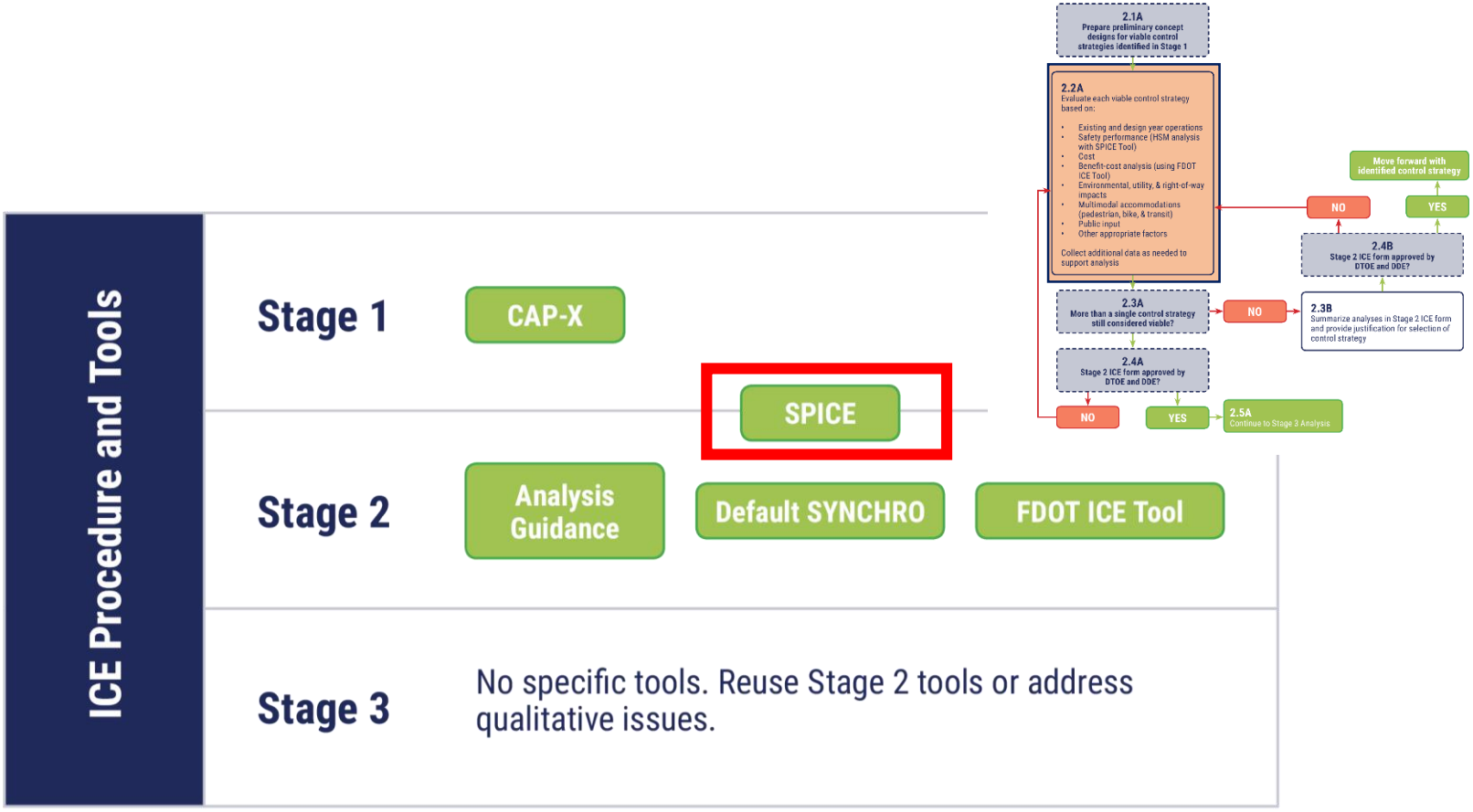
Provide any additional discussion necessary regarding the results of the operational analysis:

Costs

Remaining cognizant of the current level of detail of each control strategy's conceptual design, provide a cost estimate for each. You may want to include costs for preliminary engineering, required right-of-way acquisitions, construction, and a contingency.

Control Strategy	ROW Cost ($)	Design & Construction Cost	Control Strategy	ROW Cost ($)	Design & Construction Cost ($)
Signalized Control	$0	$0			
Median U-Turn	$1,220,000	$300,000			
Restricted Crossing U-Turn (RCUT) Signalized	$1,300,000	$400,000			

2.2 A – CONDUCT SPICE ANALYSIS



SPICE is used in both: Stage 1 and Stage 2 analyses

TOOLS

SPICE – STAGE 2

2.2A – SPICE: BASIC INPUTS AND CONTROL STRATEGY SELECTION

Control Strategy Selection and Inputs

Specify the Facility Level Inputs and the Control Strategies to be included in the SPICE Analysis.

Intersection Type	At-Grade Intersections
Analysis Year	Opening and Design Year
Opening Year	2020
Design Year	2040
Facility Type	On Urban and Suburban Arterial
Number of Legs	4-leg
1-Way/2-Way	2-way Intersecting 2-way
# of Major Street Lanes (both directions)	6 or more
Major Street Approach Speed	Less than 55 mph
Opening Year - Major Road AADT	50,000
Opening Year - Minor Road AADT	3,500
Design Year - Major Road AADT	70,000
Design Year - Minor Road AADT	5,000

For more information on how to determine these values, see the "Definitions" worksheet

Control Strategy	Include	Base Intersection		
Traffic Signal	Yes	--		
Traffic Signal (Alternative Configuration)	No	--		
Minor Road Stop	No	--		Design Year AADT Outside of SPF Development Range
All Way Stop	No	--		
1-Lane Roundabout	No	--	Opening Year AADT Outside of SPF Development Range	Design Year AADT Outside of SPF Development Range
2-Lane Roundabout	No	--	Opening Year AADT Outside of SPF Development Range	Design Year AADT Outside of SPF Development Range
Displaced Left Turn (DLT)	No	Traffic Signal		
Median U-Turn (MUT)	Yes	Traffic Signal		
Signalized Restricted Crossing U-Turn (RCUT)	Yes	Traffic Signal		
Unsignalized Restricted Crossing U-Turn (RCUT)	No	Minor Road Stop		
Continuous Green-T Intersection	No	Traffic Signal		
Jughandle	No	Traffic Signal		
Other 1	No	Traffic Signal	*Please Select	
Other 2	No	Minor Road Stop	*Please Select	

2.2A – SPICE STAGE 2: AT-GRADE INTERSECTION INPUTS

Required

Input		Control Strategy: Traffic Signal	Control Strategy: Median U-Turn (MUT)	Control Strategy: Signalized RCUT
Opening Year Major Road AADT	Optional AADT Overrides	50000	50000	50000
Opening Year Minor Road AADT		3500	3500	3500
Design Year Major Road AADT		70000	70000	70000
Design Year Minor Road AADT		5000	5000	5000
Number of Approaches with Left-Turn Lanes	Additional Required Control Strategy Inputs	0		
Number of Approaches with Right-Turn Lanes		0		
Number of Uncontrolled Approaches with Left-Turn Lanes				
Number of Uncontrolled Approaches with Right-Turn Lanes				

Optional for Stage 1, Required for Stage 2

Keep default values below here for planning-level analysis, override with actual values for full HSM Analysis

Reset Planning Inputs to Defaults	Part C CMFS Optional For Stage 1 ICE, Required for Stage 2 ICE			
Skew Angle	A yellow cell indicates the value may be used in the SPF computation	N/A	CMF - No Inputs Required	CMF - No Inputs Required
Lighting Present		No		
# of Approaches Permissive LT Signal Phasing		2		
# of Approaches Perm/Prot LT Signal Phasing		0		
# of Approaches Protected LT Signal Phasing		2		
Number of Approaches with Right-Turn-on-Red Prohibited		0		
Red Light Cameras Present		No		
Number of Major Street Through Lanes		6		
Number of Minor Street Lanes		2		
# of Major St Approaches w/ Right-Turn Channelization		0		
Number of Approaches with U-Turn Prohibited		0		
Pedestrian Volume by Activity Level		Low (50)		
User Specified Sum of all daily pedestrian crossing volumes		50		
Max # of Lanes Crossed by Pedestrians		8		
Number of Bus Stops within 1000' of Intersection		0		
Schools within 1000' of intersection		No		
Number of Alcohol Sales Establishments within 1000' of Intersection		7		

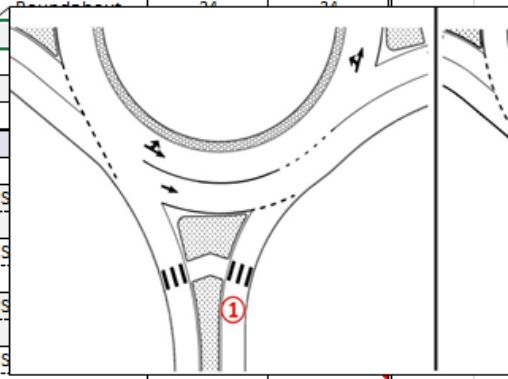
- AADT Volumes for major/minor roads for the opening and design years
- Number of major approaches with left-turn or right-turn lanes
- Pre-filled planning-level defaults
  - Can be overridden by analyst

2.2A – SPICE: ROUNDABOUT CMF INPUTS

Input		Control Strategy	
		Traffic Signal	2-lane Roundabout
	Roundabout CMF Inputs		
Inscribed Circle Diameter (ft)			
Leg 1 (Major Leg #1)	Leg 1 (Major Leg #1)		
Opening Year Entering AADT			25,000
Leg has Right-Turn Bypass			No
# of Access Points within 250' of Yield Line			
Entering Width (ft)			34
# of Entering Lanes			2
# of Circulating Lanes			2
Leg 2 (Major Leg #2)	Leg 2 (Major Leg #2)		
Opening Year Entering AADT			25,000
Leg has Right-Turn Bypass			No
# of Access Points within 250' of Yield Line			
Entering Width (ft)			34
# of Entering Lanes			2
# of Circulating Lanes			2
Leg 3 (Minor Leg #1)	Leg 3 (Minor Leg #1)		
Opening Year Entering AADT			1750
Leg has Right-Turn Bypass			No
# of Access Points within 250' of Yield Line			
Entering Width (ft)			24
# of Entering Lanes			2
# of Circulating Lanes			2
Leg 4 (Minor Leg #2)	Leg 4 (Minor Leg #2)		
Opening Year Entering AADT			1,750
Leg has Right-Turn Bypass			No
# of Access Points within 250' of Yield Line			
Entering Width (ft)			24
# of Entering Lanes			2
# of Circulating Lanes			2

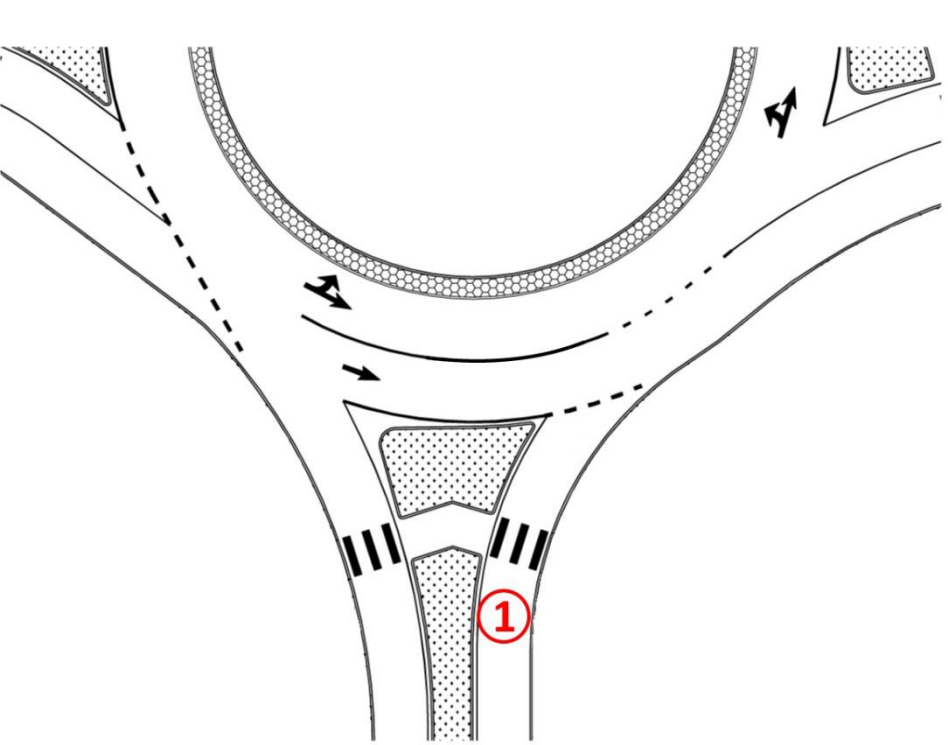
2.2A – SPICE STAGE 2: ROUNDABOUT CMF INPUTS

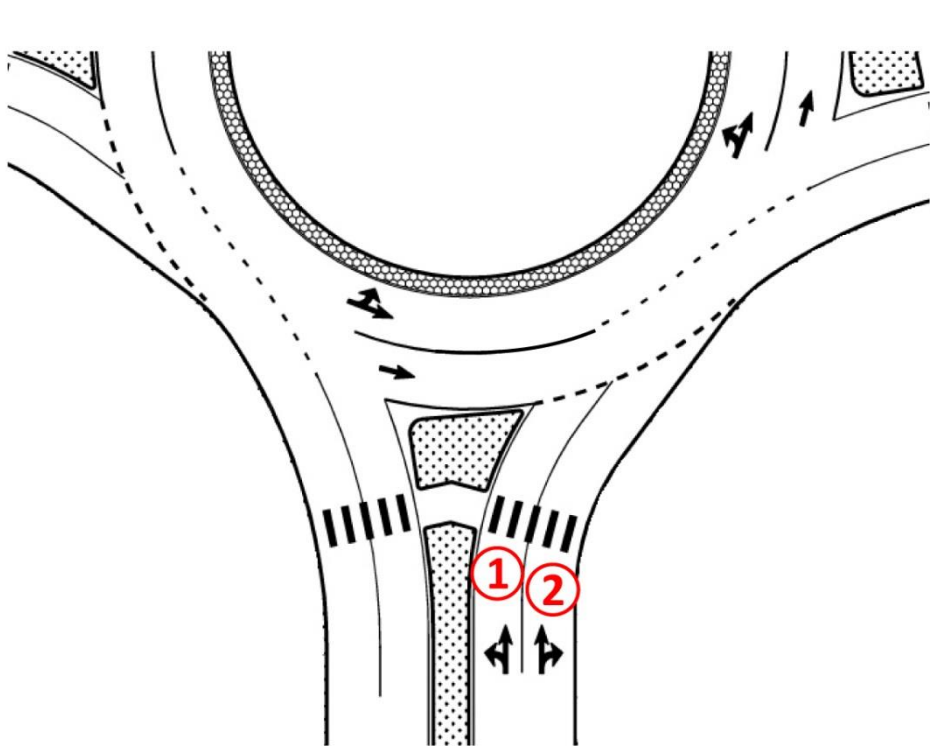
User Input Variable	Units	Definition	Applicable Ranges		
			Range for:	Lower Limit	Upper Limit
Control Strategy Selection					
Number of Major Street Lanes	lanes	Number of lanes on the major street (both directions - does not include turn lanes)	-	-	-
At-Grade Intersection Inputs					
Major/Minor Road AADT	veh/day	Average annual daily traffic (AADT) volume for the major and minor street approaches (see table for ranges).	See table starting in column I (to the right).		
Skew Angle	degrees	Intersecting angle between major street and minor street approaches *(hover cursor for graphical representation)*	-	-	-
Number of Major Street Through Lanes	lanes	Number of through lanes on the major street (both directions - includes shared through lanes)	-	-	-
Number of Minor Street Lanes	lanes	Number of lanes on the minor street (both directions - does not include turn lanes)	-	-	-
Inscribed Circle Diameter	feet		Roundabout	90	160
Opening Year Entering AADT	veh/day		Roundabout	See Table in Column O	
Leg has Right-Turn Bypass	yes/no		Roundabout	-	-
Access Point within 250' of Yield Line	-		Roundabout	0	8
Entering Width	feet				
Number of Entering Lanes	lanes	Number of lanes entering a leg of the roundabout *(hover cursor for graphical representation)*.			
Number of Circulating Lanes	lanes	Number of lanes circulating a leg of the roundabout *(hover cursor for graphical representation)*.			
Ramp Terminal Intersection Inputs					
Crossroad	-	References the major street of the ramp terminal intersection (i.e., the non-ramp terminal legs)			
Crossroad AADT - Inside Leg	veh/day	AADT volume of the crossroad leg located between the two ramp terminals of the interchange			
Crossroad AADT - Outside Leg	veh/day	AADT volume of the crossroad leg located outside of the interchange			
Ramp AADT - Exit	veh/day	AADT volume of the exit ramp			
Ramp AADT - Entrance	veh/day	AADT volume of the entrance ramp			
Exit Ramp Skew Angle	degrees	Skew angle equals 90 minus the intersection angle (in degrees) (*hover cursor for graphical representation*).	Signalized	0	31,000
Presence of Non-Ramp Public Street Leg	yes/no	Any ramp that has a fourth leg that: (1) is a public street serving two-way traffic and (2) intersects with the crossroad at the terminal. At most ramp terminals, the public street leg will be on the opposite side of the crossroad from the exit ramp.	Stop-Controlled	0	70
			-	-	-
			Stop-Controlled	1	2



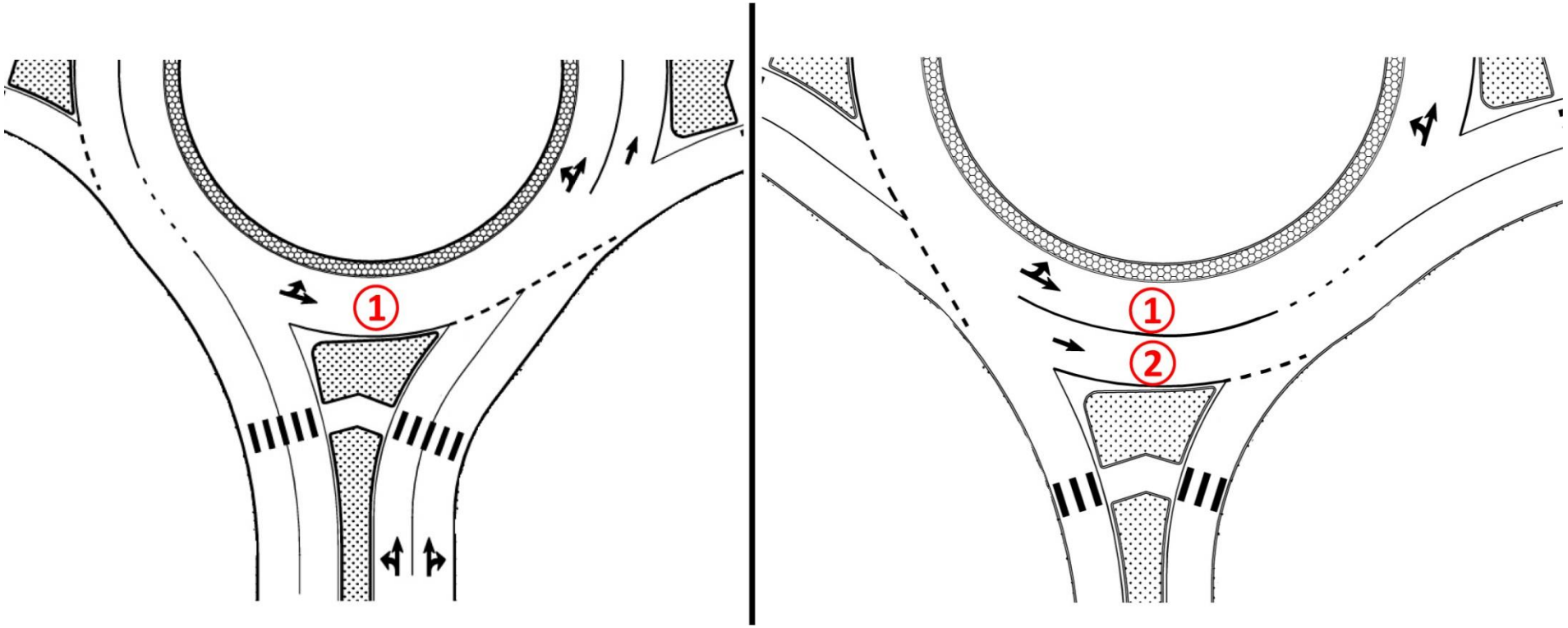
Introduction | Project Information | **Definitions** | Control Strategy Selection | At-Grade Inputs | Calibration | Historical | Results | Notes | User Selections | Labels

2.2A – SPICE STAGE 2: ROUNDABOUT ENTRY LANES





2.2A – SPICE STAGE 2: ROUNDABOUT CIRCULATING LANES



2.2A – SPICE: CMF SPECIFICATION AND OPTIONAL LOCAL CALIBRATION

- Crash Modification Factors (CMFs) used when Safety Performance Functions (SPFs) are unavailable
- Traffic signal is the base condition.

Local CMFs				
Optional - Override default CMFs with locallly-developed or new CMFs				
Control	**Type of Crashes**	**Default CMF**	**Optional User Override**	**Use Value**
Displaced Left Turn (DLT)	Total	0.88		0.88
	Fatal-Injury	0.88		0.88
Median U-Turn (MUT)	Total	0.85		0.85
	Fatal-Injury	0.70		0.70
Signalized Restricted Crossing U-Turn (RCUT), also known Superstreet	Total	0.85		0.85
	Fatal-Injury	0.78		0.78
Unsignalized Restricted Crossing U-Turn (RCUT), also known as J-Turn	Total	0.65		0.65
	Fatal-Injury	0.46		0.46
Continuous Green-T Intersection	Total	0.96		0.96
	Fatal-Injury	0.85		0.85
Jughandles	Total	0.74		0.74
	Fatal-Injury	0.74		0.74
Crossover Traffic Signal (of Diverging Diamond Interchange)	Total	0.67		0.67
	Fatal-Injury	0.59		0.59

- CMFs can be overridden with local values

- FDOT intersection calibration factors are included but can be overridden.

2.2A – SPICE: HISTORICAL CRASH DATA

- Empirical Bayes (EB) Analysis – recommend to use min. of 5 years crash data
- Existing intersection must be signalized or minor road stop
- Only applies EB to intersections with CMFs – DLT, MUT, RCUT not Roundabout

Historical Crash Data Input

Note: In order to use Empirical Bayes (EB), the historical intersection type must be a traffic signal or a minor road stop. Additionally, this alternative must be selected to be included in the analysis, and the historical intersection specified below. Up to 10 years of historical data can be used to perform the EB adjustment.

Is historical crash data available?	Yes			
Number of years available:	5	(Up to 10)	First Year Data is available:	2011
Historical Intx Type:	4SG			

Historical Crash Counts		Year										
		2011	2012	2013	2014	2015	--	--	--	--	--	Total
Combined	Total	43	49	44	30	60	--	--	--	--	--	226
	Fatal/Injury	13	9	9	8	17						56
	PDO	30	40	35	22	43						170
Single-Vehicle	Total											
	Fatal/Injury											
	PDO											
Multiple-Vehicle	Total											
	Fatal/Injury											
	PDO											
Veh-Ped	Fatal/Injury	1	2	0	1	0						4
Veh-Bike	Fatal/Injury	1	0	0	0	0						1
Total	All	45	51	44	31	60	--	--	--	--	--	231

2.2A – SPICE: CRASH PREDICTION OUTPUTS

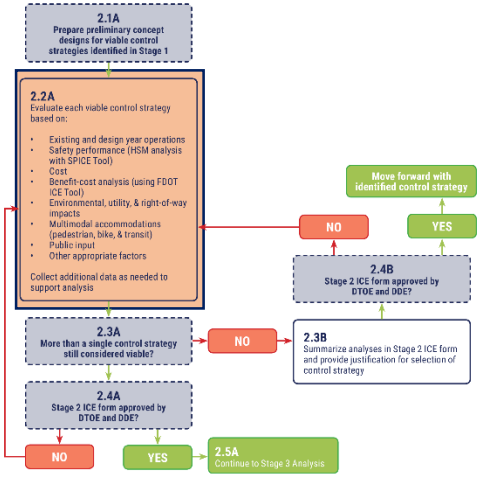
- Computes predicted crashes for all selected control strategy types
- Predicted crashes are broken into “Total” and “Fatal & Injury” groups
- Ranking is based on “Fatal & Injury” crashes.

Crash Prediction Summary							
Control Strategy	**Crash Type**	**Opening Year**	**Design Year**	**Total Project Life Cycle**	**Rank**	**AADT Within Prediction Range?**	**Source of Prediction**
Traffic Signal	Total	34.40	41.78	801.74	3	Yes	Uncalibrated SPF w/ EB
	Fatal & Injury	8.51	10.57	200.74			
Median U-Turn (MUT)	Total	29.24	35.52	681.48	1	N/A	CMF
	Fatal & Injury	5.96	7.40	140.52			
Signalized RCUT	Total	29.24	35.52	681.48	2	N/A	CMF
	Fatal & Injury	6.64	8.24	156.58			

ICE PROCEDURE

ICE Procedure and Tools

Stage 1	CAP-X	SPICE		
Stage 2	Analysis Guidance	Default SYNCHRO	FDOT ICE Tool	
Stage 3	No specific tools. Reuse Stage 2 tools or address qualitative issues.			



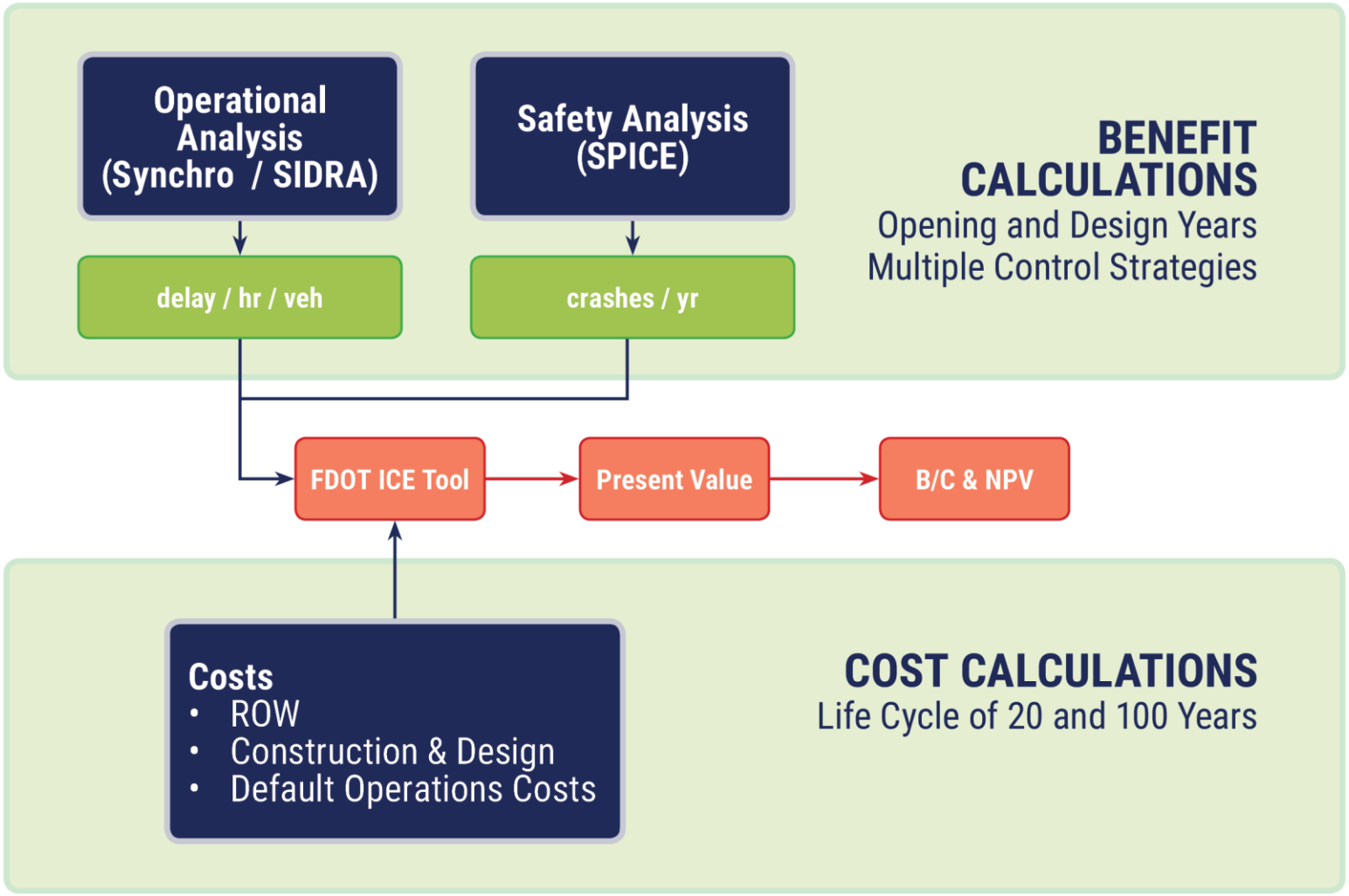
TOOLS

FDOT ICE TOOL

VISION AND NEED FOR THE FDOT ICE TOOL

- Stage 2 tool for financial analysis of intersection alternatives
- Needed inputs for life-cycle cost analysis
  - Safety - SPICE
  - Vehicular delay – SYNCHRO, VISSIM, HCS, SIDRA, etc.
  - Design, construction, right-of-way, and operating costs
- Conducts benefit-cost / net present value analysis
- Designed to be quick and easy to use – hour(s) not day(s)
  - Limit data inputs to readily available or computable values
  - Utilize information of previous stages of ICE analysis (e.g., SPICE tool)
- Flexible enough to accommodate all intersection alternatives

2.2 A – FDOT ICE TOOL OVERVIEW



2.2 A – FDOT ICE TOOL OVERVIEW

- Based on the NCHRP 3-110 Life Cycle Cost Estimation Tool (LCCET)
  - Macro-powered Excel spreadsheet
- Includes Florida hourly, daily, and monthly volume profiles for operational life-cycle cost analysis
  - Peak hour volumes are scaled to every hour of a project's lifespan
  - Defaults for urban vs rural, different functional classifications
- Major FDOT customizations
  - Simplified and improved input sheets
  - Local default values where applicable for monetized performance measures
  - Florida-specific volume profiles

2.2 A – FDOT ICE TOOL: STRATEGIES SELECTION

	Open Year	Design Year
Operating Cycle	2020	2040
Peak Hour Start	**From**	**To**
AM peak	7:00 AM	8:00 AM
PM peak	4:00 PM	5:00 PM
Weekend peak	10:00 AM	11:00 AM

Enter peak period begin and end times:

Select Analysis Basis: Specific Day/Month

Weekday Count: Tuesday, April 12, 2016 Enter dates as "mm/dd/yyyy"

Weekend Count: Enter dates as "mm/dd/yyyy"

Show/Hide Detailed Demand Profiles

Select facility type: 16 - Urban Minor Arterial

Specify total volumes or turning counts? Turning Counts (Select from drop-down menu)

Enter the turning movement counts in the DemandCounts worksheet for the peak hours. If data is not available for the weekend peak hour please leave blank.

Units	Year	
	Opening	Design
	2020	2040
	Intersection 1	
AM peak hour volume: veh/hr	3,465	4,713
PM peak hour volume: veh/hr	4,449	6,014
Weekend peak hour volume: veh/hr		
Average annual auto occupancy: Passengers per vehicle	1.0	1.0
Average annual % trucks: Average %	3.1%	3.1%

At-Grade Control Strategies

Control #	Include	Short Name	Description
1	No	MinorStop	Minor Road Stop
2	No	AllStop	All Way Stop
3	Yes	TrafficSignal	Traffic Signal
4	No	TrafficSignalAlt	Traffic Signal (Alt.)
5	No	Roundabout	Roundabout
6	No	DLT	Displaced Left Turn (DLT)
7	Yes	MUT	Median U-Turn (MUT)
8	Yes	SignalRCUT	Signalized Restricted Crossing U-Turn (RCUT)
9	No	UnsignalRCUT	Unsignalized Restricted Crossing U-Turn (RCUT)
10	No	GreenT	Continuous Green-T Intersection
11	No	Jughandle	Jughandle
12	No	Quadrant Itx	Quadrant Roadway Intersection
13	No	Other1	Other 1
14	No	Other2	Other 2

Setup Worksheets

Press the "Setup Worksheets" button to create hidden worksheets that compute performance measures for each selected control strategy.

2.2 A – FDOT ICE TOOL: FLORIDA DEMAND PROFILES

- Demand Profiles – Florida Daily & Monthly values by functional classification

Note: All charts illustrating volume profiles are shown to right of Column "R"

Review Daily Profile or Override Values:

Chart shown at right

Day of Week	04 - Rural Principal Arterial -- Other	06 - Rural Minor Arterial	07 - Rural Major Collector	08 - Rural Minor Collector	14 - Urban Principal Arterial -- Other	16 - Urban Minor Arterial	17 - Urban Major Collector
Monday	88.2%	80.6%	90.2%	79.9%	75.6%	75.1%	74.7%
Tuesday	97.9%	98.3%	96.3%	97.8%	101.3%	101.1%	101.7%
Wednesday	97.6%	102.2%	98.7%	106.1%	105.5%	106.8%	107.2%
Thursday	99.1%	103.2%	99.5%	103.8%	106.7%	107.3%	108.3%
Friday	102.6%	105.7%	102.4%	105.9%	107.3%	107.8%	108.0%
Saturday	114.3%	113.4%	112.6%	110.8%	111.2%	111.8%	109.9%
Sunday	100.1%	96.6%	100.2%	95.7%	92.4%	90.2%	90.1%

Review Monthly Profile or Override Values:

Chart shown at right

Month	Functional Class						
	04 - Rural Principal Arterial --	06 - Rural Minor Arterial	07 - Rural Major Collector	08 - Rural Minor Collector	14 - Urban Principal Arterial -- Other	16 - Urban Minor Arterial	17 - Urban Major Collector
January	92.5%	93.2%	95.7%	92.7%	98.3%	94.0%	101.7%
February	101.0%	102.6%	105.7%	102.3%	104.8%	103.1%	113.0%
March	107.1%	105.9%	110.6%	109.9%	107.1%	107.6%	113.5%
April	103.6%	103.8%	106.7%	105.2%	103.9%	100.6%	110.5%
May	103.2%	103.6%	103.1%	101.8%	98.0%	98.7%	102.7%
June	102.5%	101.0%	100.5%	95.4%	97.6%	95.0%	90.7%
July	100.2%	101.0%	97.7%	92.3%	96.2%	96.1%	89.5%
August	94.7%	98.3%	91.0%	94.6%	96.6%	96.9%	93.9%
September	94.5%	98.6%	89.2%	94.3%	96.1%	97.0%	94.7%
October	100.5%	100.6%	102.7%	100.6%	99.6%	102.5%	95.2%
November	101.5%	94.7%	98.9%	104.6%	101.2%	104.8%	96.9%
December	98.7%	96.9%	98.3%	106.4%	100.3%	103.5%	97.8%

2.2 A – FDOT ICE TOOL: FLORIDA DEMAND PROFILES

- Demand Profiles – Florida Weekday hourly values by functional classification
- Weekend values also available

Review Weekday Hourly Demand Profile or Override Values:
Chart shown at right

Category	Hour Starting	Functional Class						
		04 - Rural Principal Arterial --	06 - Rural Minor Arterial	07 - Rural Major Collector	08 - Rural Minor Collector	14 - Urban Principal Arterial --	16 - Urban Minor Arterial	17 - Urban Major Collector
Weekday	12:00 AM	0.7%	0.5%	0.5%	0.4%	0.8%	0.6%	0.5%
	1:00 AM	0.5%	0.3%	0.3%	0.2%	0.5%	0.4%	0.3%
	2:00 AM	0.4%	0.3%	0.3%	0.2%	0.4%	0.3%	0.2%
	3:00 AM	0.6%	0.4%	0.3%	0.2%	0.4%	0.3%	0.2%
	4:00 AM	1.1%	0.9%	0.8%	0.6%	0.7%	0.5%	0.4%
	5:00 AM	2.5%	2.3%	2.0%	1.8%	1.7%	1.5%	1.1%
	6:00 AM	4.8%	4.9%	4.3%	5.9%	4.2%	3.8%	3.6%
	7:00 AM	6.2%	6.9%	6.2%	8.6%	6.4%	6.2%	6.8%
	8:00 AM	5.7%	5.8%	5.7%	7.0%	6.3%	6.2%	6.7%
	9:00 AM	5.5%	5.6%	5.8%	5.0%	5.6%	5.6%	5.7%
	10:00 AM	5.8%	5.8%	6.2%	4.7%	5.6%	5.7%	5.6%
	11:00 AM	6.1%	6.2%	6.5%	4.7%	5.9%	6.1%	6.0%
	12:00 PM	6.2%	6.4%	6.7%	4.8%	6.3%	6.5%	6.4%
	1:00 PM	6.3%	6.4%	6.7%	5.3%	6.3%	6.5%	6.4%
	2:00 PM	6.6%	6.9%	7.0%	5.8%	6.6%	6.8%	6.8%
	3:00 PM	7.2%	7.7%	7.5%	7.0%	7.1%	7.4%	7.4%
	4:00 PM	7.8%	8.0%	7.8%	8.9%	7.5%	7.8%	8.0%
	5:00 PM	7.8%	8.0%	7.9%	10.2%	7.6%	7.9%	8.4%
	6:00 PM	5.8%	5.6%	5.8%	7.3%	6.0%	6.1%	6.3%
	7:00 PM	4.1%	3.9%	4.1%	4.2%	4.4%	4.5%	4.4%
	8:00 PM	3.1%	2.9%	3.0%	3.0%	3.5%	3.5%	3.4%
	9:00 PM	2.4%	2.1%	2.1%	2.0%	2.8%	2.8%	2.6%
	10:00 PM	1.7%	1.4%	1.5%	1.3%	2.1%	1.9%	1.7%
	11:00 PM	1.1%	0.9%	1.0%	0.8%	1.4%	1.2%	1.1%

2.2 A – FDOT ICE TOOL: DELAY

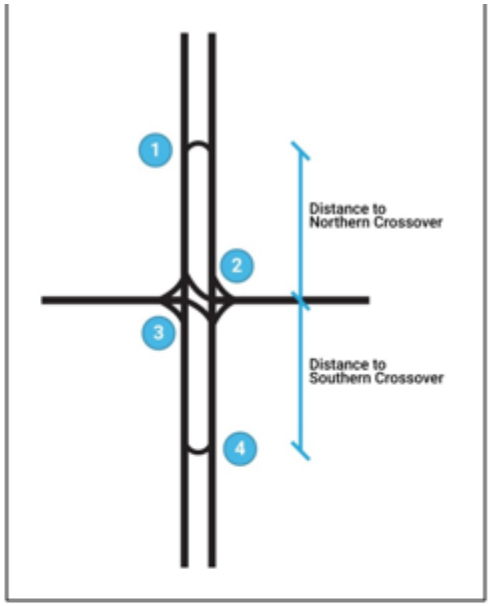
- AM and PM peak delay inputs
  - Required for opening and design years
  - Optional specification of weekend peak
  - Optional worksheets for aggregating a single delay value for MUTs, RCUTs, TWSC from multiple intersection SYNCHRO output sheets

				Opening Year			Design Year		
At-Grade Intersections				Average vehicle delay			Average vehicle delay		
Control Strategy		Delay Type	Units	AM peak	PM peak	Weekend peak	AM peak	PM peak	Weekend peak
Traffic Signal	Single Input	Single Input	sec/veh	20.1	28.9		22.2	35.4	
Median U-Turn (MUT)	Select Input Type	Worksheet (N-S)	sec/veh	12.0	14.5		12.1	23.2	
Signalized Restricted Crossing U-Turn (RCUT)	Select Input Type	Worksheet (N-S)	sec/veh	14.0	20.5		21.8	49.4	

2.2 A – FDOT ICE TOOL: DELAY WORKSHEET

RCUT N-S

Use this sheet to enter the delay information for a Signalized RCUT with the major street running North-South. (Requires turning movement count demand inputs)



User must enter value on this sheet

	Southern Crossover	Northern Crossover
Distance from main intersection to:	700	900
Free-flow speed on major street:	45	

*Volumes are computed based on values entered in DemandCounts and Exhibit 6-2 of FHWA RCUT Guide

Opening Year AM Peak				
Intersection 1	SB Thru	NB U-Turn		
Volume	1316	23		
Delay	2.4	16.7		
Intersection 2	NB Left	NB Thru	NB Right	WB Right
Volume	41	1976	8	81
Delay	35.1	6.1	2.7	25
Intersection 3	SB Left	SB Thru	SB Right	EB Right
Volume	39	1235	65	158
Delay	23.7	4.7	2.5	24.2
Intersection 4	NB Thru	SB U-Turn		
Volume	1910	115		
Delay	6.8	24.2		

Opening Year PM Peak				
Intersection 1	SB Thru	NB U-Turn		
Volume	2379	25		
Delay	5.3	34.2		
Intersection 2	NB Left	NB Thru	NB Right	WB Right
Volume	68	1834	30	64
Delay	22.4	2.4	0.1	37.7
Intersection 3	SB Left	SB Thru	SB Right	EB Right
Volume	101	2146	157	299
Delay	53.2	9.7	3.8	47.9
Intersection 4	NB Thru	SB U-Turn		
Volume	1707	225		
Delay	9.2	32.6		

Opening Year Weekend Peak				
Intersection 1	SB Thru	NB U-Turn		
Volume	0	0		
Delay				
Intersection 2	NB Left	NB Thru	NB Right	WB Right
Volume	0	0	0	0
Delay				
Intersection 3	SB Left	SB Thru	SB Right	EB Right
Volume	0	0	0	0
Delay				
Intersection 4	NB Thru	SB U-Turn		
Volume	0	0		
Delay				

2.2 A – FDOT ICE TOOL: SAFETY

- Requires Total and Fatal & Injury crashes for each intersection
- Input SPICE Tool outputs

At-Grade Intersection	Crash Type	Opening Year	Design Year
Traffic Signal	Total	34.44	41.83
	Fatal & Injury	8.55	10.62
Median U-Turn (MUT)	Total	29.27	35.56
	Fatal & Injury	5.99	7.43
Signalized Restricted Crossing U-Turn (RCUT)	Total	29.27	35.56
	Fatal & Injury	6.67	8.28

CMFs			
	Median U-Turn (MUT)	Total	0.85
		Fatal & Injury	0.70
	Signalized Restricted	Total	0.85
		Fatal & Injury	0.78

This table contains the same CMFs as the FDOT SPICE tool. The CMFs are automatically applied to the user inputs for Traffic Signal or Minor Road Stop, an can be overridden at the user's discretion.

2.2 A – FDOT ICE TOOL: OUTPUTS

Analysis Summary

Cost Categories	Net Present Value of Costs		
	Traffic Signal	Median U-Turn (MUT)	Signalized Restricted Crossing U-Turn (RCUT)
Planning, Construction & Right of Way Costs	$ -	$ 1,600,000	$ 1,780,000
Post-Opening Costs	$ 98,229	$ 238,276	$ 238,276
Auto Passenger Delay	$ 35,897,182	$ 20,203,649	$ 30,687,128
Truck Delay	$ 6,142,739	$ 3,456,863	$ 5,246,883
Safety	$ 155,464,037	$ 131,988,027	$ 131,750,017
Total cost	**$197,602,186**	**$157,486,816**	**$169,702,305**

→ Net present value of costs

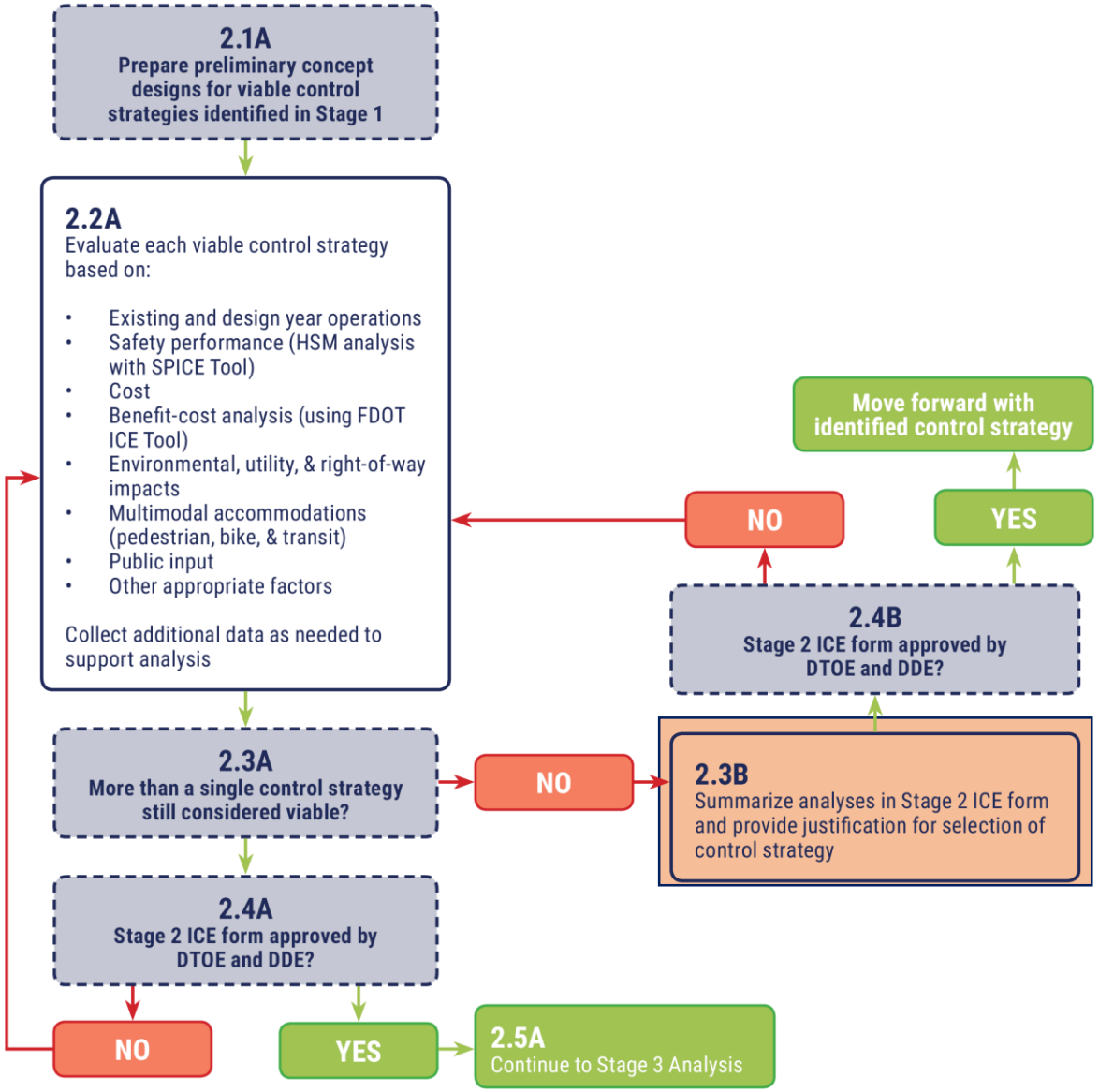
Select Base Case for Benefit-Cost Comparison:	Traffic Signal

Benefit Categories	Net Present Value of Benefits Relative to Base Case		
	Traffic Signal	Median U-Turn (MUT)	Signalized Restricted Crossing U-Turn (RCUT)
Auto Passenger Delay		$ 15,693,533	$ 5,210,053
Truck Delay		$ 2,685,875	$ 895,856
Safety		$ 23,476,009	$ 23,714,019
Net Present Value of Benefits		**$ 41,855,417**	**$ 29,819,928**
Net Present Value of Costs		**$ 1,740,048**	**$ 1,920,048**
Net Present Value of Improvement		**$ 40,115,369**	**$ 27,899,881**
Benefit-Cost (B/C) Ratio		**24.05**	**15.53**
Delay B/C		**10.56**	**3.18**
Safety B/C		**13.49**	**12.35**

→ Net present value of Benefits

→ Benefit-Cost Ratio (if Base Case exists)

ICE STAGE 2 PROCESS



Reference: FDOT Manual of Intersection Control Evaluation; Nov. 1, 2017; Figure 3; Page 14

2.2 A – ICE FORM STAGE 2: DOCUMENTATION OF EVALUATION

Safety Performance

Enter the most recent five (5) years of crash data from the CAR System.

Crash Type		Most recent year of data available		2015			Total
		2011	2012	2013	2014	2015	
Combined	Total	43	49	44	30	60	226
	Fatal/Injury	13	9	9	8	17	56
	PDO	30	40	35	22	43	170
Single-Vehicle	Total	0	0	0	0	0	0
	Fatal/Injury	0	0	0	0	0	0
	PDO	0	0	0	0	0	0
Mutiple-Vehicle	Total	0	0	0	0	0	0
	Fatal/Injury	0	0	0	0	0	0
	PDO	0	0	0	0	0	0
Vehicle-Pedestrian	Fatal/Injury	1	2	0	1	0	4
Vehicle-Bicycle	Fatal/Injury	1	0	0	0	0	1
Total	All	45	51	44	31	60	231

Apply the FDOT SPICE Tool to model anticipated safety performance of each control strategy. For intersection types not accommodated in the tool, manually apply crash modification factors detailed in the ICE procedures document or qualitatively describe anticipated safety impacts.

Control Strategy	Anticipated Impact on Safety Performance	Opening Year		Design Year	
		Predicted Total Crashes	Predicted Fatal & Injury Crashes	Predicted Total Crashes	Predicted Fatal & Injury Crashes
Signalized Control	The signalized control alternative is predicted to have the highest number of overall crashes as well as fatal/injury related crashes.	34.44	8.55	41.83	10.62
Median U-Turn	PARTIAL - The MUT North-South control alternative is predicted to have lowest overall crashes and the third lowest number of fatal/injury crashes.	29.27	5.99	35.56	7.43
Restricted Crossing U-Turn (RCUT) Signalized	The RCUT control alternative is predicted to have lowest overall crashes along with MUT and the second lowest number of fatal/injury crashes.	29.27	6.67	35.56	8.28

Benefit/Cost Ratios

Apply the FDOT ICE Tool to determine the delay benefit-cost ratio (B/C), safety B/C, and overall B/C for each control strategy.

Control Strategy	Delay B/C	Safety B/C	Overall B/C
Signalized Control	-	-	-
Median U-Turn	10.56	13.49	26.48
Restricted Crossing U-Turn (RCUT) Signalized	3.18	12.35	15.53

2.2 A – ICE FORM STAGE 2: DOCUMENTATION OF EVALUATION

Multimodal Accommodations

Note the existing/anticipated level of pedestrian/bicyclist activity at the study intersection during the peak hours of the typical day. See ICE procedures document for activity level thresholds:

	AM Peak Hour		PM Peak Hour		
	Major Street	**Minor Street**	**Major Street**	**Minor Street**	
# of pedestrian crossings (both approaches, if	17	20	67	14	Level of pedestrian activity: Medium
# of bicyclists (both approaches, if app.):	0	0	0	0	Level of bicycle activity: Low

Summarize the ability of each viable control strategy to accommodate the existing/anticipated level of:

Control Strategy	Pedestrians and Bicycles	Transit Services	Freight Needs
Signalized Control	The signalized control allows for ped crossing maneuvers. Bicycle facilities should still be	No change from existing.	No change from existing.
Median U-Turn	PARTIAL - The MUT would allow ped crossings upstrea and downstream scenario.	No change from existing.	No change from existing.
Restricted Crossing U-Turn (RCUT) Signalized	The RCUT would continue to allow for ped crosswalks on each leg of the intersection.	No change from existing.	No change from existing.

Environmental, Utility, and Right-of-Way Impacts

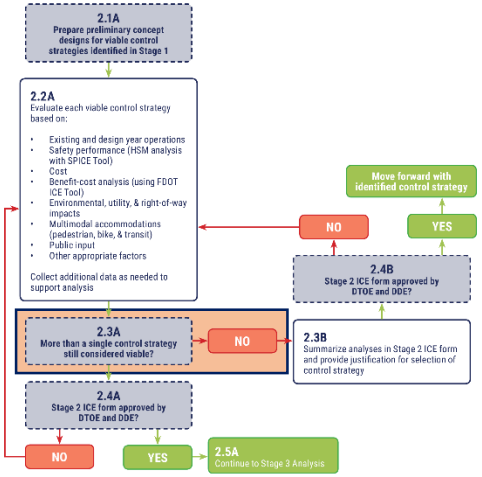
Summarize any issues related to environmental, utility, or right-of-way (to include relocations) impacts specific to each control strategy. Be sure to consider the NEPA requirements for each control type.

Signalized Control	No impacts anticipated.
Median U-Turn	ROW acquisition needed on the SW corner of the intersection.
Restricted Crossing U-Turn (RCUT) Signalized	ROW acquisition needed on the west side of the intersection.

Public Input/Feedback (if appropriate)

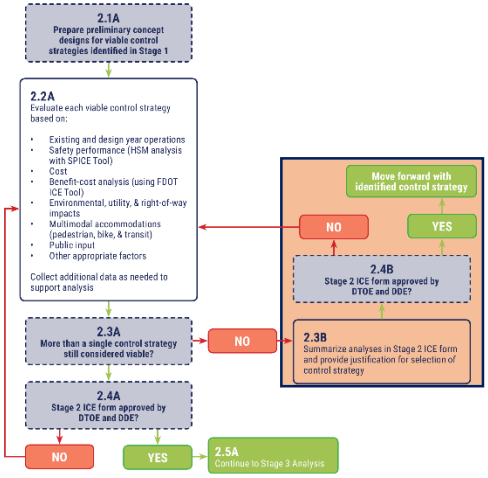
Summarize any agency or public input regarding the control strategies:	None performed to date.

2.3 A – ICE FORM STAGE 2: VIABLE CONTROL STRATEGIES SELECTION

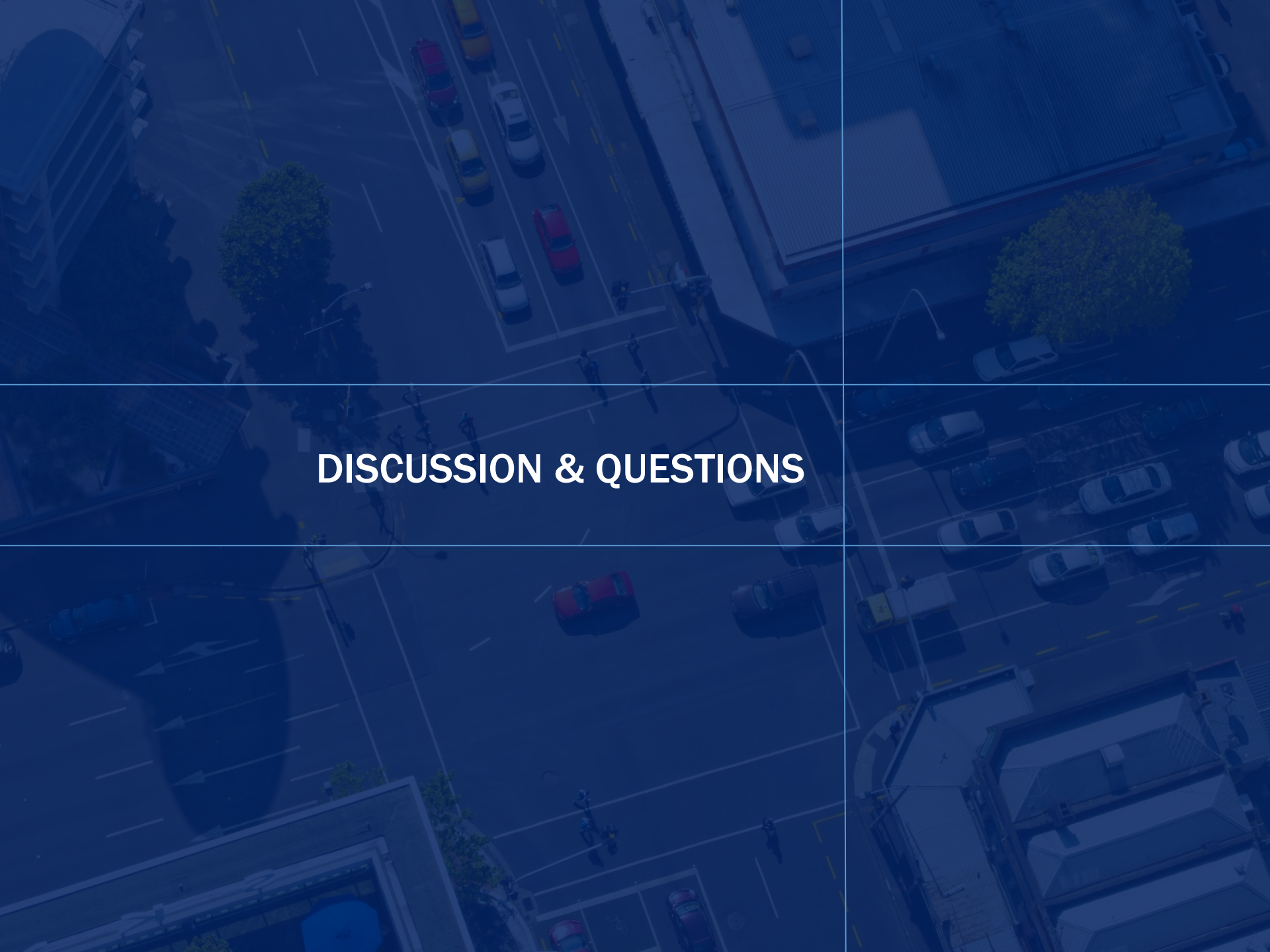


Control Strategy Evaluation		
Provide a brief justification as to why each of the following is either viable or not viable. If a single control strategy is recommended, select it as the only control strategy to be advanced.		
Control Strategy	**Strategy to be Advanced?**	**Justification**
Signalized Control	NO	The signalized control operates slightly better than the RCUT but worse than the Partial MUT. From a safety perspective, the traffic signal performs worse than both the RCUT and PMUT.
Median U-Turn	YES	PARTIAL - The MUT operates better than both the signalized and RCUT control alternatives in terms of operations and safety.
Restricted Crossing U-Turn (RCUT) Signalized	NO	The RCUT operates the worst when compared to the signal and PMUT alternatives. The RCUT and the PMUT perform similarly in terms of safety benefit.

2.4 B – FDOT ICE FORM APPROVAL – STAGE 2



Resolution			
To be filled out by FDOT District Traffic Operations Engineer and District Design Engineer			
Project Determination			
Comments			
DTOE Name *(Type)*		Signature	Date
DDE Name *(Type)*		Signature	Date



DISCUSSION & QUESTIONS

Georgia's ICE Policy and Tools

Christina Barry, P.E.

Georgia Department of Transportation

Office of Traffic Operations

Overview

- ❖ Quick Facts
- ❖ GDOT's ICE Policy
  - Background
  - ICE Policy
  - ICE Process
- ❖ Lessons Learned

Georgia Quick Facts

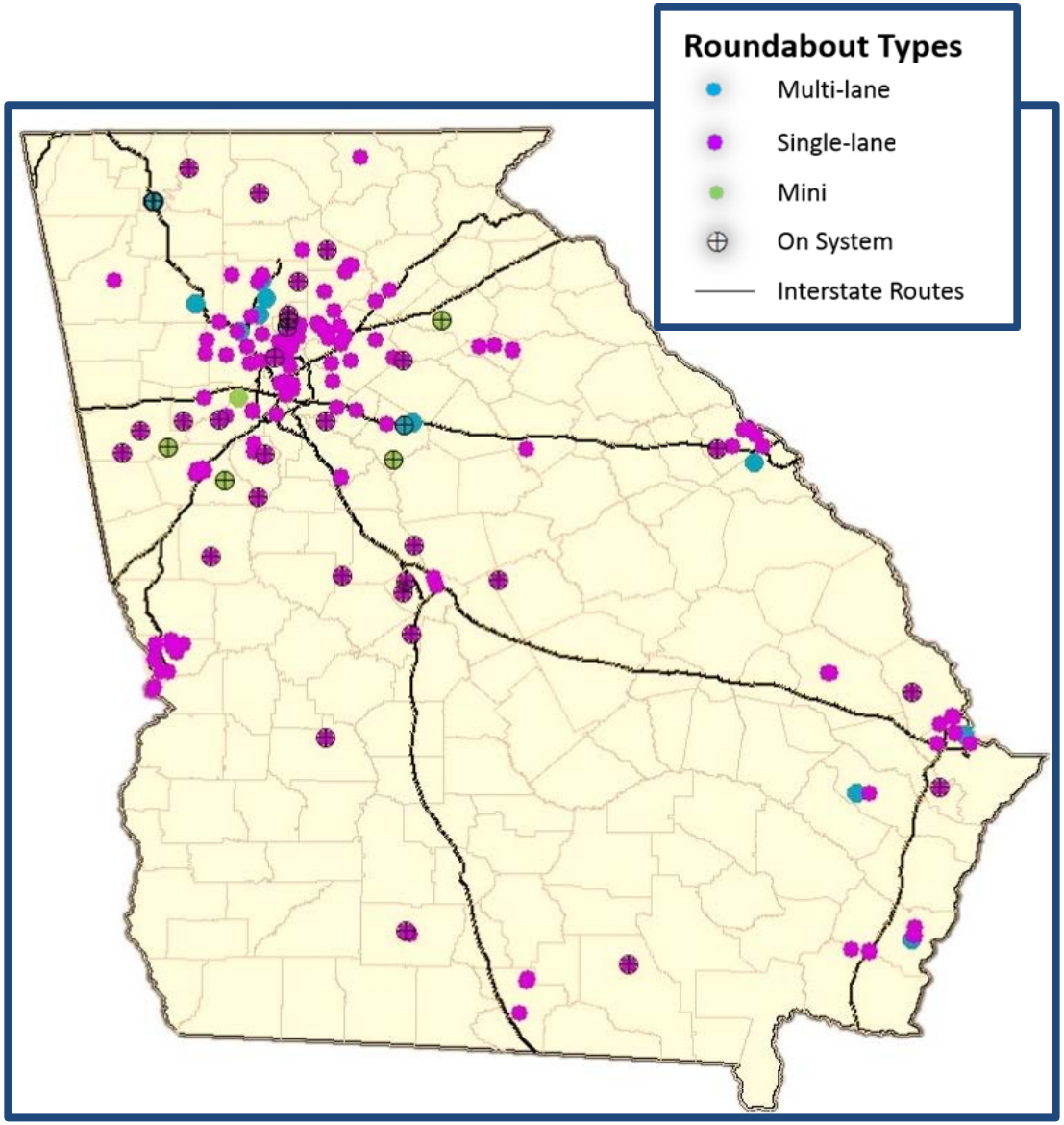
Intersection Types

- 9,500+ Traffic Signals
- 100+ On System AWSC

Georgia Quick Facts

Intersection Types

- 9,500+ Traffic Signals
- 100+ On System AWSC
- 175+ Roundabouts

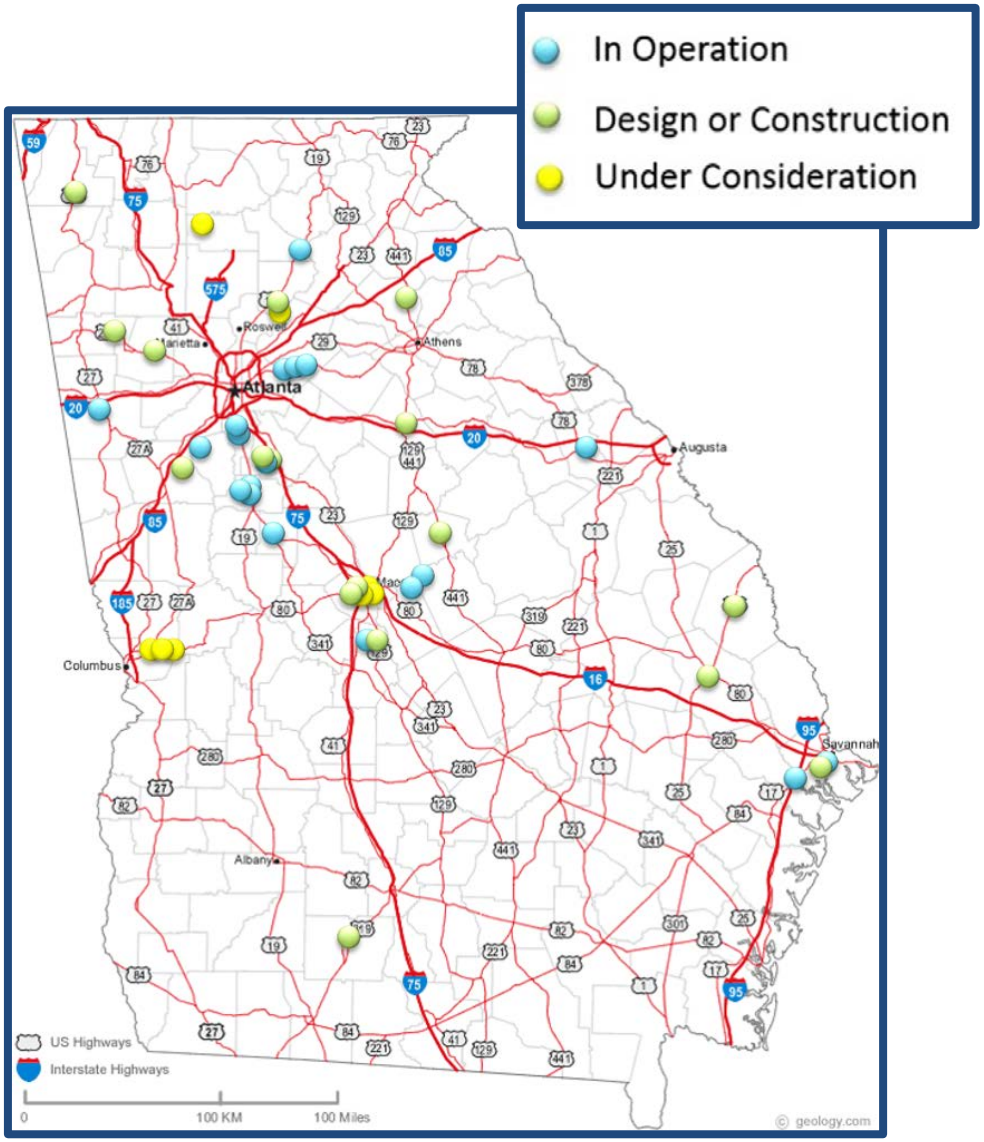


I-285 @ Riverside Dr

Georgia Quick Facts

Intersection Types

- 9,500+ Traffic Signals
- 100+ On System AWSC
- 175+ Roundabouts
- 30+ RCUTS

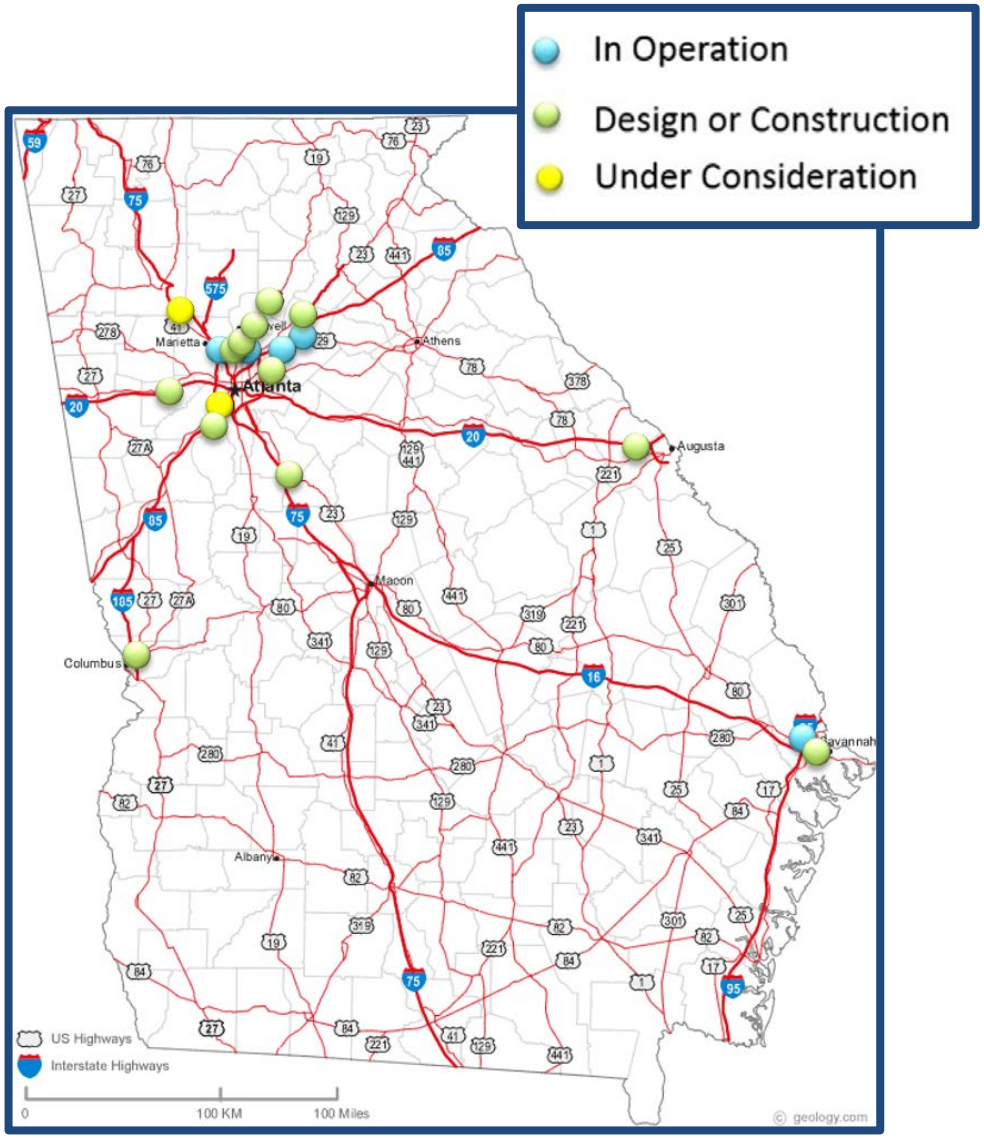


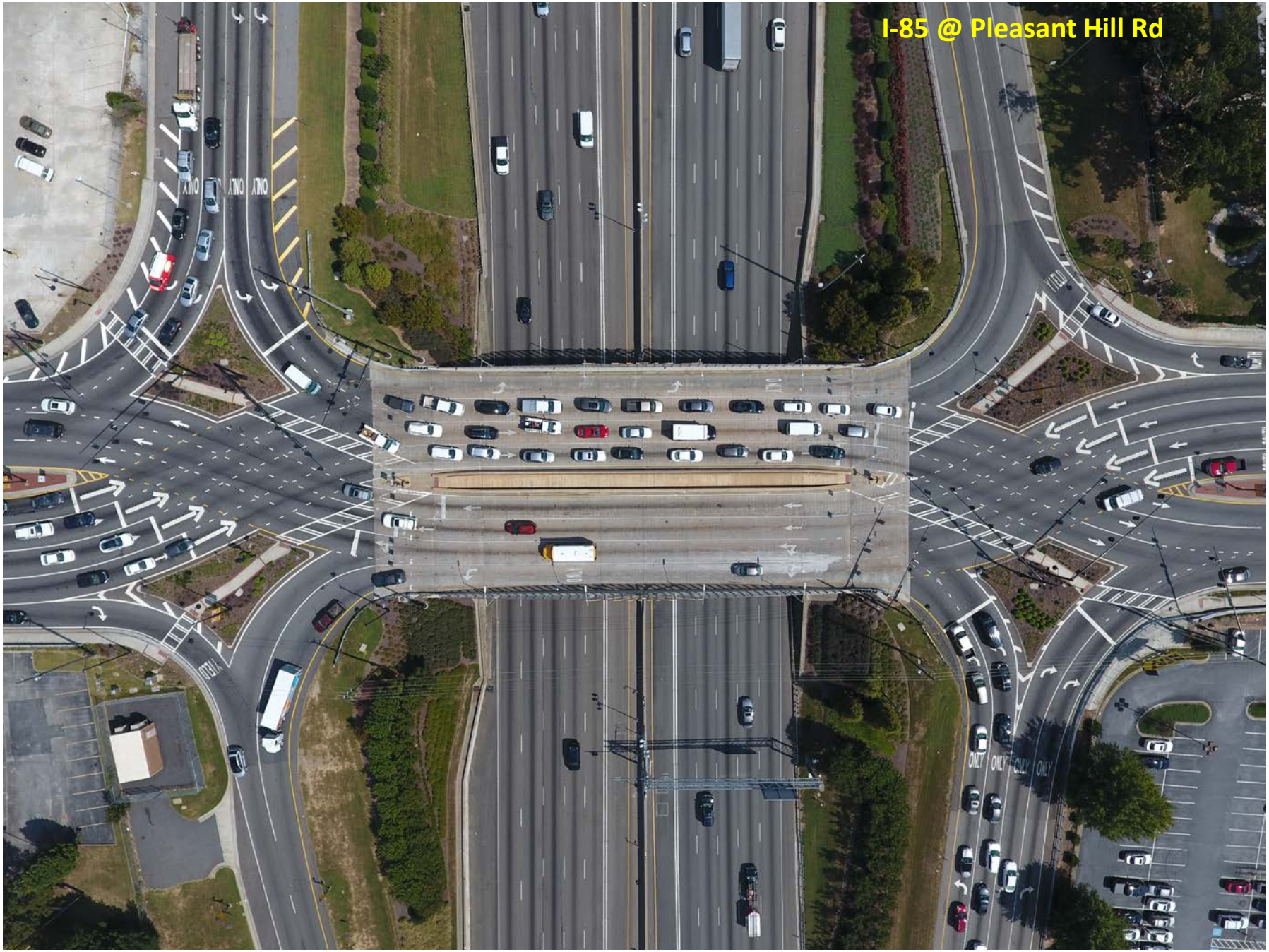

SR 400 @ N 400 Center Ln

Georgia Quick Facts

Intersection Types

- 9,500+ Traffic Signals
- 100+ On System AWSC
- 175+ Roundabouts
- 25+ RCUTS
- 5 DDIs

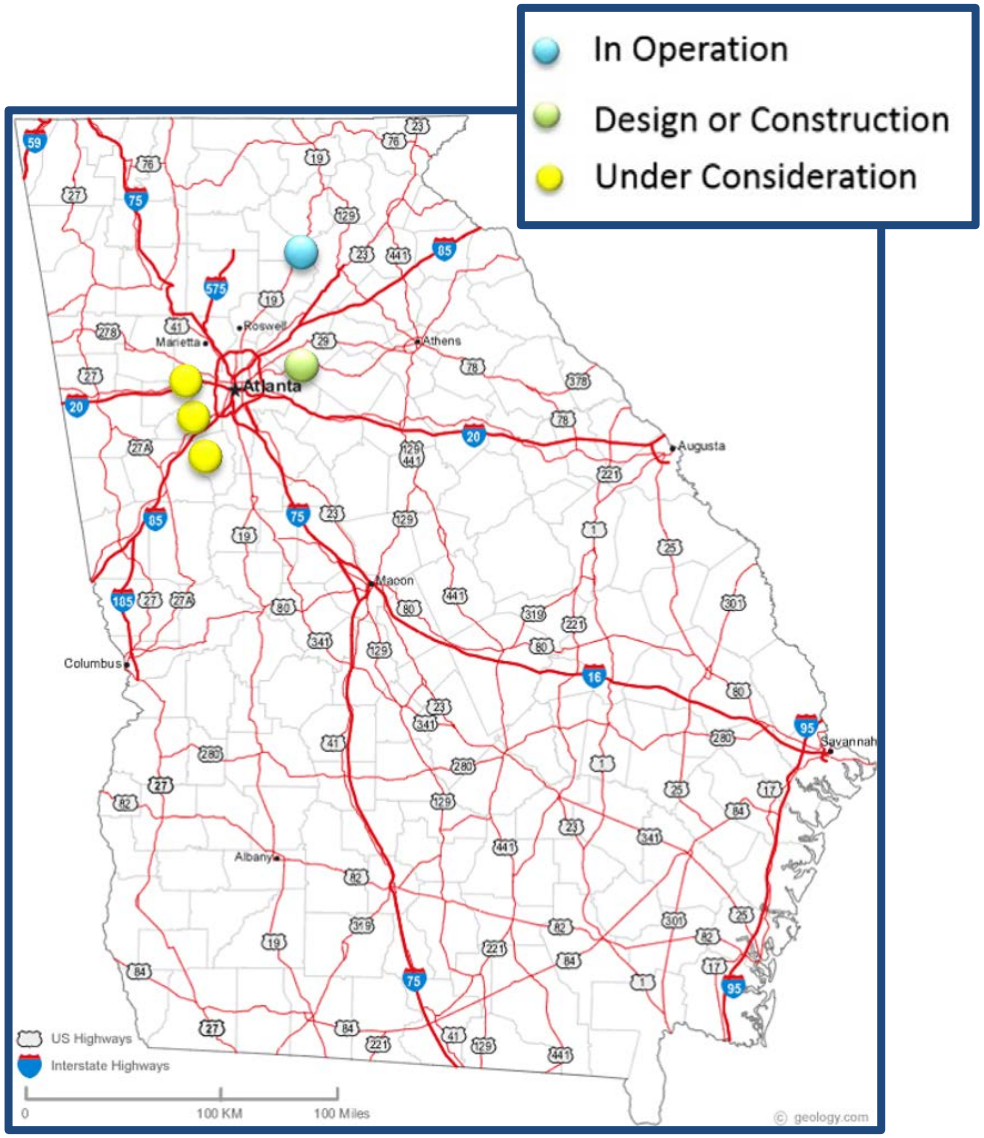



I-85 @ Pleasant Hill Rd

Georgia Quick Facts

Intersection Types

- 9,500+ Traffic Signals
- 100+ On System AWSC
- 175+ Roundabouts
- 25+ RCUTS
- 5 DDIs
- 1 CFI

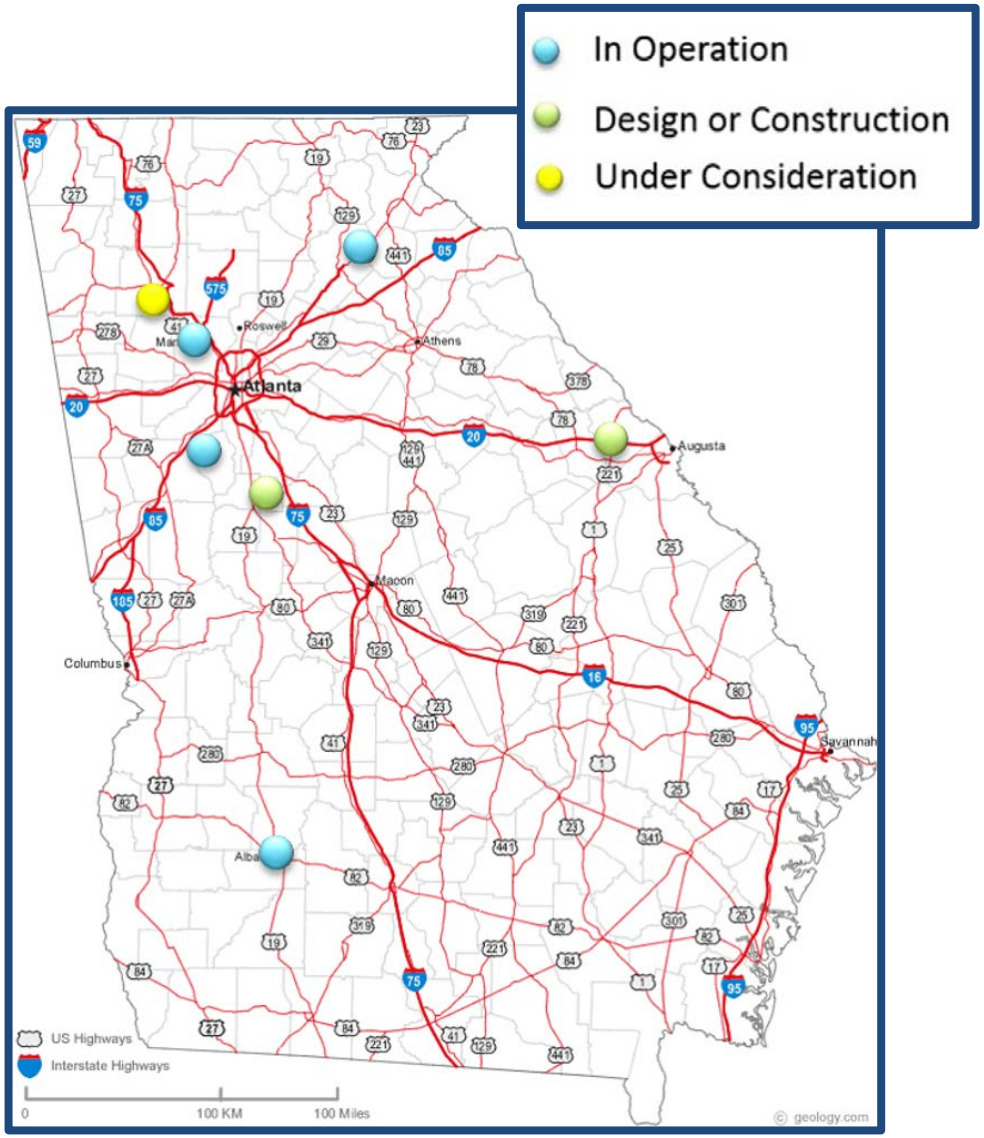



SR 400 @ SR 53

Georgia Quick Facts

Intersection Types

- 9,500+ Traffic Signals
- 100+ On System AWSC
- 175+ Roundabouts
- 25+ RCUTS
- 5 DDIs
- 1 CFI
- 5+ Continuous Green T



Intersection Control Evaluation

BACKGROUND

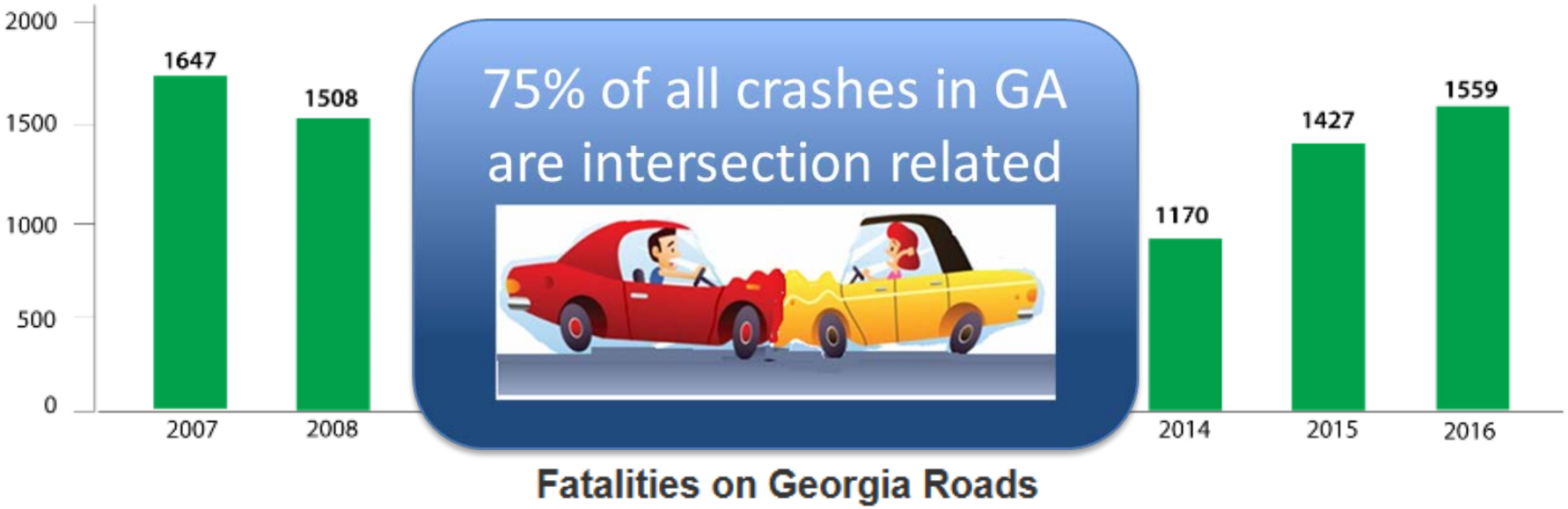
GDOT Mission Statement

Deliver a transportation system focused on innovation, safety, sustainability and mobility

http://alphastockimages.com/

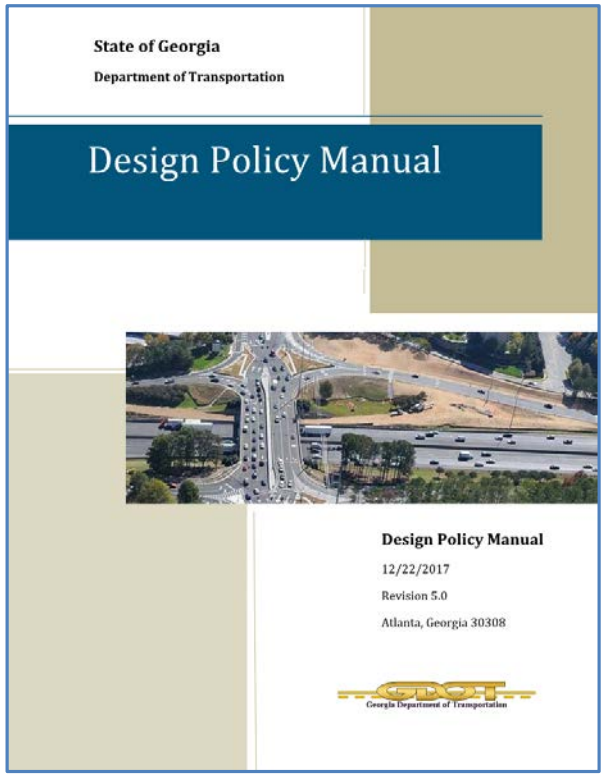
Why ICE??

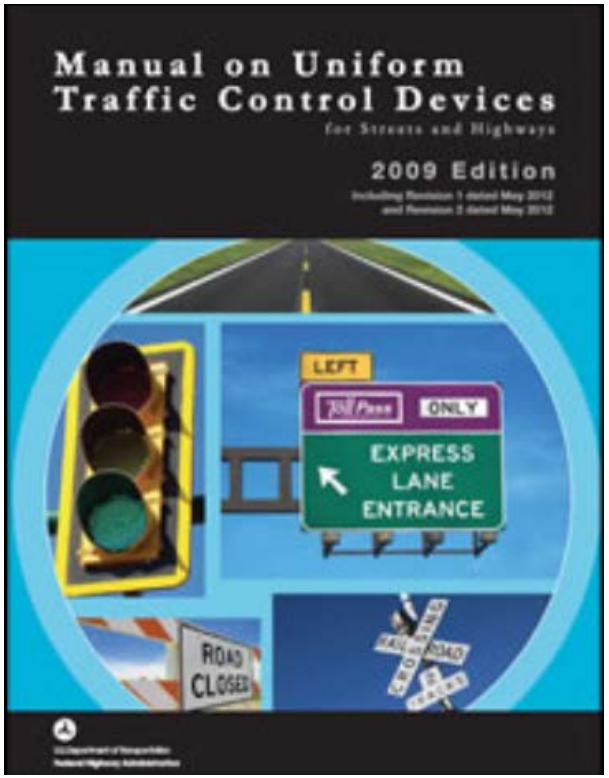
Integrate safety into our decision making process for intersection control on **ALL** projects



Intersection Control Policy Before ICE

- **GDOT Design Policy Manual**
  - **Ch. 7 Design Policy Manual: At Grade Intersections**
  - **Ch. 8 Design Policy Manual: Roundabouts**
- **MUTCD**

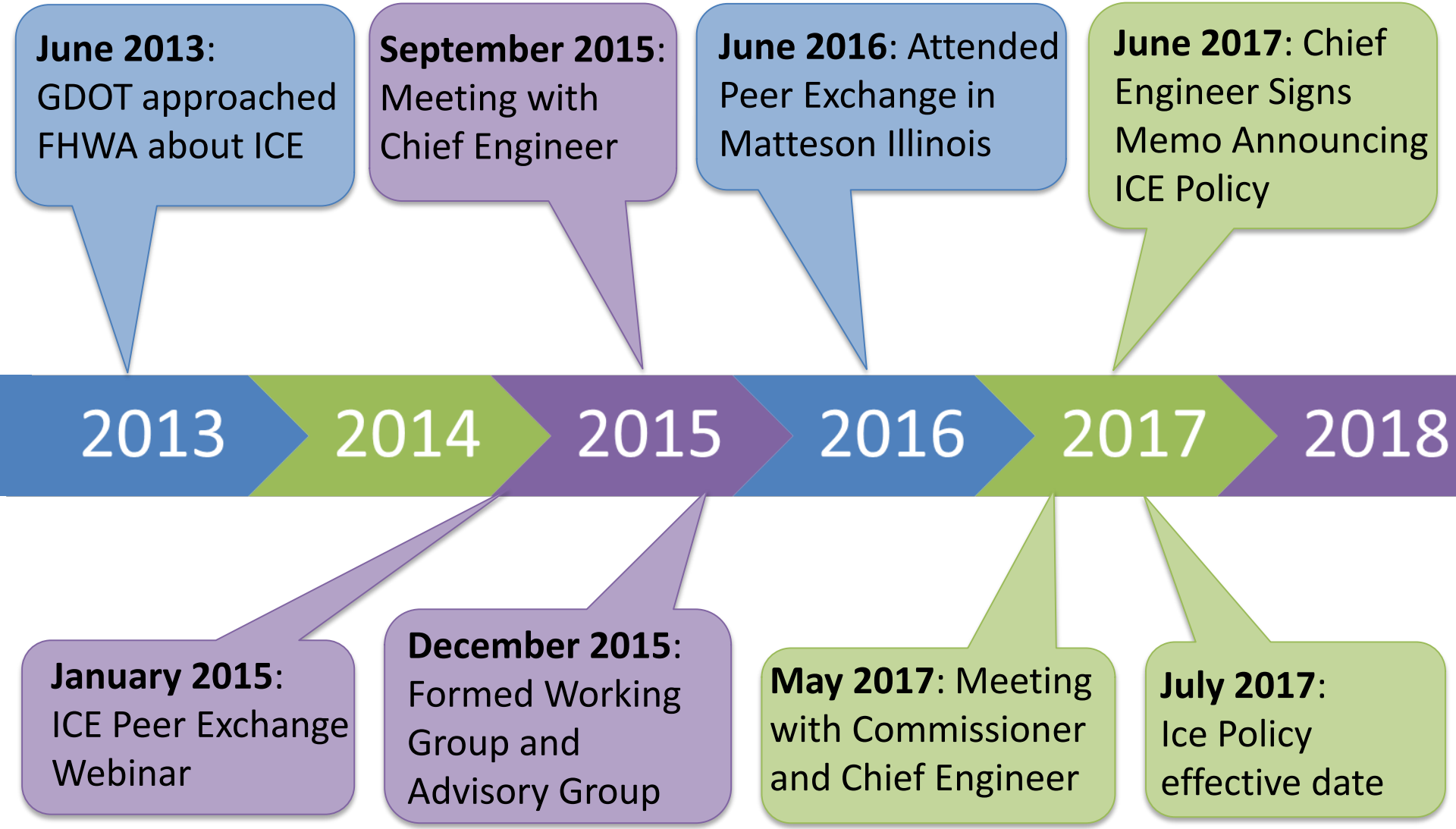




Leading up to ICE

- Frustration due to the lack of non-traditional alternatives considered
- Create a level playing field for all alternatives
- Desire to infuse safety throughout our decision making process by bringing attention to “non-traditional” intersection types
- Provide documentation to support the intersection control decision

ICE Policy Timeline



Implementation

- ICE is required for all projects that do not have concept approval by **July 1, 2017**
- If ICE would delay the concept report submittal for any projects that **have schedules set by July 1, 2017**, ICE may be completed during the preliminary design phase
- Submittals during preliminary design must occur **no later than 1/3** of the way through the time allotted for preliminary design

Intersection Control Evaluation

THE POLICY

Location and format

http://www.dot.ga.gov/

Intersection Control Evaluation
ICE Policy Training Presentation
ICE Tool Training Presentation
Intersection Control Evaluation (ICE) Policy
Intersection Control Evaluation (ICE) Policy: Appendix A - Stage 1
Intersection Control Evaluation (ICE) Policy: Appendix B - Stage 2
Intersection Control Evaluation (ICE) Policy: Appendix C
Intersection Control Evaluation (ICE) Policy: Appendix D
Intersection Control Evaluation (ICE) Policy: Tool V2.01
Intersection Control Evaluation (ICE) Policy: Tool V2.01 Example
Memo

Scroll to bottom of the page

Requirements & Waiver

Not Required	Required	Waiver
No changes to intersection footprint or control	Project is on State route/NHS and/or uses State or Federal money	ICE ***may*** be waived based on appropriate evidence and a written request

Approvals

Level 1: Chief Engineer (or Designee)

- Projects going through Plan Development Process
- New or revised signal permits
- New median openings

Level 2: District Engineer with notification to Chief Engineer

Projects that are not level 1 where:

- Leg is added to intersection
- Intersection control is changes

Level 3: District Engineer

- QR, Driveway Permits, Maintenance Work that does not qualify as level 2

Intersection Control Evaluation

THE PROCESS

ICE – The Process

Screening effort to eliminate non-competitive options and identify alternatives for further consideration

Detailed evaluation of the alternatives identified in Stage 1 in order to support the selection of the preferred alternative that will be advanced to detailed design

Stage 1 - Screening

Unsignalized

- Minor Stop
- All-Way Stop
- Mini Roundabout
- Single Lane Roundabout
- Multilane Roundabout
- RCUT
- RIRO w/Downstream U-Turn
- High-T (unsignalized)
- Offset-T Intersections
- Diamond Interchange (Stop)
- Diamond Interchange (RAB)
- Turn Lane/Median Improvements
- Other

Stage 1 - Screening

Signalized

- Signal
- Median U-Turn
- RCUT
- Displaced Left Turn (CFI)
- Continuous Green-T
- Jughandle
- Diamond Interchange (signal)
- Quadrant Roadway
- Diverging Diamond
- Single Point Interchange
- Turn Lane/Median Improvements
- Other

Stage 1 - Screening

1. Does alternative address the **project need** in a **balanced manner** and **in scale** with the project?
2. Does alternative **improve safety performance** in terms of reducing severe crashes?
3. Does alternative incorporate **convenience** and **accessibility** for **pedestrians and/or bicyclists**
4. Does alternative **improve (or preserve) traffic operations** (congestion, delay, reliability, etc.)?
5. Does alternative **appear feasible** given the site **characteristics, constrains and location context**?
6. Does alternative **appear feasible** with respect to **other project factors**?
7. **Overall feasible alternative?**

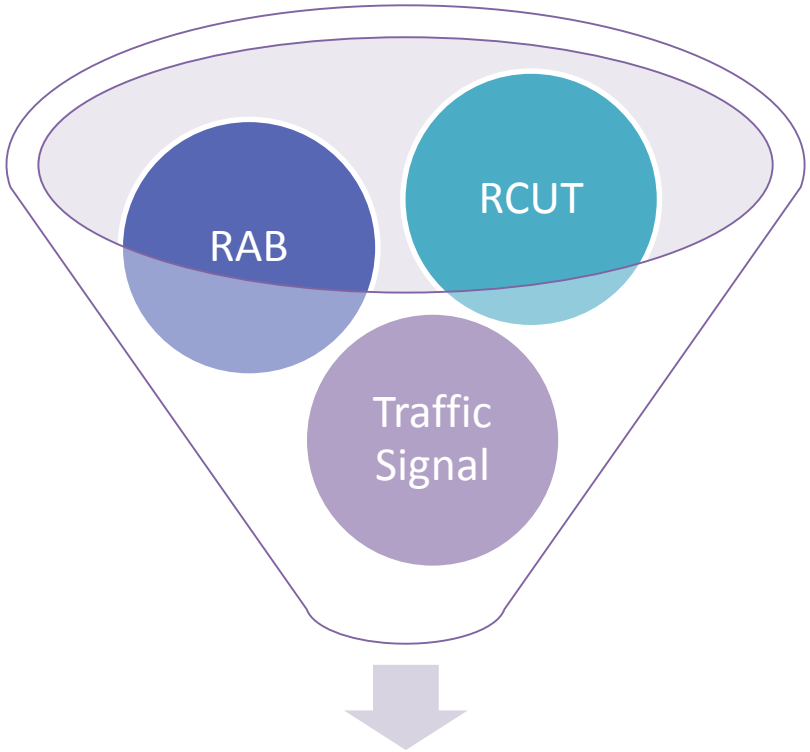
ICE Documentation

Stage 1

- Completed Stage 1 Decision Record
- Single intersection projects may proceed seamlessly to Stage 2
- For corridor projects a concurrence memo is recommended

Stage 2 - Alternative Selection

Shortlist of Alternatives from Stage 1



Preferred Alternative

- Total Project Cost
- Traffic Operations
- Safety Analysis
- Environmental Impacts
- Stakeholder Posture

ICE Documentation

Stage 1

- Completed Stage 1 Decision Record
- Single intersection projects may proceed seamlessly to Stage 2
- For corridor projects a concurrence memo is recommended

Stage 2

- Completed Alternative Selection Decision Record with Supporting documentation
- Included in Project Concept Report or as a stand-alone document
- Completed waiver form if the ICE recommended alternative is not selected as the preferred alternative

Intersection Control Evaluation

THE TOOL

ICE Tool

- Excel Based
- Streamline the process for evaluating alternatives
- Provide standardized decision records for Stage 1 and Stage 2
- Assists the analyst in choosing the best alternative for the intersection

Location and format

http://www.dot.ga.gov/

Intersection Control Evaluation
ICE Policy Training Presentation
ICE Tool Training Presentation
Intersection Control Evaluation (ICE) Policy
Intersection Control Evaluation (ICE) Policy: Appendix A - Stage 1
Intersection Control Evaluation (ICE) Policy: Appendix B - Stage 2
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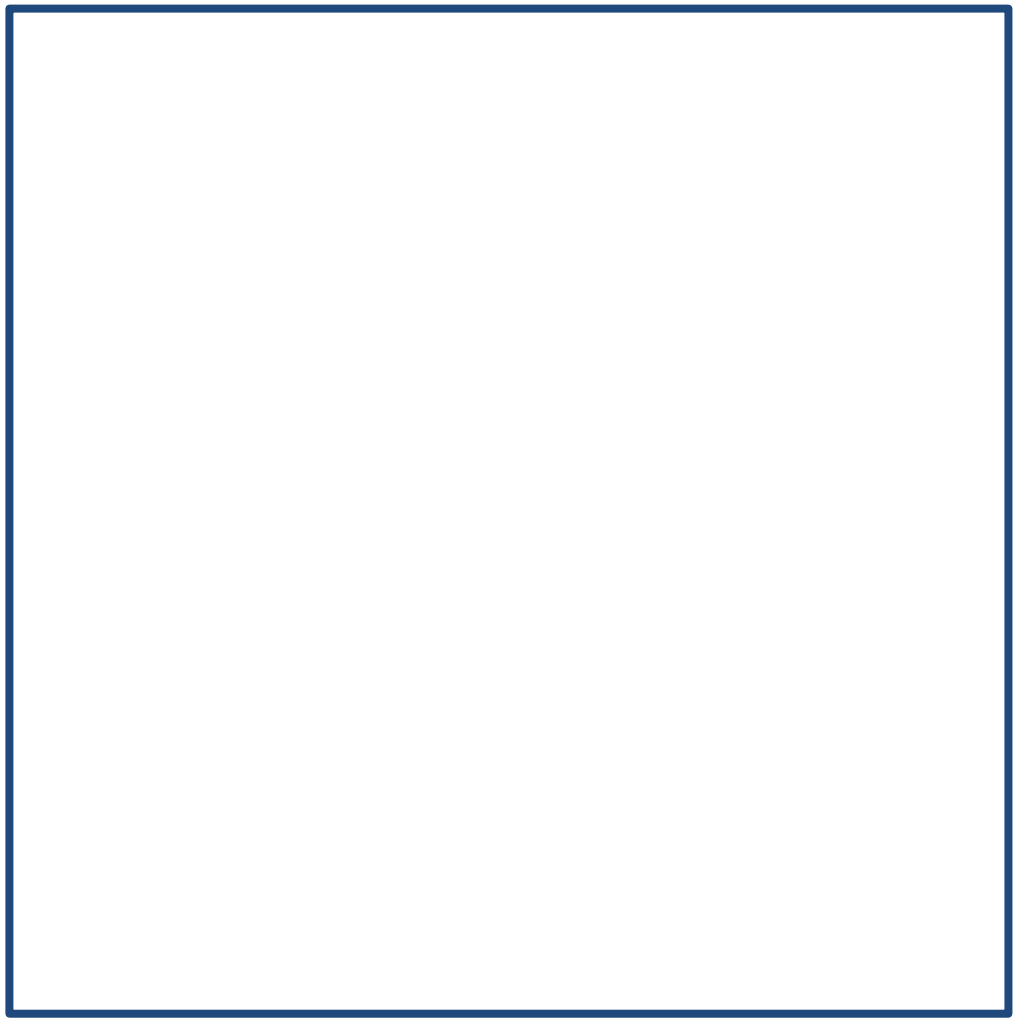
Intersection Control Evaluation (ICE) Policy: Appendix D
Intersection Control Evaluation (ICE) Policy: Tool V2.01
Intersection Control Evaluation (ICE) Policy: Tool V2.01 Example
Memo

Scroll to bottom of the page

Introduction

- Project information will be automatically populated to other tabs
- Cell Colors: White = Automatically populated; Blue = Editable; Gray = Drop Down

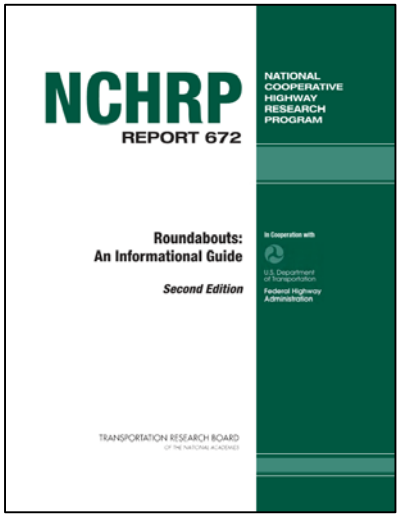
Stage 1

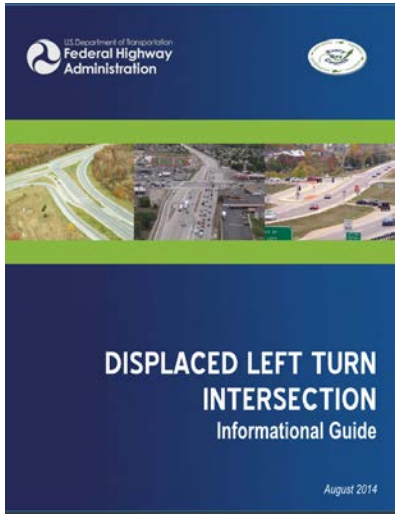


- Yes/no questions for each alternative
- Enter screening justification decision
- May attach additional sheets if needed
- Row will turn Green if question 7 is answered with “yes”

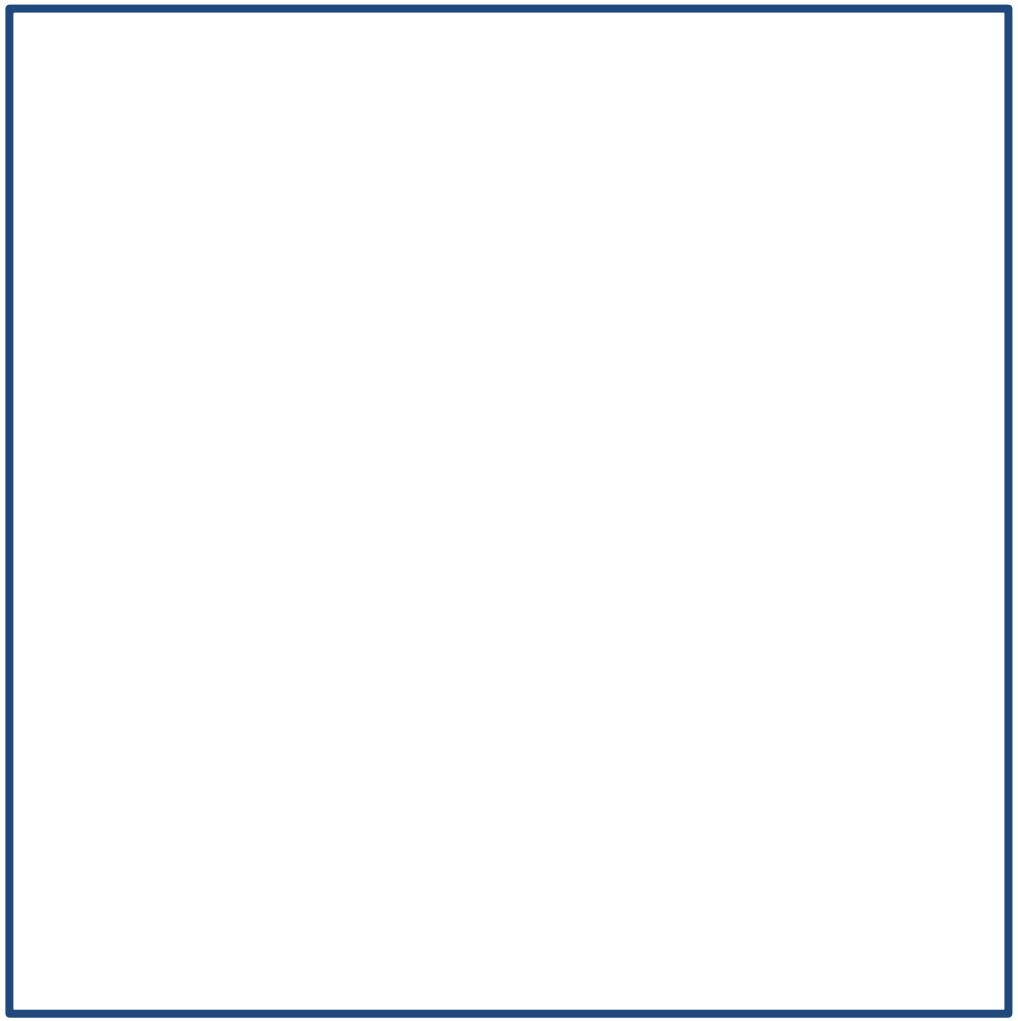
Intersections Tab

- Intersection descriptions and pictures
- Click on a picture for more information





Stage 1

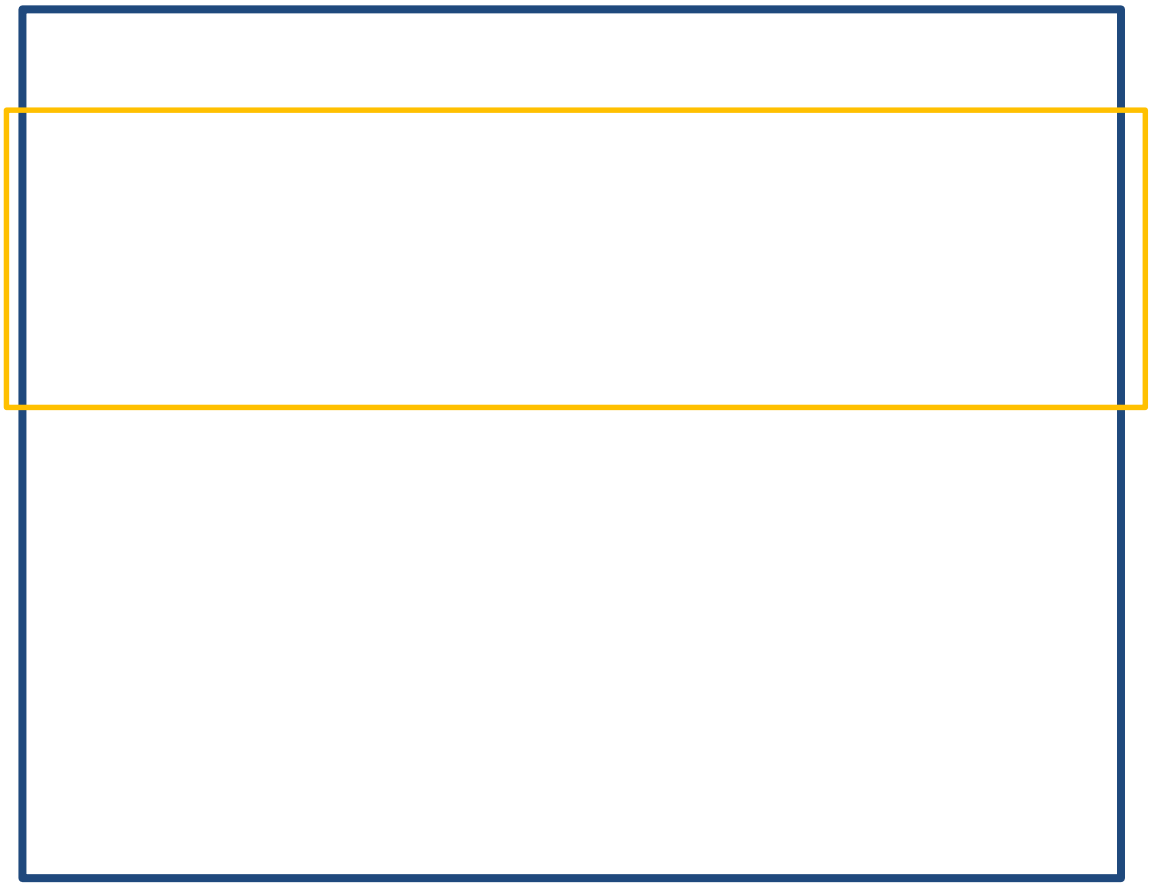


- Yes/no questions for each alternative
- Enter screening justification decision
- May attach additional sheets if needed
- Row will turn Green if question 7 is answered with “yes”

Stage 2

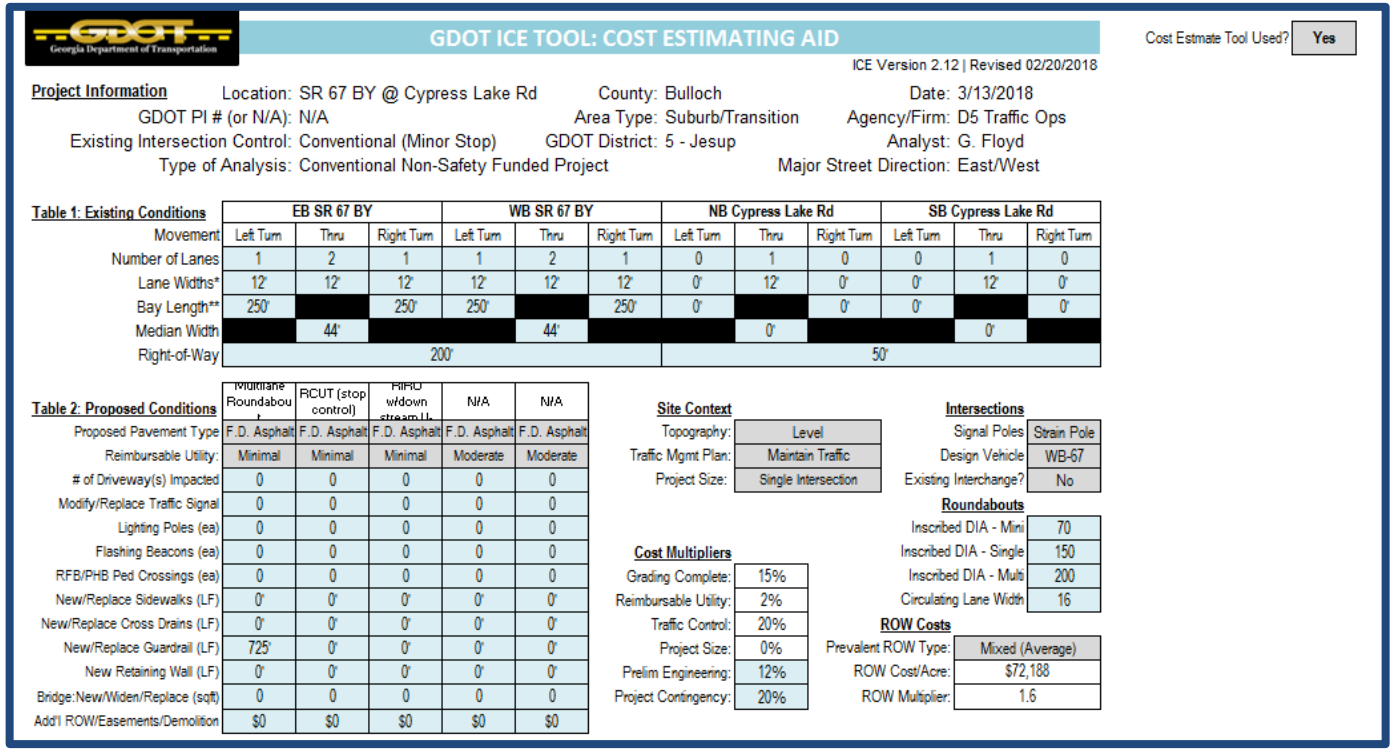
- Comparison between alternatives
- Warrant analysis, no build operational analysis, crash data entered at top of

Stage 2



- **Project Cost:** Project Cost can be estimated using the CostEst Tab or by another method
- **Traffic Operations:** AM and PM DHV analysis
- **Safety analysis:**
  - Prepopulated based on existing intersection control
  - CRFs from FHWA Clearinghouse
  - Can be overridden with user defined CRFs

Cost Tab



GDOT ICE TOOL: COST ESTIMATING AID

ICE Version 2.12 | Revised 02/20/2018

Cost Estmate Tool Used? Yes

Project Information

Location: SR 67 BY @ Cypress Lake Rd
County: Bulloch
Date: 3/13/2018
GDOT PI # (or N/A): N/A
Area Type: Suburb/Transition
Agency/Firm: D5 Traffic Ops
Existing Intersection Control: Conventional (Minor Stop)
GDOT District: 5 - Jesup
Analyst: G. Floyd
Type of Analysis: Conventional Non-Safety Funded Project
Major Street Direction: East/West

Table 1: Existing Conditions

Movement	EB SR 67 BY			WB SR 67 BY			NB Cypress Lake Rd			SB Cypress Lake Rd		
	Left Turn	Thru	Right Turn	Left Turn	Thru	Right Turn	Left Turn	Thru	Right Turn	Left Turn	Thru	Right Turn
Number of Lanes	1	2	1	1	2	1	0	1	0	0	1	0
Lane Widths*	12'	12'	12'	12'	12'	12'	0'	12'	0'	0'	12'	0'
Bay Length**	250'		250'	250'		250'	0'		0'	0'		0'
Median Width		44'			44'			0'			0'	
Right-of-Way	200'						50'					

Table 2: Proposed Conditions

	Multilane Roundabout	RCUT (stop control)	RIRO w/down stream U-t	N/A	N/A
Proposed Pavement Type	F.D. Asphalt	F.D. Asphalt	F.D. Asphalt	F.D. Asphalt	F.D. Asphalt
Reimbursable Utility:	Minimal	Minimal	Minimal	Moderate	Moderate
# of Driveway(s) Impacted	0	0	0	0	0
Modify/Replace Traffic Signal	0	0	0	0	0
Lighting Poles (ea)	0	0	0	0	0
Flashing Beacons (ea)	0	0	0	0	0
RFB/PHB Ped Crossings (ea)	0	0	0	0	0
New/Replace Sidewalks (LF)	0'	0'	0'	0'	0'
New/Replace Cross Drains (LF)	0'	0'	0'	0'	0'
New/Replace Guardrail (LF)	725'	0'	0'	0'	0'
New Retaining Wall (LF)	0'	0'	0'	0'	0'
Bridge:New/Widen/Replace (sqft)	0	0	0	0	0
Add'l ROW/Easements/Demolition	$0	$0	$0	$0	$0

Site Context

Topography:	Level
Traffic Mgmt Plan:	Maintain Traffic
Project Size:	Single Intersection

Cost Multipliers

Grading Complete:	15%
Reimbursable Utility:	2%
Traffic Control:	20%
Project Size:	0%
Prelim Engineering:	12%
Project Contingency:	20%

Intersections

Signal Poles	Strain Pole
Design Vehicle	WB-67
Existing Interchange?	No

Roundabouts

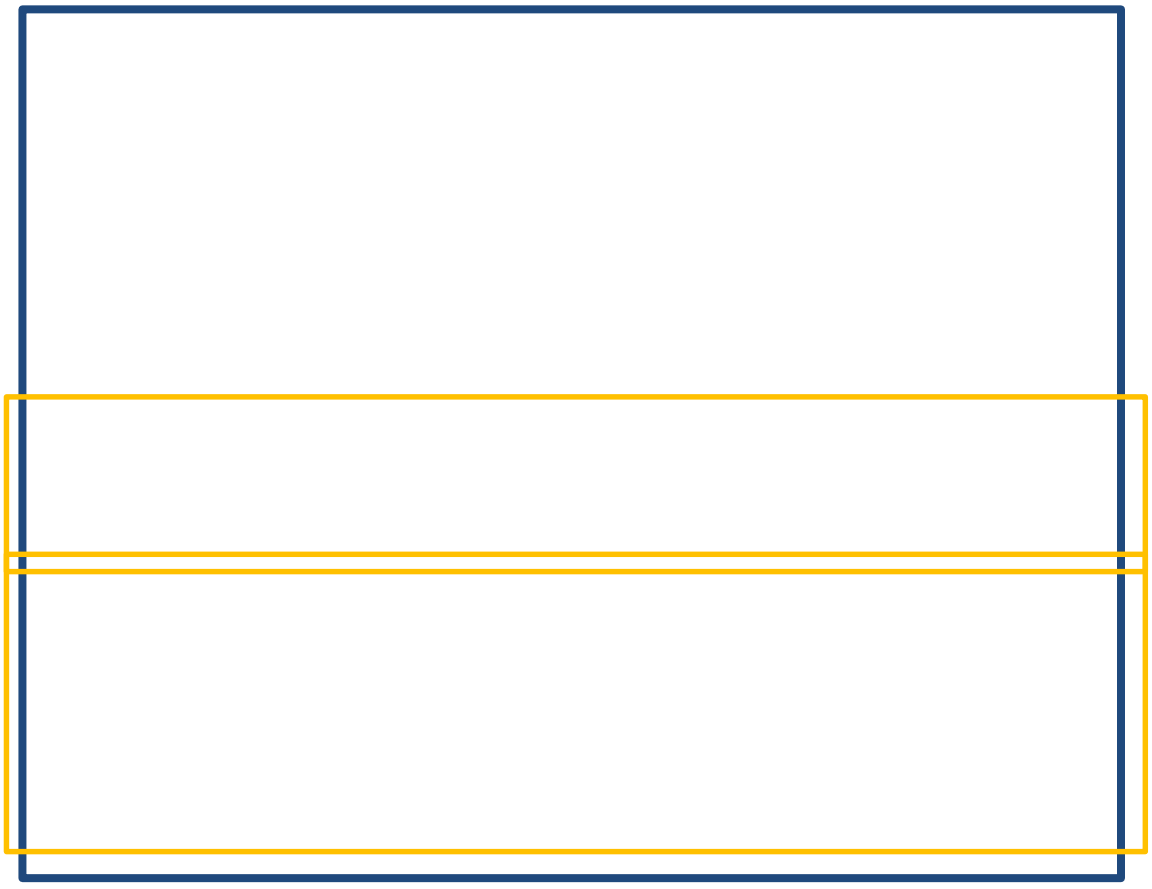
Inscribed DIA - Mini	70
Inscribed DIA - Single	150
Inscribed DIA - Multi	200
Circulating Lane Width	16

ROW Costs

Prevalent ROW Type:	Mixed (Average)
ROW Cost/Acre:	$72,188
ROW Multiplier:	1.6

- Must indicate if tab will be used
- Enter information for Existing and Proposed conditions
- Provides high level planning cost estimate for the purpose of comparison between alternatives

Stage 2

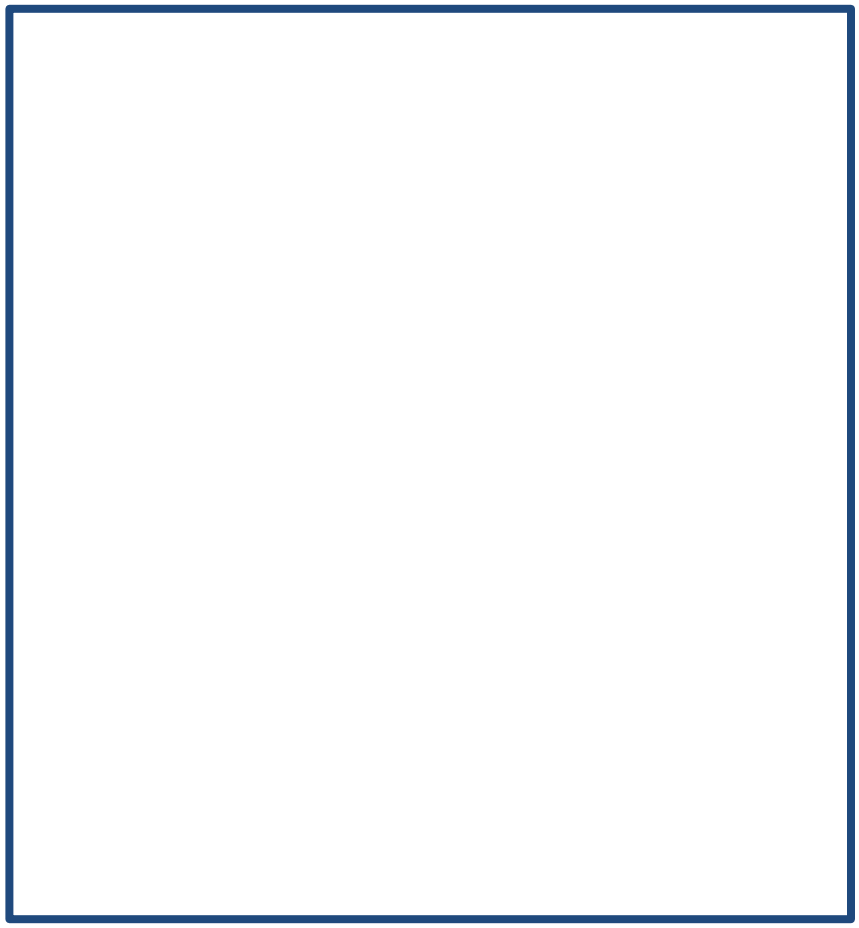


- **Project Cost:** Project Cost can be estimated using the CostEst Tab or by another method
- **Traffic Operations:** AM and PM DHV analysis
- **Safety analysis:**
  - Prepopulated based on existing intersection control
  - CRFs from FHWA Clearinghouse
  - Can be overridden with user defined CRFs

Stage 2

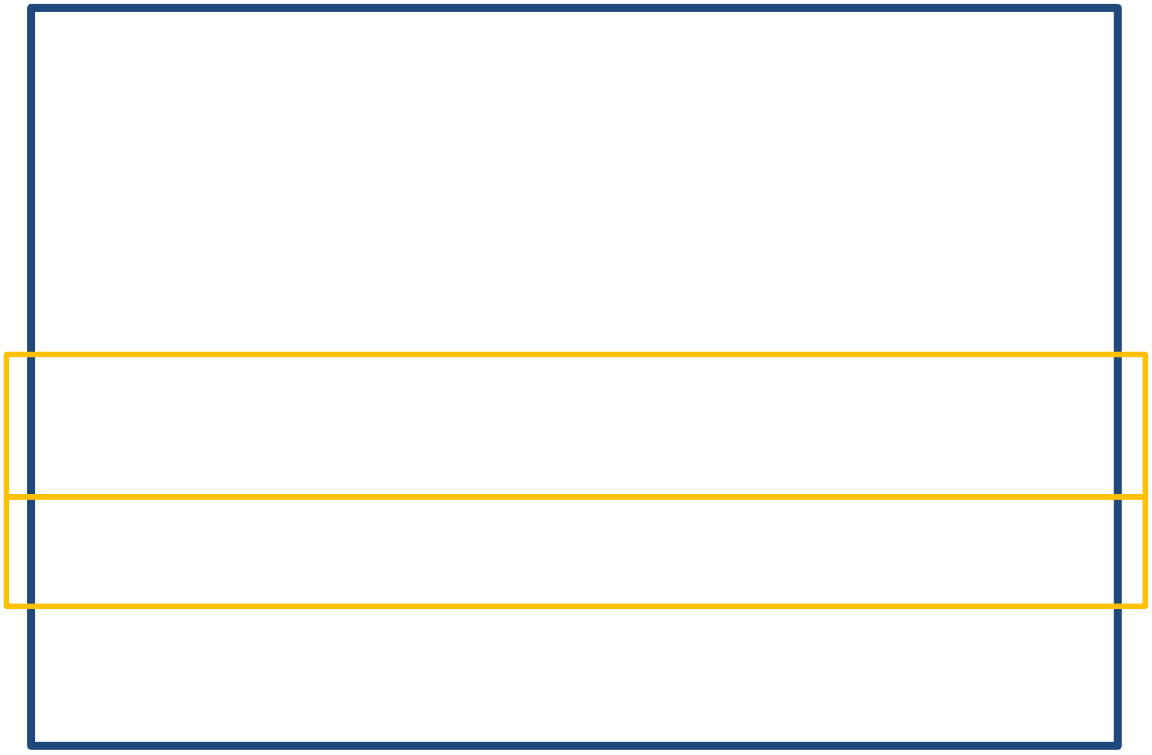
- **Environmental:** None, Minimal, or Adverse
- **Stakeholder Posture:** 6 choices including unknown
- **Score:** Ranks alternatives based on the 5 sections of the Alternatives analysis
- **Additional Comments:** Provide additional comments or explanation to support the analysis

Environmental Tab



- Optional; but should be used where an adverse environmental impact is indicated
- Attach additional sheets as necessary

Stage 2



- **Environmental:** None, Minimal, or Adverse
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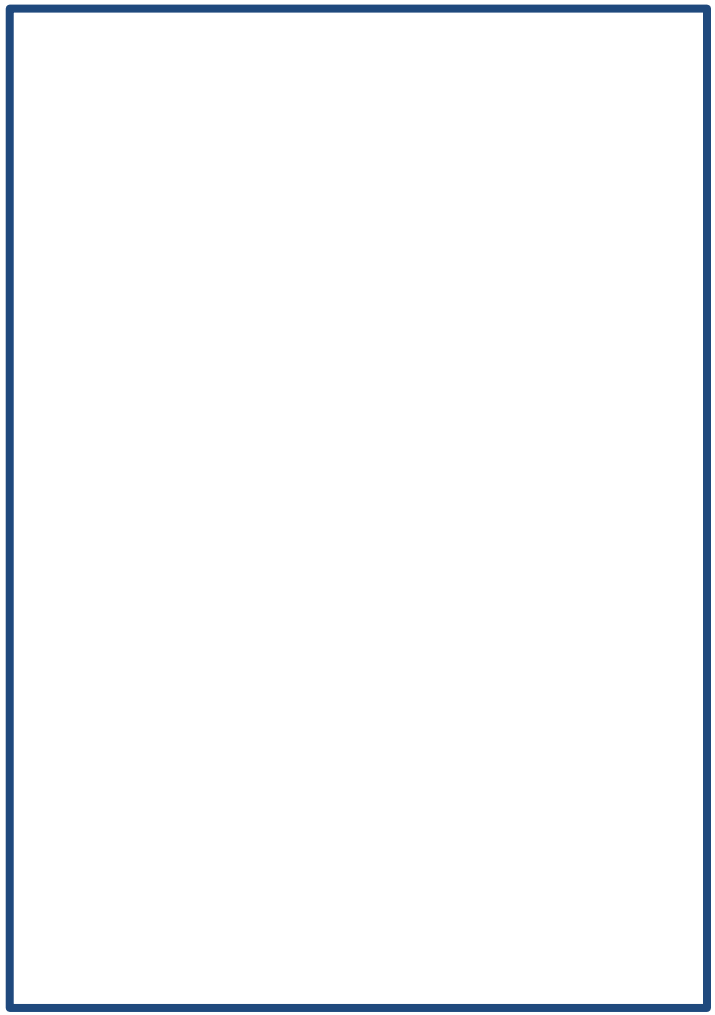
- **Score:** Ranks alternatives based on the 5 sections of the Alternatives analysis
- **Additional Comments:** Provide additional comments or explanation to support the analysis

Waiver



- May be used for waiving:
  - ICE Stage 1 and Stage 2 analysis
  - Stage 2 when only 1 alternative is feasible from stage 1
  - Results from Stage 2
- Enter enough information to justify waiver request

FAQ

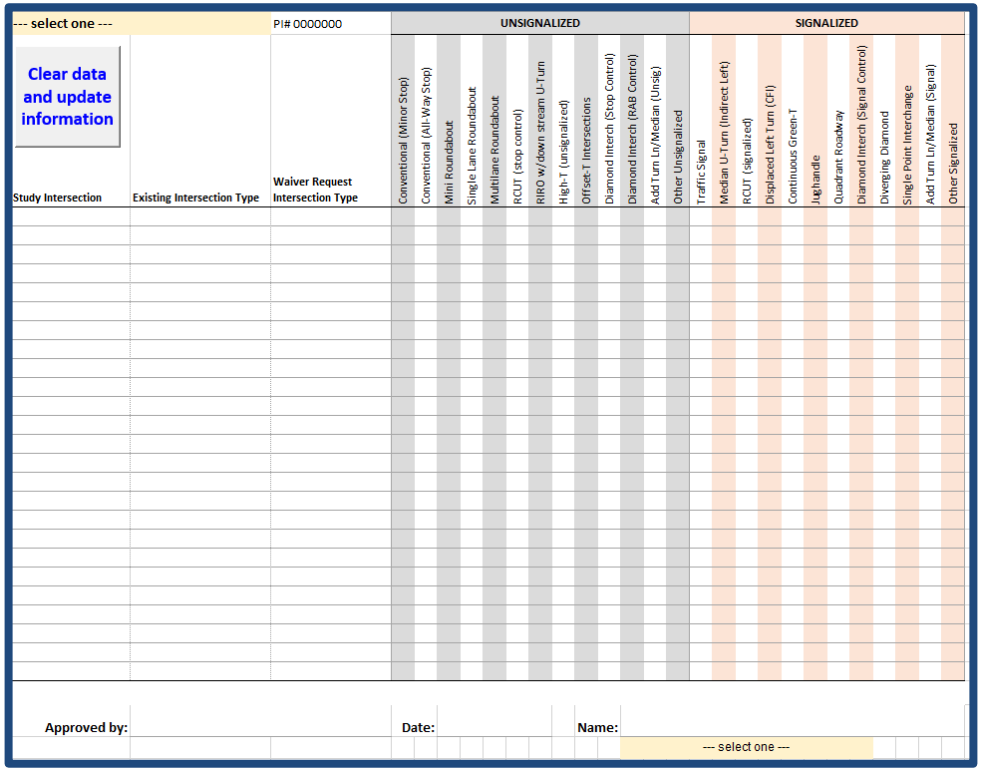
- Frequently Asked Questions
- Update log for Tool Versions
- Contact Information

Companion Tool

Multi-file ICE Summary Spreadsheet

Multi-File Results Tab: Summary for longitudinal Projects with more than one intersection going through ICE

RIRO Waivers: Form to waiver multiple low volume right in/right out intersections



--- select one ---

PI# 0000000

Clear data and update information

Study Intersection	Existing Intersection Type	Waiver Request Intersection Type	UNSIGNALIZED: Conventional (Minor Stop)	Conventional (All-Way Stop)	Mini Roundabout	Single Lane Roundabout	Multilane Roundabout	RCUT (stop control)	RIRO w/down stream U-Turn	High-T (unsignalized)	Offset-T Intersections	Diamond Interch (Stop Control)	Diamond Interch (RAB Control)	Add Turn Ln/Median (Unsig)	Other Unsignalized	SIGNALIZED: Traffic Signal	Median U-Turn (Indirect Left)	RCUT (signalized)	Displaced Left Turn (CFI)	Continuous Green-T	Jughandle	Quadrant Roadway	Diamond Interch (Signal Control)	Diverging Diamond	Single Point Interchange	Add Turn Ln/Median (Signal)	Other Signalized

Approved by: Date: Name:

--- select one ---

ICE Progress

- Every project letting out of Traffic Ops has had ICE performed during concept development
- Several Corridor projects are going back though and making ICE related changes
- More alternative intersection forms being considered and chosen in concept
- To date have held 15 training classes for GDOT, consultants, local government officials with more planned (trained over 400 people)

Lessons Learned

- Important to have support and buy-in from upper management
- Policy needs to have enough teeth to be effective but allow enough flexibility to be able to work within different programs
- Policy is a living document
- Important to conduct proactive training and technical assistance

Acknowledgments

- Jeff Shaw & FHWA partners
- GDOT Management
- Jonathan Reid - Arcadis

Thank You!

Thank you!

Christina Barry, P.E.

cbarry@dot.ga.gov

404-635-2922

Georgia Department of Transportation

Office of Traffic Operations

Intersection Control Evaluation for Roundabouts and Alternative Intersections

Pennsylvania's ICE experience

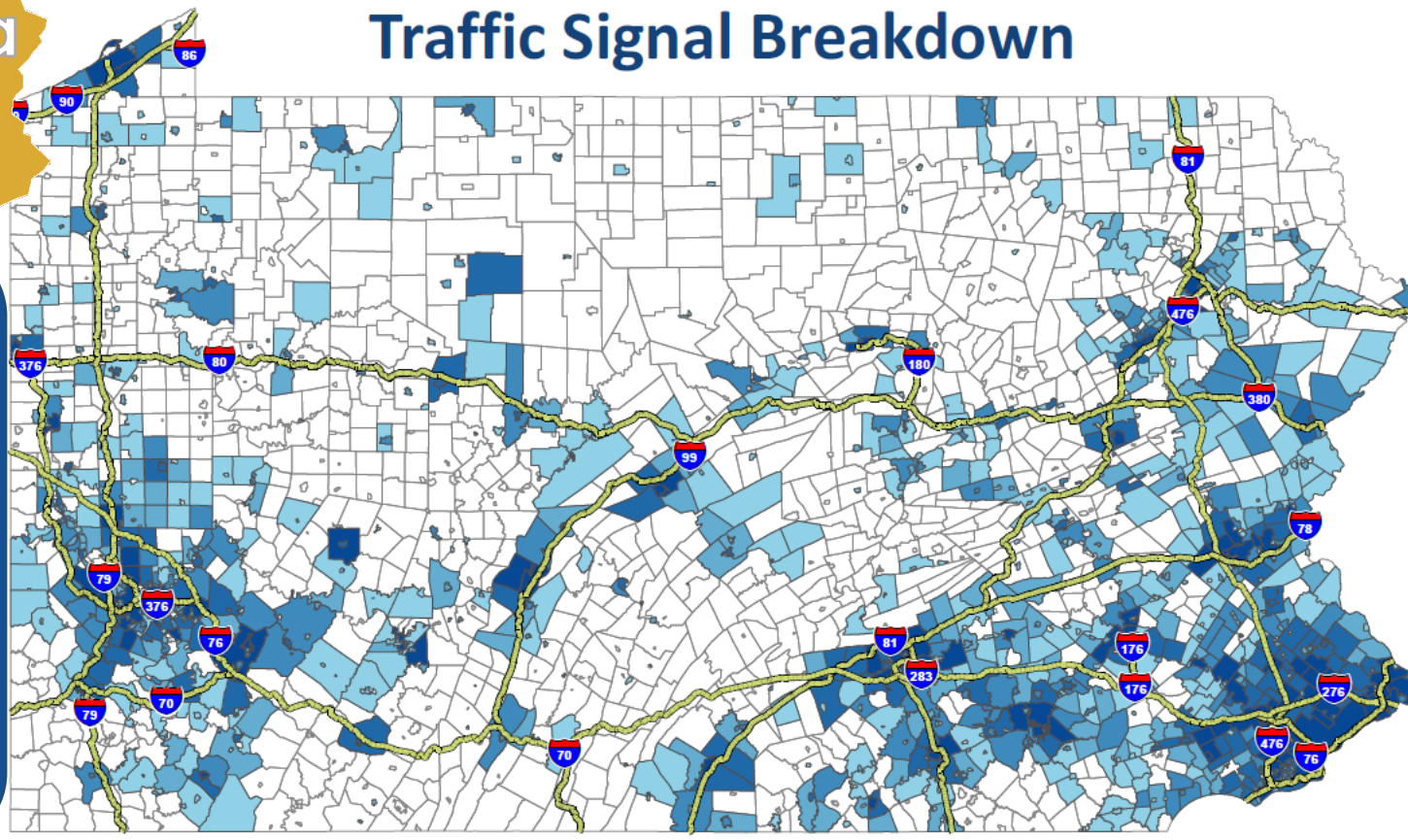
Daniel Farley
Traffic Operations Deployment and Maintenance

Pennsylvania Department of Transportation

Pennsylvania Facts

- 1,200 municipal signal owners
- 14,000 signals in Pennsylvania
- 75% own less than 10 signals
- 80%+ maintained by contractors
- 10,500 (77%) on state highways

Traffic Signal Breakdown



PENNSYLVANIA INFRASTRUCTURE	PENNSYLVANIA DEMOGRAPHIC	PENNSYLVANIA MOBILITY	PENNSYLVANIA TRAFFIC	PENNSYLVANIA ENVIRONMENTAL	PENNSYLVANIA CONGESTION
40K mi of state-owned roadway	**12.8M** people	**102B** VMT annually	**264M+** annual hours of delay	**133M+** gallons of wasted fuel	**$6T** annual cost o congestion
5th largest nationally	6th largest state	Circle the world more than 4M times	31.5 hours per driver	11.1 gallons per vehicle	$730 per driver

- 1 or 2 Traffic Signals
- 3 to 5 Traffic Signals
- 6 to 10 Traffic Signals
- 11 to 25 Traffic Signals
- More than 25 Traffic Signals

Why ICE in Pennsylvania

- **Focus beyond capacity analysis to determine solution**
  - Incorporation of the Highway Safety Manual
  - Appropriate consideration of the latest innovations to intersection control
- **Improve Intersection Safety**
  - 40 % of all Crashes and 25% of all fatal and major injuries occur at intersections
- **Documentation of project conditions and engineering judgment**
  - Roundabout vs. Traffic Signal debate
  - Consistent, Transparent, and Accurate determination of the alternative
- **Considering the entire life cycle costs associated with the solution and not just the capital costs**
- **PennDOT Connects**

Intersection Control Evaluation (ICE) Background

- States with objective intersection control evaluation policies:
  - **California**
  - **Indiana**
  - **Minnesota**
  - **Wisconsin**
  - **Washington**
  - Georgia
  - Florida
  - Others pending

ICE Policy Interviews

- Supported by FHWA's Every Day Counts Initiative
  - Shortening project delivery
  - Enhancing roadway safety
  - Protecting the environment

- FHWA provides guides on Alternative Intersections and Interchanges

"DOTs should consider and evaluate [roundabouts, diverging diamond interchanges (DDIs) and intersections with displaced left-turns or variations on U-turns] early in the project scoping, planning and decision-making stages, as they may serve as more efficient, economical and safer solutions than traditional designs."
-FHWA

http://www.fhwa.dot.gov/everydaycounts/edctwo/2012/geometrics.cfm

State Interview Results

Policy Origins:

- **Policies focused around increased frequency and consistency of alternatives, particularly roundabouts**
- **Existing roundabout policies along were not enough to ensure appropriate project consideration**
- **Increased awareness and consideration of alternative intersections**

Policy Evaluation Methods:

- **3 states developed policy requiring staff to submit memos summarizing the alternatives considered**
- ***2 states require completed short forms to ensure consistency***
- ***All states encouraged the attachment of supplemental forms and documentation***

State Interview Results

Enforcement:

- **3 states made the ICE policy a mandatory step in the project development process**
  - States not requiring this part of the policy have seen mixed results in the terms of use.
- **3 states placed responsibility of enforcement at the District/Regional level which has helped getting buy-in and acceptance of ICE**

Implementation:

- **All states indicated training staff across the entire agency is critical.**
- **All states indicated the importance of flexibility of the policy. Allowing those filling out the forms or developing memos the ability to use ICE to best fit their needs.**

ICE Implementation in Pennsylvania

Purpose: To consistently consider and screen among many proven combinations of geometry and traffic control when a new intersection or existing intersection modification is first contemplated.

Goal: To better inform, identify, and select an alternative that meets the project purpose and reflects the overall best value, in terms of specific performance-based criteria within available resources.

ICE Implementation in Pennsylvania

- **What is an Intersection?**
  - The connection or crossing of two or more roadway facilities

- **Typical focus: At-grade conflicts**
  - We have been challenged implementing roundabouts over the last 15 years
  - We now have more “innovative” forms to consider
    - Mostly treatments of left-turning vehicles

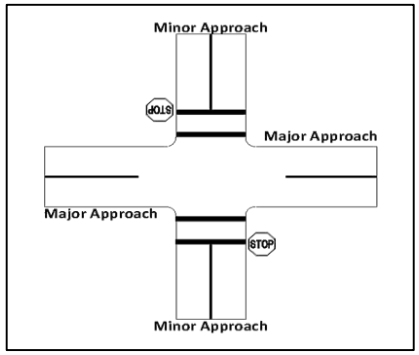
- **Intersection control evaluations apply to grade separated facilities**
  - Objective look at interchange form and function
  - Focus is most often upon the ramp terminal intersection control

ICE-Required Projects

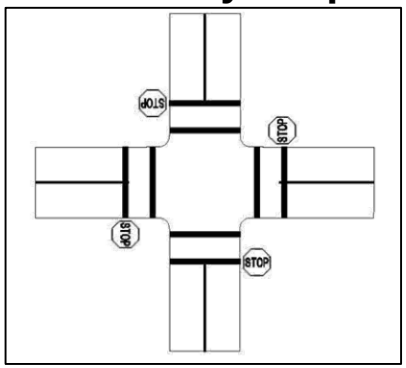
- Creation of a new intersection
- Creation of a medium volume or high volume driveway Adding a leg to an existing intersection
- Adding a through lane or turning lane at an existing intersection, or changing the lane configuration at an existing intersection
- Changing control at an existing intersection
- Full-depth reconstruction of an existing intersection
- Other efforts determined by DTE

ICE Evaluation Types

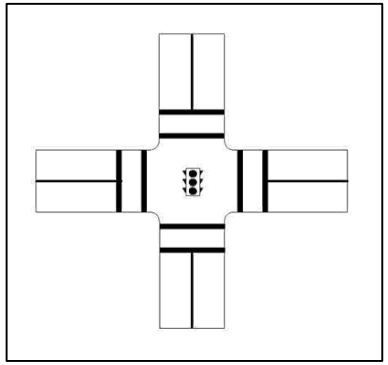
Two Way Stop



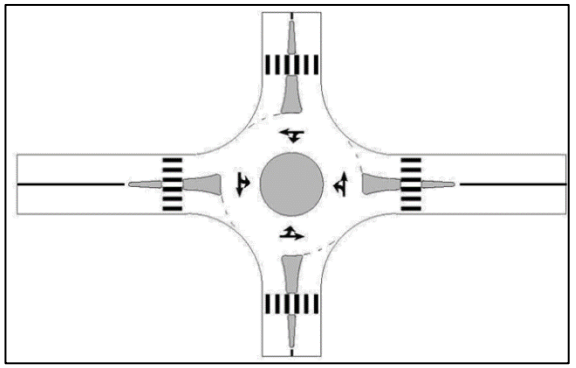
All Way Stop



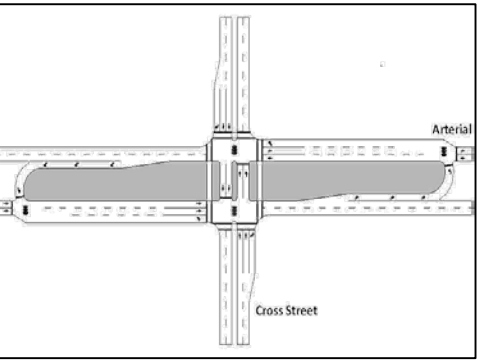
Signalized Control



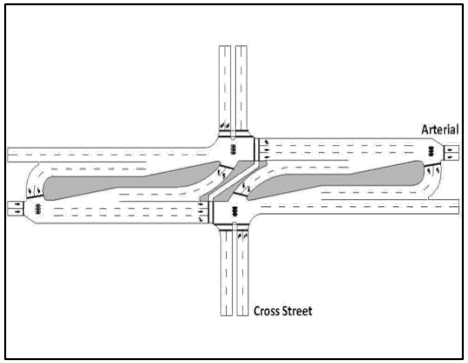
Roundabout



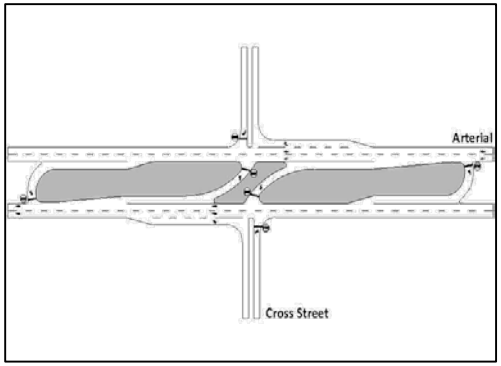
Median U-Turn



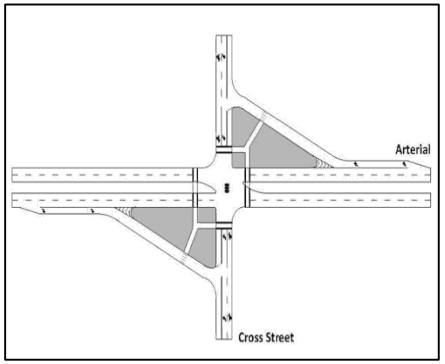
Superstreet



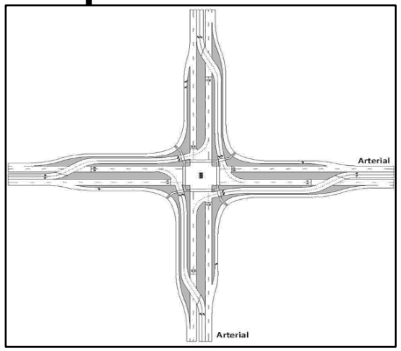
J-Turn



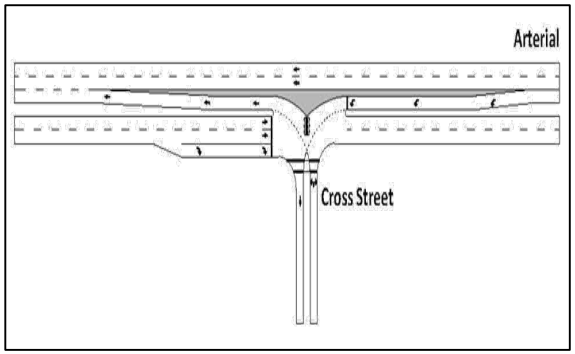
Jughandle



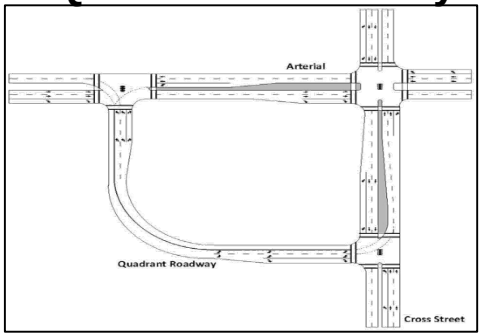
Displaced Left Turn



Continuous Green Tee



Quadrant Roadway



Pennsylvania ICE Policy Overview

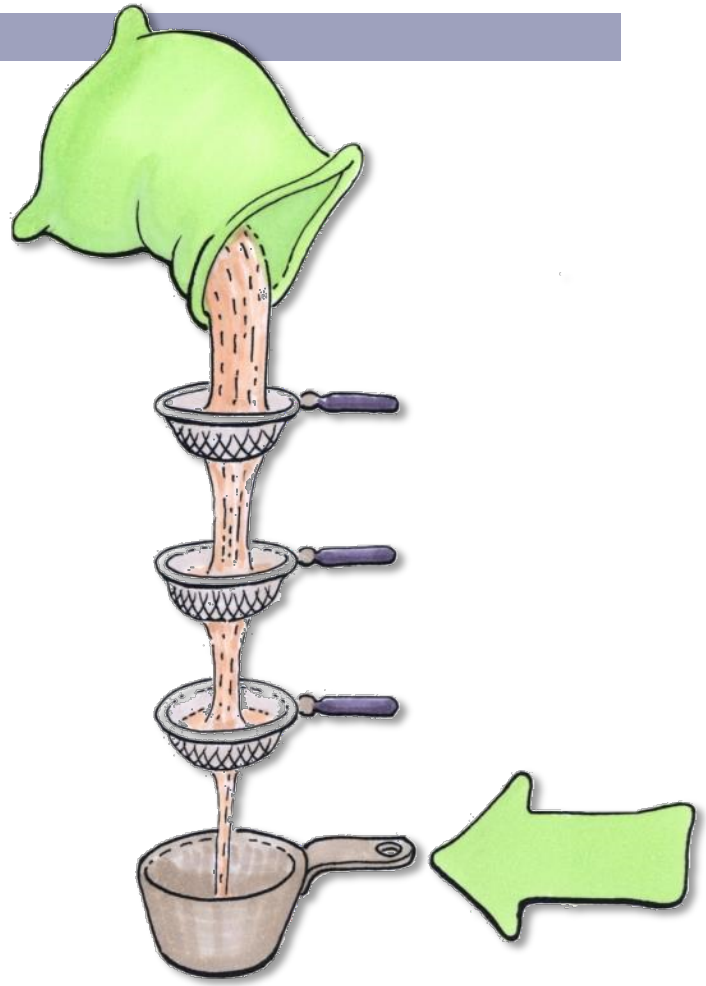
- **Will be incorporated into PennDOT's Design Publications (DM1-X) and Highway Occupancy Permit (Pub. 282) procedures**
- **Scalable 3-Stage Screening Process**
- **Key Evaluation Criteria**
  - Capacity Analysis /Traffic Operations (HCM)
  - Safety (HSM)
  - Multimodal access (Transit, rail, ride-sharing, bike, pedestrian, etc…)
  - Life Cycle Costs and requirements
  - Land access
  - Public feedback

3 – Step Screening Process

- **<u>Stage 1: Screening</u> – completed during a project's scoping stage**
  - High Level determination of challenges and alternatives
- **<u>Stage 2: Initial Control Strategy Assessment</u> – completed following a project's scoping stage**
  - Evaluation of Key Evaluation Criteria
- **<u>Stage 3: Detailed Control Strategy Assessment</u> – completed prior to Design Field View**
  - In-Depth evaluation of remaining Alternatives

Stages of ICE

- Each stage requires completion of a form
- Memo/report/analysis outputs may be helpful, but not required
- Spreadsheet tool geared towards Stage 2 analysis
- District Traffic Engineer approves form
- Stages 2 and 3 are not always required



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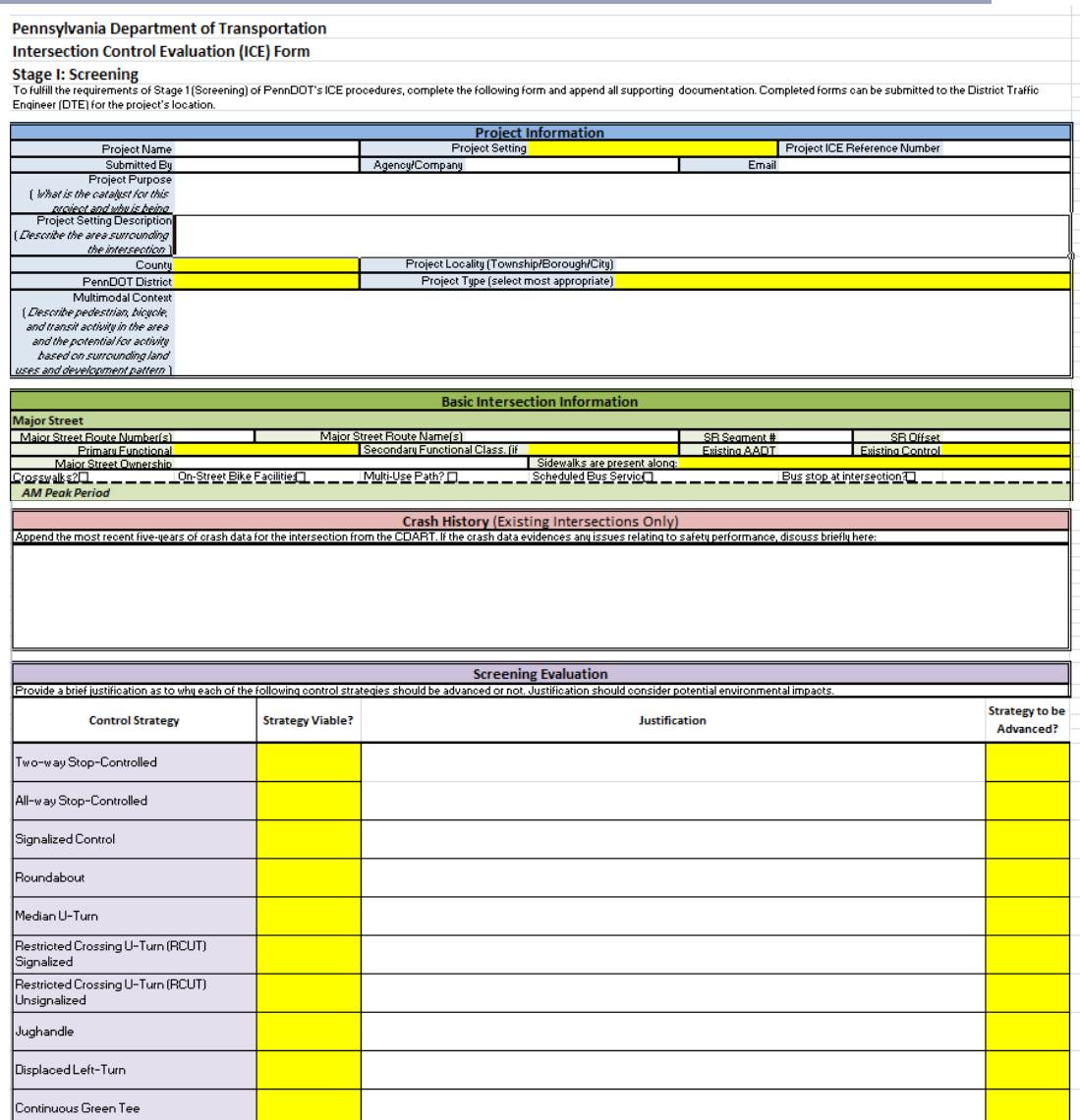
ICE Stage 1 – Preliminary Analysis

- Determines if there is one viable alternative or more than one
  - If only 1 alternative, Stage 2 and 3 are not necessary
- **Intent** – Don't make ICE a burden if the choice is straightforward



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Intersection Control Evaluation (ICE) Form

Stage I: Screening

To fulfill the requirements of Stage 1 (Screening) of PennDOT's ICE procedures, complete the following form and append all supporting documentation. Completed forms can be submitted to the District Traffic Engineer (DTE) for the project's location.

Project Information

Project Name	Project Setting	Project ICE Reference Number
Submitted By	Agency/Company	Email
Project Purpose (*What is the catalyst for this project and why is being*)		
Project Setting Description (*Describe the area surrounding the intersection*)		
County	Project Locality (Township/Borough/City)	
PennDOT District	Project Type (select most appropriate)	
Multimodal Context (*Describe pedestrian, bicycle, and transit activity in the area and the potential for activity based on surrounding land uses and development pattern*)		

Basic Intersection Information

Major Street

Major Street Route Number(s)	Major Street Route Name(s)	SR Segment #	SR Offset
Primary Functional	Secondary Functional Class. (if	Existing AADT	Existing Control
Major Street Ownership	Sidewalks are present along:		

Crosswalk? ☐ On-Street Bike Facilities ☐ Multi-Use Path? ☐ Scheduled Bus Servic ☐ Bus stop at intersection? ☐

AM Peak Period

Crash History (Existing Intersections Only)

Append the most recent five-years of crash data for the intersection from the CDART. If the crash data evidences any issues relating to safety performance, discuss briefly here:

Screening Evaluation

Provide a brief justification as to why each of the following control strategies should be advanced or not. Justification should consider potential environmental impacts.

Control Strategy	Strategy Viable?	Justification	Strategy to be Advanced?
Two-way Stop-Controlled			
All-way Stop-Controlled			
Signalized Control			
Roundabout			
Median U-Turn			
Restricted Crossing U-Turn (RCUT) Signalized			
Restricted Crossing U-Turn (RCUT) Unsignalized			
Jughandle			
Displaced Left-Turn			
Continuous Green Tee			

ICE Stage 2 – Concept Design

- **Consider a wide range of criteria**
  - Operations **(HCM Analysis)**
  - Safety Performance **(HSM Analysis)**
  - Right-of-way impacts
  - Costs **(PennDOT ICE Spreadsheet Tool)**
  - Environmental impacts
  - Political/public considerations
  - Terrain **(Asset Info – RMS)**
  - Adjacent intersections and coordinated systems **(Asset Info – TSAMS)**
  - System consistency
  - Pedestrian/bike accommodations **(Program Plans)**

ICE Stage 2 – Concept Design

- **Detailed analysis to help differentiate alternatives**
- **Summarize and document findings and justification** why alternatives where either considered or not
- **Possible outcomes**
  - One alternative is clearly preferred – ICE ends
  - Further analysis needed – Continue to Stage 3

Stage 2: Initial Control Strategy Assessment

Pennsylvania Department of Transportation

Intersection Control Evaluation (ICE) Form

Stage 2: Initial Control Strategy Assessment

To fulfill the requirements of Stage 2 (Intersection Control Strategy) of PennDOT's ICE procedures, complete the following form and append all supporting documentation. Completed forms can be submitted to the District Traffic Engineer (DTE) for the project's location.

Project Information			
Project Name		Project ICE Reference Number	
Submitted By	Agency/Company	Email	
List all viable intersection control strategies identified in Phase 1 (Screening):			

Operational Analysis

Summarize the results of the peak hour analysis performed for each control strategy. Select analysis year based on guidance in the ICE procedures document.

Overall Intersection Performance

Opening Year

Control Strategy	Analysis Year / Peak Hour				Peak Hour Analyzed			
	LOS	V/C	Delay (sec.)	All queues accommodated?	LOS	V/C	Delay (sec.)	All queues accommodate

Design Year

Control Strategy	Analysis Year / Peak Hour				Peak Hour Analyzed			
	LOS	V/C	Delay (sec.)	All queues accommodated?	LOS	V/C	Delay (sec.)	All queues accommodate

Provide any additional discussion necessary regarding the results of the operational analysis:

Stage 2: Initial Control Strategy Assessment

Costs

Remaining cognizant of the current level of detail of each control strategy's conceptual design, provide a cost estimate for each. You may want to account for preliminary engineering, required right-of-way acquisitions, construction, and a contingency.

Control Strategy	Cost ($)	Estimate Includes:	Control Strategy	Cost ($)	Estimate Includes:

Safety Performance

Apply the PennDOT HSM Analysis Tool and provide the "Safety B/C" ratio provided by the tool's output. You may wish to append the complete output to this form. For intersection types not accommodated in the tool, manually apply crash modification factors detailed in the ICE policy document or qualitatively describe safety impacts.

Control Strategy	Anticipated Impact on Safety Performance	Predicted Total Crashes	Predicted Fatal & Injury Crashes	Safety B/C

Multimodal Accommodations

Note the existing/anticipated level of pedestrian/bicyclist activity at the study intersection during the peak hours of the typical day.

	AM Peak Hour		PM Peak Hour	
	Major Street	Minor Street	Major Street	Minor Street
# of pedestrian crossings (both approaches,				
# of bicyclists (both approaches, if app.):				

Summarize the ability of each viable control strategy to accommodate the existing/anticipated level of:

Control Strategy	Pedestrians and Bicycles	Transit Services	Freight Needs

Stage 2: Initial Control Strategy Assessment

ICE Stage 3 – Detailed Design Analysis

- **Consider the same criteria as Stage 2, but in greater detail**
  - More developed drawings and associated information (costs, impacts, etc.)
  - Additional public and local government outreach
  - Additional traffic analysis- microsimulation or modeling?
  - Additional pedestrian and bicycle needs assessment
- May have fewer alternatives than Stage 2
- Alternatives evaluation and determination
  - **Example**: Do I install a Roundabout or Traffic Signal and what factors and justification lead to this decision?

Stage 3: Detailed control strategy assessment

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Intersection Control Evaluation (ICE) Form

Stage 3: Detailed Control Strategy Assessment

To fulfill the requirements of Stage 3 (Detailed Control Strategy Assessment) of PennDOT's ICE procedures, complete the following form and append all supporting documentation, which may include detailed design plans of each control strategy analyzed. Completed forms can be submitted to the District Traffic Engineer (DTE) for the project's location.

Project Information			
Project Name		Project ICE Reference Number	
Submitted By	Agency/Company	Email	
List all viable intersection control strategies identified at the end of Phase 2 (Initial Control Strategy Assessment):			

Additional Analysis	
What issues and/or findings to date have led to a control strategy **NOT** being selected in Stage 2?	
Category	**Description of Issues/Findings**
Describe specific evaluation activities undertaken in Stage 3 analysis to identify a preferred control strategy and discuss the findings:	
Category	**Description of Additional (Stage 3) Analysis**

Public Input/Feedback	
If not discussed as a part of the preceding section, summarize public input received or stakeholder considerations regarding the control strategies:	

Stage 3: Detailed control strategy assessment

Control Strategy Evaluation		
Provide a brief justification as to why each of the following was either selected or not selected after conducting the additional analysis. ICE Stage 3 activities should result in a single control		
Control Strategy	**trol Strategy Selec**	**Justification**

Resolution			
To be filled out by PennDOT District Traffic Engineer or designee only			
Project Determination			
Comments			
DTE or Designee Name:		Signature	Date

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PennDOT ICE Tool

- **Stage 2 tool for financial analysis of intersection alternatives**
- **Based on the NCHRP 3-110 Life Cycle Cost Estimation Tool (LCCET)**
  - Macro-powered Excel spreadsheet
- **Needed inputs for life-cycle cost analysis**
  - **Safety** – PennDOT HSM Tool and built-in CMFs for alternative intersections
  - **Vehicular delay** – SYNCHRO, VISSIM, HCS, SIDRA, etc.
  - **Design, construction, right-of-way, and operating costs**
- **Conducts benefit-cost / net present value analysis**
- **Designed to be quick and easy to use** – hour(s) not day(s)
  - Limit data inputs to readily available or computable values
- **Flexible enough to accommodate most common alternative intersections**
- **5 cases studies to assist engineers with similar project considerations**

Key Policy Reference Materials

Category	Title	Description	Web Link
Operational and Safety Performance Evaluation Tools	PennDOT HSM Tools A and B	Excel spreadsheet-based calculators to apply Pennsylvania-specific HSM analysis	ECMS File Cabinet
	PennDOT Crash Modification Factor (CMF) Guide	Inventory of crash modification factors and recommended models for Pennsylvania	Appendix of http://www.dot.state.pa.us/public/pubsforms/Publications/PUB%20638.pdf
	Safety Performance for Intersection Control Evaluation (SPICE) Tool	Excel spreadsheet-based safety performance screening tool for conventional and alternative intersection types	Under development by FHWA
	Capacity Analysis for Planning of Junctions (CAP-X) Tool	Excel spreadsheet-based critical lane method operational analysis tool	http://www.fhwa.dot.gov/downloads/research/operations/cap-x/FHWA%20Capacity%20Analysis%20for%20Planning%20of%20Junctions%20(CAP-X)_Software.zip]
	Highway Capacity Manual	Definitive reference for traffic analysis of intersections and underlying basis of many intersection operation software packages	http://www.trb.org/main/blurbs/175169.aspx
Life-Cycle Cost Analysis Tools	PennDOT ICE Tool	Excel spreadsheet-based economic evaluation tool. Modified from NCHRP Project 3-110 tool	Being determined at this time
Intersection Control Type Reference Guides	Unsignalized Intersections Improvement Guide (UIIG)	PDF report documenting safety, mobility, and accessibility improvements to unsignalized intersections	http://www.ite.org/uiig/
	FHWA-SA-13-027: Signalized Intersections Informational Guide, 2nd Edition	PDF report providing guidance on enhancing the safety of signalized intersections	http://safety.fhwa.dot.gov/intersection/conventional/signalized/fhwasa13027/fhwasa13027.pdf
	NCHRP 672 - Roundabouts: An Informational Guide, 2nd Edition	PDF report discussing roundabout design and evaluation	http://www.trb.org/Publications/Blurbs/164470.aspx
	FHWA-SA-14-069: Median U-Turn Intersection Informational Guide	PDF report providing guidance on median U-turn (MUT) intersections	http://safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14069_mut_infoguide.pdf
	FHWA-HRT-09-055: Displaced Left-Turn Intersection	PDF report providing guidance on displaced left-turn intersections	http://www.fhwa.dot.gov/publications/research/safety/09055/09055.pdf
	FHWA-SA-14-070: Restricted Crossing U-Turn Intersection Informational Guide	PDF report providing guidance on restricted crossing U-turn (RCUT) intersections	http://safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14070_rcut_infoguide.pdf
	FHWA-HRT-07-032: Traffic Performance of Three	PDF report providing guidance on New Jersey Jughandle	http://www.fhwa.dot.gov/publications/research/safety/

Category	Title	Description	Web Link
	Typical Designs of New Jersey Jughandle Intersections	intersections	07032/07032.pdf
	FHWA-SA-14-068: Displaced Left-Turn Intersection Informational Guide	PDF report providing guidance on displaced left-turn (DLT) intersections	http://safety.fhwa.dot.gov/intersection/alter_design/pdf/fhwasa14068_dlt_infoguide.pdf
	FHWA-SA-09-016: Continuous Greet T-Intersections	PDF report providing guidance on continuous green T-intersections	http://safety.fhwa.dot.gov/intersection/innovative/others/casestudies/fhwasa09016/fhwasa09016.pdf
	FHWA-HRT-09-058: Quadrant Roadway Intersection	PDF report providing guidance on quadrant roadway intersections	http://www.fhwa.dot.gov/publications/research/safety/09058/09058.pdf
	FHWA-HRT-09-060: Alternative Intersections/Interchanges : Informational Report (AIIR)	PDF report providing guidance on various alternative intersection control types. Information on MUT, RCUT, and DLT intersections superseded by the individual guidebooks above.	http://www.fhwa.dot.gov/publications/research/safety/09060/09060.pdf

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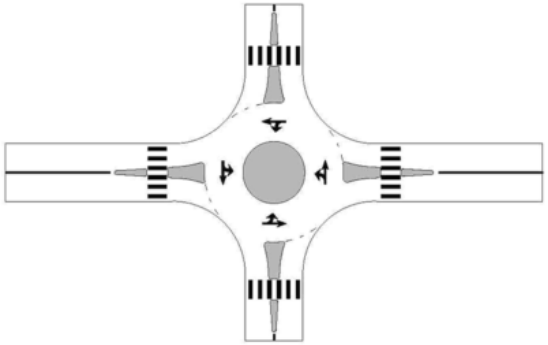
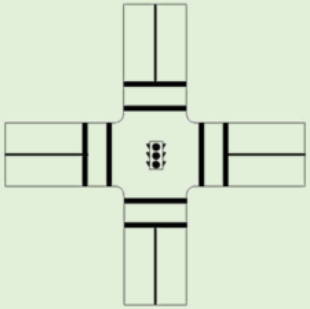
Intersection Type Reference

Intersection Control Type			Mode Accommodations			Reference Material	Recommended Analysis Tool
Intersection Name	Illustration[1]	Description	Vehicles	Pedestrians	Bicycles		
Roundabout		A subset of circular intersections that feature yield control of all entering vehicles, channelized approaches, and horizontal curvature and roadway elements to induce desirable vehicle speeds.	Vehicles approaching the intersection must yield to vehicles circulating within the circulatory roadway.	Pedestrian crossings are located only across the legs of the roundabout, typically separated from the circulatory roadway by at least one vehicle length.	Bicyclists may ride in the roadway with vehicles or transition to multi-use paths via bicycle ramps (if present). Bike lanes should not be used at roundabouts	NCHRP 672	HCS, SIDRA with US HCM Model for designs not supported by HCS
Signalized Control		Conventional intersection control type in which each approach is controlled by a traffic signal.	Vehicular movements on each approach are controlled through protected, permissive, or prohibited lights on the traffic signal.	Pedestrian phases can be built into the signal timing to allow for permissive pedestrian crossings at the designated crosswalks. Accessible pedestrian signals and pushbuttons can be utilized.	Ride on street in travel lane or bicycle lane (if available), unless multi-use path is present.	Signalized Intersection Guide, 2nd Edition	HCS, Synchro

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- Christina Berry, *Georgia Department of Transportation*, cbarry@dot.ga.gov
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