ARCADIS Design & Consultancy for natural and built assets

Intersection Control Evaluation

Update on State Implementations



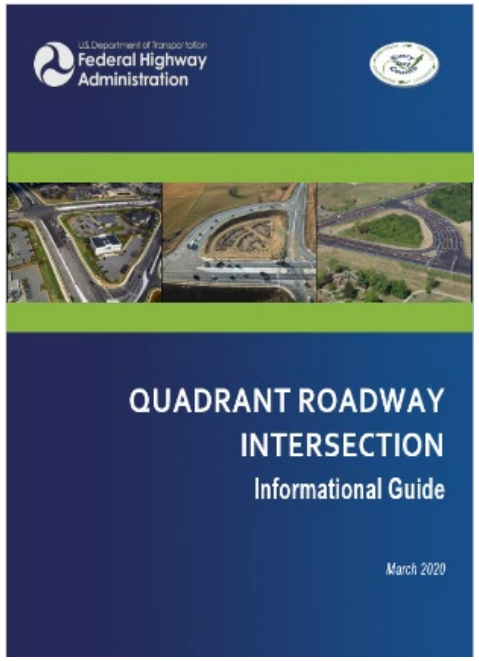
Jonathan Reid, PE, PTOE, RSP

NCSITE Safety Users Group Meeting

Thursday, September 29, 2022

Jonathan Reid, PE, PTOE, RSP

- Arcadis Transportation Practice lead for Carolinas
- 6 years with Arcadis / 27 years total
- Traffic / safety engineer with specialty in alternative intersections
- Several publications for FHWA/ NCHRP including Quadrant Roadway Informational Guide (2000)
- Developed ICE Tool for Georgia DOT



Intersection Control Evaluation

ICE is **data-driven,** performance-based **framework and approach** to objectively **screen alternatives** and identify an **optimal intersection geometric and control solution**
– FHWA

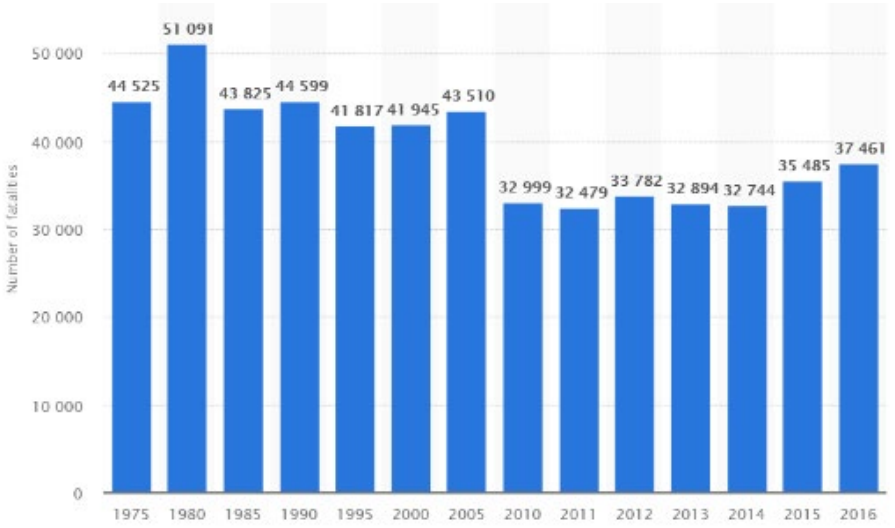
*Process to identify the **best intersection control** thru a **comprehensive analysis and documentation** of technical economic, and political issues of **viable alternatives***
– MnDOT

***Select optimal control**, lane configuration and intersection type **based on objective analysis** of existing & future needs*
– WisDOT

Why ICE?

- 40% of ALL crashes, 25% fatal/injuries crashes at intersections
- Total number of fatalities up 15% since 2011
- Pedestrian fatalities rising faster (27% last decade)
- Safety should be part of selecting intersection control, not design afterthought





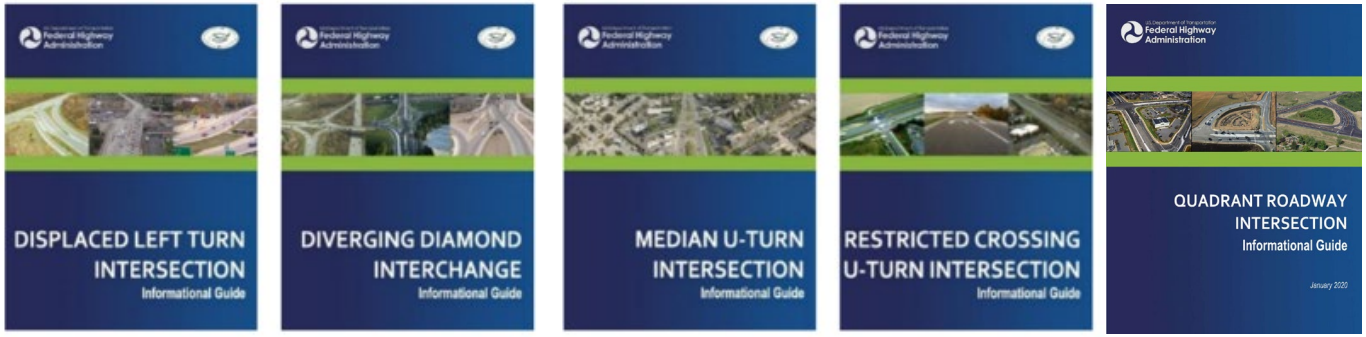
Why ICE?

Highway Safety Improvement Program: Focus on areas with greatest potential to improve safety

- Focus on intersection safety
- Quantitative analysis to select control
- Consider context-sensitive control strategies
- Consider project life cycle costs (not just capital)
- Safe facilities for all users & overall best value
- Consideration of alternative intersection types



Core Federal-aid program purposed to achieve a significant reduction in fatalities and serious injuries on all public roads



Core Benefits of ICE

SAFETY

- Fewer, less severe conflict points
- Speed management potential
- Significant crash reductions

MOBILITY

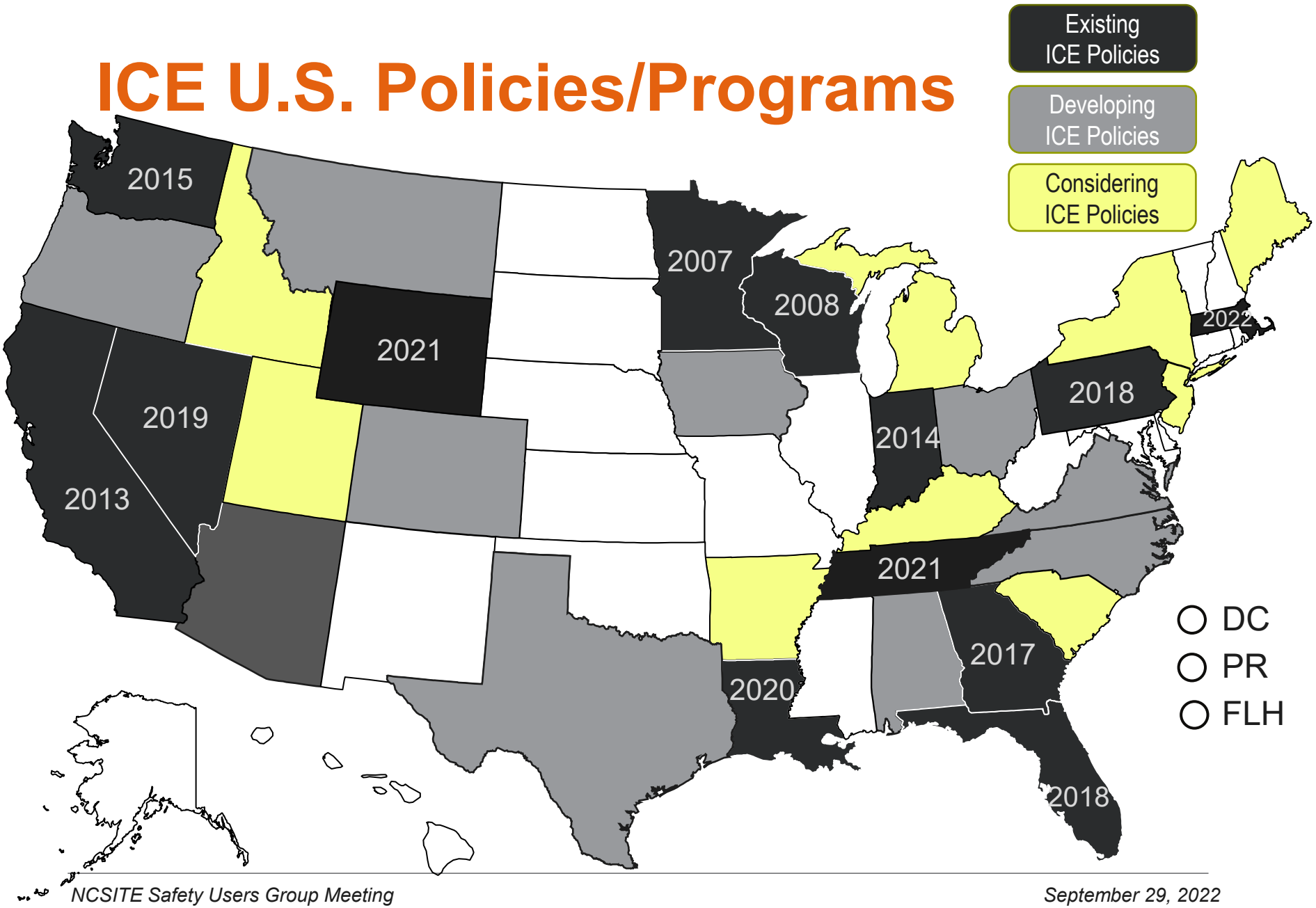
- Less delay
- Reduced congestion
- New/more pedestrian and bike opportunities



VALUE

- All Users
- Less ROW
- Decreased costs
- Quicker construction
- Balanced solutions

ICE U.S. Policies/Programs



How ICE has Helped States Meet Needs

- Incorporate safety performance into project scoping stage
- Helped innovative intersections / interchanges become mainstream common solutions
- Vet possibilities for context and risk
- Address concerns about documentation, sufficiency and consistency
- Provide a basis for early non-motorized assessment
- Incremental, measurable system improvement



ICE Interest Across the Globe

- At 2022 ISHGD/USS conference, hosted Sunday workshop on alternative intersections
- 30 participants representing 13 countries & 5 continents
- **Most expressed interest for methods to select optimal intersection design**

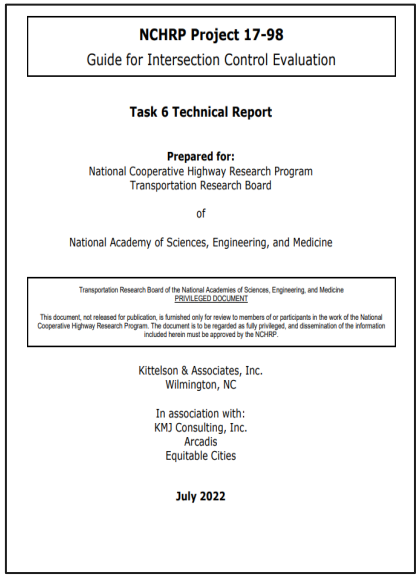




6th International Symposium on HIGHWAY GEOMETRIC DESIGN

National ICE Guide (NCHRP 17-98)

- Comprehensive review of state processes & practices
- Case study data & evaluations using existing ICE tools
- Pedestrian and bicycle safety methods
- Goal: Develop framework for developing ICE process
- Will include new planning-level analysis tools
- Schedule:
  - Fall of 2022: Guide development complete
  - End of 2022: Development of computational tools
  - Spring 2022: Review and finalization of Guide
  - Summer of 2023: NCHRP Report complete



NCHRP Project 17-98
Guide for Intersection Control Evaluation

Task 6 Technical Report

Prepared for:
National Cooperative Highway Research Program
Transportation Research Board

of

National Academy of Sciences, Engineering, and Medicine

Transportation Research Board of the National Academies of Sciences, Engineering, and Medicine
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Kittelson & Associates, Inc.
Wilmington, NC

In association with:
KMJ Consulting, Inc.
Arcadis
Equitable Cities

July 2022

Safe System Intersections (SSI)

- RJ Porter developed mathematical approach to SSI in 2001 TRB paper
- SSI is wholistic approach to evaluate intersection safety by conflicts, speeds, crash angle and control devices
- Allows equitable calculation of predictive impact severity
- Work has been done expanding calculations for multiple control types
- Recently embedded within several state ICE tools (limited new data input)
  - GDOT ICE
  - FDOT SPICE

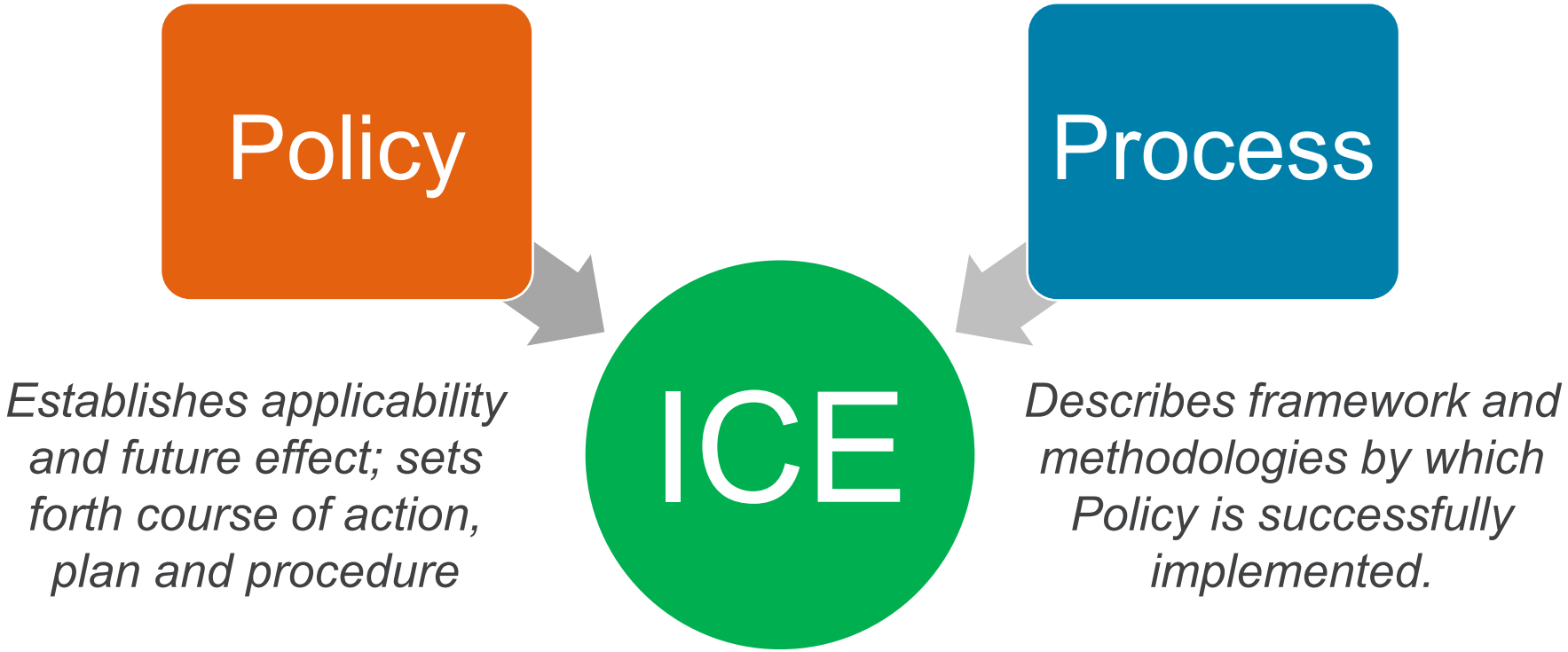
Safe System Intersections (SSI)

Intersection Type	$SSI_{Crossing}$	$SSI_{Merging}$	$SSI_{Diverging}$	$SSI_{Non-Motor}$	$SSI_{Intersection}$
Traditional 4-Leg Intersection (Allway Stop)	87.75	99.84	100.00	78.66	91.11
Traditional 4-Leg Intersection (Minor Stop)	17.90	97.53	92.27	38.32	49.85
Traditional 4-Leg Intersection (Signalized)	24.75	98.02	96.02	60.33	61.22
Single Lane Roundabout	-	97.99	63.01	89.43	82.04
2x1 Roundabout	98.14	99.72	99.98	84.22	95.28
RIRO with Downstream U-turn (Unsignalized)	-	53.89	13.60	23.36	25.77
RIRO with Downstream U-turn (Signalized)	-	59.17	23.54	43.46	39.27
Median U-Turn (Unsignalized U-Turn)	30.54	79.16	54.88	53.21	51.55
Median U-Turn (Signalized U-Turn)	30.54	76.42	61.67	53.21	52.61
Unsignalized J-Turn	67.53	75.26	89.06	60.61	72.37
RCUT / RCI / Superstreet	76.08	78.25	91.95	76.33	80.40
Partial Displaced Left Turn	8.52	92.84	71.33	41.75	39.17
Full Displaced Left Turn	17.32	91.74	69.01	32.23	43.36
Bowtie Intersection	17.97	94.19	79.29	53.34	51.72
Jughandle	18.42	94.69	76.01	54.21	51.78
Quadrant Roadway Intersection NW	10.95	91.17	58.05	69.37	44.78



Is ICE a Policy or Process?

Ans: ICE is BOTH a policy AND a process



Intersection Control Evaluation

THE PROCESS



Stage 1: Alternative Screening

- Cap-X or other V/C tools
  - Vehicle capacity focused; limited customization
- Context questions
  - Context, safety, bike/peds, capacity, in scale, feasibility
  - Typically qualitative; can be subject to bias
- Safety performance
  - Use of weighted factors for safety
  - Larger data / calculation requirements sometimes not available at planning level
- Still work to be done to develop consistent, equitable, bias-free, simplified process to develop shortlist

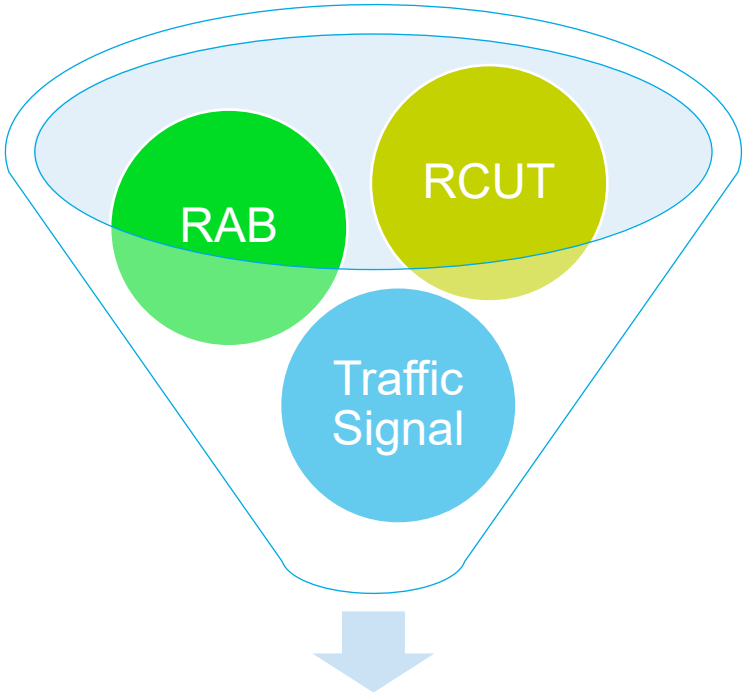
Stage 2 - Alternative Selection

Factor Considerations

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

Still work to be done in weighing factors to score and select

Shortlist of Alternatives from Stage 1



Preferred Alternative

Intersection Control Evaluation

STATE PROGRAMS / PROGRESS

Indiana Decision Process

Record Sheet for Stage 1: Initial, Feasibility Screening

Alternative		Answer to Question #1	Answer to Question #2	Answer to Question #3	Answer to Question #4	Feasible or Infeasible?	Specific Notes
Conventional Intersection		○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	
Median U-Turn Inter-section	Boule-vard Left	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	
	J-Turn or RCUT	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	
Roundabout Intersection		○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	○ Yes ○ No	

http://www.safetyanalysis.today/docs/TUES_PM_1C_ICE_Schmidt.pdf

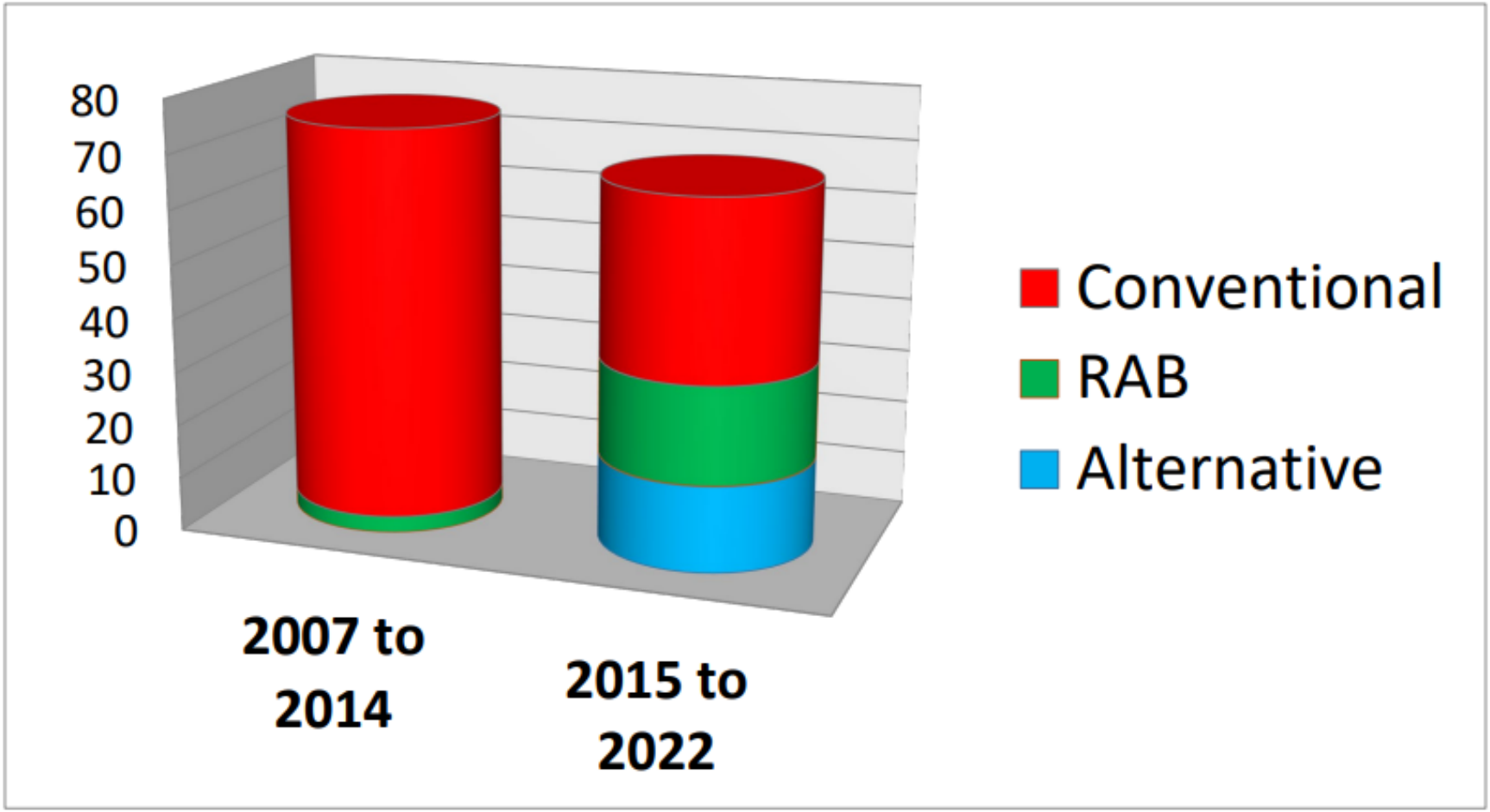
Indiana Decision Process

Stage II Record Sheet

Alternative		Feasible (from Stage 1)	Answer to Question #1	Answer to Question #2	Answer to Question #3-a (mobility)	Answer to Question #3-b (safety)	Answer to Question #4 (____ efficient)	Overall Qualitative Appraisal?	Selected as Best?
Conventional Intersection		● Yes ○ No	45 & 10 veh-hrs; C/D; 15 queue	CR = 20 reduced / year	CE(mob)= $150k / 45 & 10; C/D; 15 queue	CE(sfty)= $7,500 / crash reduced	Highly	Good	○ Yes ● No
Median U-Turn Inter-section	Boule-vard Left	○ Yes ● No							○ Yes ○ No
	J-Turn or RCUT	● Yes ○ No	35 & 10 veh-hrs; B/C; 8 queue	CR = 35 reduced / year	CE(mob)= $100k / 35 & 10; B/C; 8 queue	CE(sfty)= $2,900 / crash reduced	Highly	Excellent	● Yes ○ No

http://www.safetyanalysis.today/docs/TUES_PM_1C_ICE_Schmidt.pdf

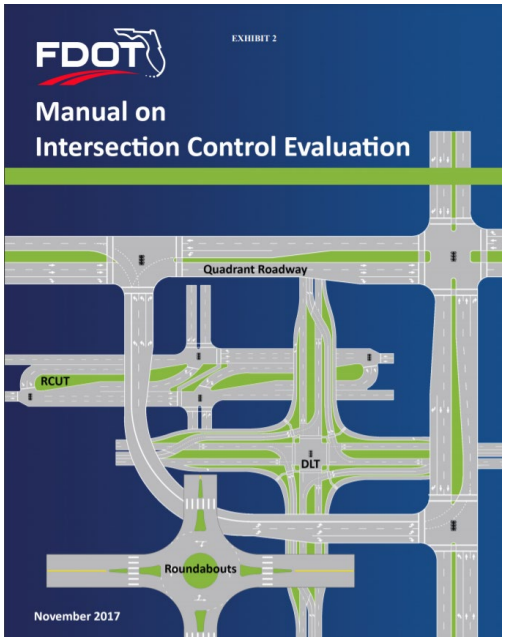
Indiana Decision Process



http://www.safetyanalysis.today/docs/TUES_PM_1C_ICE_Schmidt.pdf

Florida ICE/SPICE Tool

- Three stage process:
  - **Stage 1:** Screening using expanded SPICE CAP-X analysis tool
  - **Stage 2:** Preliminary Control Strategy Assessment using:
    - Synchro templates for operations analysis
    - Benefit-cost analysis
    - Safety-performance analysis (SPFs / CMFs)
  - **Stage 3:** Detailed Control Strategy Assessment to address qualitative issues



Florida ICE/SPICE Tool

Federal Highway Administration (FHWA)

Safety Performance for Intersection Control Evaluation Tool

Compute Results

Results

Summary of crash prediction results for each alternative

Project Information

Project Name:	14th/15th Street ICE Analysis	**Intersection Type**	At-Grade Intersections
Intersection:	15th St@13th Ave	**Opening Year**	2025
Agency:	FDOT	**Design Year**	2045
Project Reference:		**Facility Type**	On Urban and Suburban Arterial
City:	Tampa	**Number of Legs**	4-leg
State:	FL	**1-Way/2-Way**	1-way Intersecting 1-way
Date:	4/16/2021	**# of Major Street Lanes (both directions)**	5 or fewer
Analyst:		**Major Street Approach Speed**	Less than 55 mph

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	2.29	3.59	62.38	2	No	Uncalibrated SPF
	Fatal & Injury	0.61	0.91	16.19			
Minor Road Stop	Total	2.74	5.67	88.03	4	No	Calibrated SPF w/ EB
	Fatal & Injury	1.33	2.56	40.88			
All Way Stop	Total	3.20	5.82	94.96	3	N/A	N/A
	Fatal & Injury	1.12	2.12	33.95			
1-lane Roundabout	Total	2.66	4.15	71.82	1	No	Uncalibrated SPF
	Fatal & Injury	0.53	0.92	15.29			
2-lane Roundabout	Total	9.47	18.91	296.49	5	No	Uncalibrated SPF
	Fatal & Injury	1.67	3.59	54.71			

GDOT ICE STAGE 1

GDOT ICE STAGE 1: SCREENING DECISION RECORD

ICE Version 2.1 Revised 10/23/2017

GDOT PI #	0013332
Project Location:	SR 22 @ Fulton Mill Rd
Prepared by:	Arcadis
Analyst:	J. Reid
Date:	8/31/2017

Answer "Yes" or "No" to each policy question for each control type to identify which alternatives should be evaluated in the Stage 2 Decision Record; enter justification in the rightmost column

Note: Up to 5 alternatives may be selected and evaluated; Use this ICE Stage 1 to screen 5 or fewer alternaitves to evaluate in Stage 2

	Intersection Alternative (see "Intersections" tab for detailed description of intersection/interchange type)	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 & location context?	6. Does alternative appear feasible with respect to other project factors?	7. Overall feasible alternative (select alternative for further evaluation in Stage 2)?	Screening Decision Justification:
Unsignalized	Conventional (Minor Stop)	No	No	No	No	No	No	No	Existing Conditions
	Conventional (All-Way Stop)	No	No	**Yes**	No	**Yes**	No	No	AWS not viable because of multi-lane approaches and wide median
	Mini Roundabout	**No**	**Yes**	**Yes**	**No**	**Yes**	**No**	**Yes**	**Control not appropriate for high-speed, multi-lane roadway**
	Single Lane Roundabout	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Yes**	**Potential solution to evaluate**
	Multilane Roundabout	**Yes**	**Yes**	No	**Yes**	**Yes**	**Yes**	No	Potential solution to evaluate
	RCUT (stop control)	**No**	**Yes**	**No**	**Yes**	**Yes**	**Yes**	**Yes**	**Potential solution to evaluate**
	RIRO w/downstream U-Turn	No	**Yes**	**Yes**	No	**Yes**	No	No	Through traffic volumes too high
	High-T (unsignalized)	No	No	No	No	No	No	No	Not at T-intersection
	Offset-T Intersections	No	**Yes**	**Yes**	No	No	No	No	Signifigant impact to corner parcels due to skew
	Diamond Interch (Ramp Stop Control)	No	No	No	No	No	No	No	Not cost feasible alternative

GDOT ICE STAGE 2

GDOT ICE STAGE 2: ALTERNATIVE SELECTION DECISION RECORD

ICE Version 2.1 | Revised 12/13/2017

GDOT PI # (or N/A): 0013332
County: Bibb
Project Location: SR 22 @ Fulton Mill Rd
Existing Intersection Control: Conventional (Minor Stop)

GDOT District: 3 - Thomaston
Area Type: Rural

Date: 12/15/2017
Agency/Firm: Arcadis
Analyst: J. Reid
Type of Analysis: Conventional Non-Safety Funded Project

Opening / Design Year Traffic Operations

Intersection meets signal/AWS warrants?	Meets Signal Warrants	
Traffic Analysis Measure of Effectiveness	Intersection Delay	
Traffic Analysis Software Used	Synchro 9	
Analysis Time Period	AM Peak Hr	PM Peak Hr
2017 Peak Hour Intersection Delay	20.6 sec	27.8 sec
2017 Intersection V/C ratio	0.52	0.67
2027 Design Yr No-Build Intersection Delay	74.5 sec	80.5 sec
2027 Design Yr No-Build Intersection V/C ratio	1.04	1.15

Complete Streets Warrants Met?

- ☐ PEDESTRIANS
- ☐ BICYCLES
- ☐ TRANSIT

Crash Type

Crash Data: Enter 5 most recent years of intersection crash data	Crash Severity: PDO	Injury Crash*	Fatal Crash*	
Angle	7	8	1	29%
Head-On	1	0	2	5%
Rear End	25	5	0	54%
Sideswipe - same	0	0	0	0%
Sideswipe - opposite	1	0	0	2%
Not Collision w/Motor Veh	3	3	0	11%
TOTALS:	37	16	3	56

* Number of crashes resulting in injuries / fatalities, not number of persons

Alternatives Analysis:

	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Proposed Control Type/Improvement:	Single Lane Roundabout	Multilane Roundabout	RCUT (stop control)	Add Left Turn Lanes	Traffic Signal
Project Cost: (From CostEst Worksheet)	*Additional description here*	*Additional description here*	*Additional description here*	*Additional description here*	*Add three LT bays*
Construction Cost	$1,412,000	$2,037,000	$479,000	$588,000	$401,000
ROW Cost	$76,000	$149,000	$12,000	$0	$0
Environmental Cost	$0	$66,000	$10,000	$10,000	$0
Reimbursable Utility Cost	$42,000	$119,000	$16,000	$20,000	$8,000
Design & Contingency Cost	$394,000	$588,000	$122,000	$149,000	$140,000
Cost Adjustment (justification req'd)	0%	0%	0%	0%	0%
Total Cost	$1,924,000	$2,959,000	$639,000	$767,000	$549,000

Traffic Operations:										
Traffic Analysis Software Used	GDOT RND Tool 4.1		GDOT RND Tool 4.1		Synchro 9		Synchro 9		Synchro 9	
Analysis Period	AM Peak Hr	PM Peak Hr	AM Peak Hr	PM Peak Hr	AM Peak Hr	PM Peak Hr	AM Peak Hr	PM Peak Hr	AM Peak Hr	PM Peak Hr
2027 Design Yr Build Intersection Delay	16.5 sec	21.0 sec	10.8 sec	11.7 sec	32.0 sec	40.8 sec	74.0 sec	78.2 sec	27.9 sec	32.0 sec
2027 Design Yr Build Intersection V/C	0.59	0.65	0.51	0.58	0.65	0.74	1.03	1.13	0.67	0.75

Safety Analysis:					
Predefined CRF: PDO	71%	63%	20%	48%	44%
Predefined CRF: Fatal/Inj	87%	63%	36%	58%	40%
Predefined CRF Source:	FHWA Clearinghouse #s 229 / 230	FHWA Clearinghouse #s 4927 / 4927	FHWA Clearinghouse #s 351 / 353	FHWA Clearinghouse #s 268 / 272	FHWA Clearinghouse #s 7982 / 7984

GDOT ICE STAGE 2

GDOT ICE STAGE 2: ALTERNATIVE SELECTION DECISION RECORD

ICE Version 2.1 | Revised 12/13/2017

GDOT PI # (or N/A): 0013332
County: Bibb
Project Location: SR 22 @ Fulton Mill Rd
Existing Intersection Control: Conventional (Minor Stop)

GDOT District: 3 - Thomaston
Area Type: Rural

Date: 12/15/2017
Agency/Firm: Arcadis
Analyst: J. Reid
Type of Analysis: Conventional Non-Safety Funded Project

Opening / Design Year Traffic Operations

Intersection meets signal/AWS warrants?	Meets Signal Warrants	
Traffic Analysis Measure of Effectiveness	Intersection Delay	
Traffic Analysis Software Used	Synchro 9	
Analysis Time Period	AM Peak Hr	PM Peak Hr
2017 Peak Hour Intersection Delay	20.6 sec	27.8 sec
2017 Intersection V/C ratio	0.52	0.67
2027 Design Yr No-Build Intersection Delay	74.5 sec	80.5 sec
2027 Design Yr No-Build Intersection V/C ratio	1.04	1.15

Complete Streets Warrants Met?

- ☐ PEDESTRIANS
- ☐ BICYCLES
- ☐ TRANSIT

Crash Type (*Crash Data:* Enter 5 most recent years of intersection crash data)	Crash Severity: PDO	Injury Crash*	Fatal Crash*	
Angle	7	8	1	29%
Head-On	1	0	2	5%
Rear End	25	5	0	54%
Sideswipe - same	0	0	0	0%
Sideswipe - opposite	1	0	0	2%
Not Collision w/Motor Veh	3	3	0	11%
TOTALS:	37	16	3	56

* Number of crashes resulting in injuries / fatalities, not number of persons

Alternatives Analysis:	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Proposed Control Type/Improvement:	Single Lane Roundabout	Multilane Roundabout	RCUT (stop control)	Add Left Turn Lanes	Traffic Signal
Environmental Impacts:[1]					
Historic District/Property	None	None	None	None	None
Archaeology Resources	None	None	None	None	None
Graveyard	None	None	None	None	None
Stream	None	Minimal	None	None	None
Underground Tank/Hazmat	None	None	None	None	None
Park Land	None	None	None	None	None
EJ Community	None	None	None	None	None
Wooded Area	None	None	Minimal	Minimal	None
Wetland	None	None	None	None	None
Stakeholder Posture:					
Local Community Support	Neutral	Negative	Neutral	Supportive	Supportive
GDOT Support	Supportive	Neutral	Supportive	Neutral	Neutral

[1] *Environmental impacts are only preliminary estimates; detailed environmental impact documentation will be included with project concept report*

Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
7.0	5.5	5.3	4.6	6.0
1	3	4	5	2

Colorado ICAT

ICAT STAGE 1: ALTERNATIVE SHORT-LIST DECISION RECORD

Developed and Maintained in Cooperation with

CDOT ICAT Version 1.0 | Release Date: 8/30/2021

Project Number:	0012345
Project Location:	Colorado Street @ 30th Street
Existing Control:	Conventional Minor Stop
Prepared by:	Region Traffic Engineer
Date:	7/27/2021

1. Answer questions 1-16 with rating of 0, 1 or 2.
2. Deselect or select any alternative by placing an X or Y (respectively) in column to right of score; Enter change justification in rightmost column

Use this Stage 1 assessment form to select **2 to 5 alternatives** to be carried into Stage 2 evaluations; Intersection control alternatives with the highest total weighted scores will be highlighted in **BLUE** and automatically carried forward into the Stage 2 assessment worksheet.

Number of Alternatives to be Evaluated in Stage 2: 5

		Right of Way			*Safety*				*Roadway Context*				*Operations/Maintenance*			*Costs*			
	Intersection Alternatives: (see Intersections tab for detailed description of intersection/interchange type)	Q1: Is ROW on major road constrained? (0=no, 1=somewhat, 2=highly)	Q2: Is ROW on minor road constrained? (0=no, 1=somewhat, 2=highly)	Q3: Intersection quadrants constrained? (0=no, 1=somewhat, 2=highly)	Q4: Are there intersection safety issues? (0=low, 1=moderate, 2=crash hot spot)	Q5: Are there significant pedestrian crossings? (0=none/low, 1=moderate, 2=high)	Q6: Is there significant bicycle activity? (0=none/low, 1=moderate, 2=high)	Q7: Are one or more approach speeds high? (0=no, 1=moderate, 2=high)	Q8:Do roadway contexts, characteristics transiti at intersection? (0=no, 1=yes)	Q9: Are there numerous driveways near intersection? (0=no, 1=few, 2=many)	Q10: What is adjacent intersection spacing? (0=isolated, 1=network, 2= dense network)	Q11: Is this a T-intersection? Or can minor ST t or left turns be eliminated? (0=No, 1=Yes)	Q12: Are design yr no-build volumes high? No-Build 2043 V/C=1.65; (0=low, 2=mod, 4=high)	Q13: Are exist LT volumes high? (Max 2021 LT =400 vph) ; (0=no, 1=somewhat, 2=yes)	Q14: Could intersection become interchange in 20 yrs? (0=no, 1=maybe, 2=probably)	Q15: Are costs a primary decision factor? (0=no, 1=somewhat, 2=yes)	**Total Stage 1 Screening Evaluation Score**	Alternative choice override (justification required)	**Scoring Override Justification:**
		2	1	0	2	1	1	0	1	1	1	1	4	2	0	2			
Conventional Improvements	-- select --																		
	-- select --																		
	Minor Street Stop	0.89	0.89	3	1	1	3	2	0	0	3	2	0	0	0	3	**19.7**		
	All-Way Stop	0.89	0.89	3	3	1	2	1	1	0	1	2	0	0	0	3	**21.7**		
Unsignalized Intersections	Right-In/Right-out	0.89	0.89	3	3	2	2	2	0	0	3	3	0	0	0	3	**24.7**		
	Right-in/Right-out/Left-in (3/4 access)	0.31	0.89	3	2	2	2	2	1	0	3	3	1	2	0	3	**30.5**	X	Does not address project needs
	RIRO w/downstream U-Turn	-0.13	0.89	1	3	2	2	2	1	-1	2	2	1	1	0	2	**24.6**		
	Mini Roundabout	1.09	1.09	3	2	1	2	1	2	-1	2	3	0	1	0	3	**24.3**		
	Single Lane Roundabout	1.09	1.09	2	3	1	2	2	3	-1	2	3	1	2	0	2	**31.3**	X	Multi Lane Roads
	Multilane Roundabout	**0.57**	**0.89**	**1**	**2**	**1**	**1**	**1**	**3**	**-2**	**1**	**2**	**2**	**3**	**1**	**1**	**28.0**	Y	**Public endorsed solution**
	RCUT / J-Turn (stop control)	-0.13	0.53	1	2	2	2	2	2	-1	2	2	1	2	1	3	**27.3**		
	High-T (unsignalized)	0.27	0.44	3	1	0	1	2	1	-2	0	4	1	2	0	2	**19.0**		
	Unsignalized Offset-T Intersection	0.44	0.89	3	1	1	2	2	2	-1	0	4	1	1	0	2	**21.8**		
	Other Signalized Intersection (Describe)																		
ections	**Signalized Intersection**	**0.47**	**0.89**	**3**	**2**	**2**	**2**	**2**	**1**	**-1**	**2**	**2**	**2**	**2**	**0**	**2**	**29.8**		
	Median U-Turn	-0.13	0.53	1	2	2	3	3	1	-1	2	1	3	1	3	1	**28.3**		
	Superstreet / RCI	**-0.13**	**0.53**	**1**	**2**	**2**	**3**	**3**	**1**	**-1**	**2**	**2**	**3**	**2**	**3**	**1**	**31.3**		
	Displaced Left-Turn / CFI	**-1.12**	**-1.71**	**0**	**1**	**0**	**1**	**2**	**1**	**-2**	**0**	**1**	**3**	**3**	**0**	**0**	**17.0**	Y	**Locally Preferred Option**

https://www.codot.gov/programs/operations/tsmo-evaluation

2020 LADOTD

a. A project that will change capacity, geon
defined in this EDSM.
b. All traffic engineering studies that chang
existing and no build traffic operations a
level analysis of possible alternatives an
operations and safety. The Traffic Engine
used as guidance to satisfy the traffic en
c. This policy applies to all improvements t
or federal monies or constructed by per
government.
d. This policy applies to improvements on
e. This policy applies to the studies require
and EDSM VI.1.1.9 Access Management
a waiver signed by the Chief Engineer. T
(http://wwwsp.dotd.la.gov/Inside_LaDO
(http://wwwsp.dotd.la.gov/Inside_LaDO
f. If the outcome of a study is a recommen
be adopted, the associated report must
Engineer and approved by the Traffic En

http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions

Traffic Analysis

DOTD uses an integrated, systematic and performance based approach to traffic engineering. For our intersection control evaulation policy, please see **EDSM VI.1.1.2 Intersection Control Evaluation (ICE) Requirements**.

The following definitions are provided for clarification purposes:

- Traffic Signal Upgrade: Work which involves any one of the following for non-emergency purposes; the installation of a new controller and cabinet, rewiring the entire signal, installing all new poles or changing the layout of the signal.
- Restricted Crossing U-Turn (RCUT): Intersection is defined as a non-traditional intersection system that utilizes a combination of one partial median opening and two directional median openings. This type of intersection is typically the crossing of major and minor arterials where the left turn moves are relatively high. The openings must be appropriately spaced with one directional u-turn opening or one partial median opening on each side of the partial median opening. The distance between two of these systems is also critical. The intersection and u-turns may be unsignalized or signalized, depending on volumes.
- Median U-Turn (MUT) Intersection: Intersection is defined as the use of two or four directional u-turn openings, placed on each side of an intersection, combined with the prohibition of all left turns at the intersection. This type of intersection is typically the crossing of two major arterials where the through move is heavier than the left turns. All through movements and right turns at the intersection are permitted. The openings must be appropriately spaced with one directional median opening on each side of the partial median opening. The distance between two of these treatments is also critical. The main intersection is typically signalized and the u-turns may be unsignalized or signalized, depending on volumes.
- Full Access Traffic Signal: A traffic signal where all approaches are allowed to turn left out and left in.

Software Resources

Type	Name	Modified	File Size
	DOTD Sidra Parameters	4/29/2022 1:41 PM	427 KB
	DOTD Vissim Parameters	3/9/2022 1:35 PM	128 KB
	DOTD Vissim Vehicles	3/9/2022 1:35 PM	10286 KB
	Microsimulation Policy	11/7/2019 3:24 PM	414 KB
	Traffic Analysis Software Selection	11/7/2019 3:24 PM	341 KB

Tier 1 Analysis Tools

- FHWA Capacity Analysis for Planning of Junctions (Cap-X)
  - Cap-X 2018 Tool
  - Cap-X 2018 Tool User Guide
- FHWA Safety performance for Intersection Control Evaluation (SPICE)
  - ICE Primer
  - SPICE Tool
  - SPICE Tool User Guide

Pennsylvania DOT

Pennsylvania Department of Transportation
Intersection Control Evaluation (ICE) Form
Stage 2: Initial Control Strategy Assessment

pennsylvania DEPARTMENT OF TRANSPORTATION

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	Case Study #5			Project ICE Reference Number	XXXX-XXXX
Submitted By	XXX	Agency/Company	PennDOT	Email	XXXX.XXXX@state.pa.us

List all viable intersection control strategies identified in Phase 1 (Screening):

Signalized Control	Median U-Turn	Restricted Crossing U-Turn (RCUT) Signalized

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

	Analysis Year	2017						
	Peak Hour Analyzed	Weekday AM Peak			Peak Hour Analyzed	Weekday AM Peak		
Control Strategy	LOS	V/C	Delay (sec.)	All queues accommodated?	LOS	V/C	Delay (sec.)	All queues accommodated?
Signalized Control	C	0.85	27.2	Yes	C	0.73	31.5	Yes
Median U-Turn	C	0.91	44.5	Yes	D	0.81	42.7	Yes
Restricted Crossing U-Turn (RCUT) Signalized	F	1.24	178.4	No	E	1.32	65.6	No

Design Year

	Analysis Year	2037						
	Peak Hour Analyzed	Weekday PM Peak			Peak Hour Analyzed	Weekday PM Peak		
Control Strategy	LOS	V/C	Delay (sec.)	All queues accommodated?	LOS	V/C	Delay (sec.)	All queues accommodated?
Signalized Control	E	1.11	63.7	Yes	D	0.90	42.1	Yes
Median U-Turn	E	1.13	79.1	Yes	E	0.98	79.6	Yes
Restricted Crossing U-Turn (RCUT) Signalized	F	2.54	396.7	No	F	2.45	120.0	No

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

Both the modified traffic signal and median u-turn operate acceptably under year 2017 traffic volumes and can accommodate future design year growth. To achieve these levels of operation under signalized control, additional northbound and southbound through lanes should be provided and signal timing plan should be adjusted and optimized.

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:
Signalized Control	$500,000	PE, ROW, & Construction			
Median U-Turn	$2,000,000	PE, ROW, & Construction			
Restricted Crossing U-Turn (RCUT) Signalized	$10,000,000	PE, ROW, & Construction			

Pennsylvania DOT

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
Signalized Control	Improving the existing signal timing plan would reduce the number of severe collisions by producing smoother traffic flow and fewer stops. As a result, the number of rear-end crashes would be anticipated to be reduced.	7.99	6.98	0.20
Median U-Turn	A median U-turn design is anticipated to have better safety performance, as it has fewer vehicle-vehicle conflict points. Installing a median U-turn would reduce the probability of head-on and angle crashes that typically have high percentage of injury severity.	7.15	3.05	4.16
Restricted Crossing U-Turn (RCUT) Signalized	Installing an RCUT would reduce the number of conflict points at the intersection and consequently result in a reduction in crashes, especially right angle crashes.	7.15	3.39	2.90

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 ped. crossings (both approaches, if app.):	0	0	0	0
# of bicyclists (both approaches, if app.):	0	0	0	0

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	No existing or anticipated ped and bike activities in site vicinity.	The modified signal control would continue to adequately accommodate bus service operating along SR 19.	Modifications would accommodate WB-67 design vehicle
Median U-Turn	No existing or anticipated ped and bike activities in site vicinity.	The design of the median U-turn intersection would not impact existing bus service along SR 19.	Accomodates WB-67 design vehicle
Restricted Crossing U-Turn (RCUT) Signalized	No existing or anticipated ped and bike activities in site vicinity.	The design of the restricted crossing U-turn intersection would not impact existing bus service along SR 19.	Accomodates WB-67 design vehicle

https://www.dot.state.pa.us/public/Bureaus/BOMO/Portal/TSPortal/ICE.html

TDOT ICE Stage I

Intersection Location:	SR 1 at Penny Lane in Davidson County				
Number of Intersection Legs:	4	**PIN:**	12345.00	**Date:**	9/3/20
Existing Control Type:	Two-Way Stop Control	**Analyst:**	JHS, ABC Consultant	Version:	09142020

TDOT IIE Stage I Form - Scoping

Control Type	Conflict Point Score (lower # is better)	Is the option feasible and reasonable?	Is the option likely to improve or maintain safety?	Is the option likely to improve operations?	Is the Optoin likely to improve or maintain multimodal access?	AM V/C Ratio (CAP X)	PM V/C Ratio (CAP X)	Should the Option proceed to Stage II?	
At-Grade Intersection	Safety	Q1	Q2	Q3	Q4	Capacity		Decision	Screening Decision Justification
Traffic Signal	48	Yes	Yes	Yes	Yes	0.22	0.34	Yes	Should proceed to Stage II
Two-Way Stop Control	48	Yes	Yes	No	Yes	0.19	1.17	No	Over capacity
All-Way Stop Control	48	Yes	Yes	No	Yes	0.73	1.04	No	Over capacity, Do not want multilane stop control
Continuous Green T	n/a	-	-	-	-			No	Not applicable
Quadrant Roadway	40	No	-	-	-			No	No ROW for connecting road
Partial Displaced Left Turn	44	No	-	-	-			No	Not necessary for volumes
Displaced Left Turn	40	No	-	-	-			No	Not necessary for volumes
Signalized RCUT	20	Yes	Yes	Yes	No	0.22	0.31	No	Pedestrian crossing is important, no U-turn option
J-Turn (Unsignalized RCUT)	20	Yes	Yes	Yes	No	0.18	0.47	No	Pedestrian crossing is important, no U-turn option
Median U-Turn	20	No	-	-	-			No	Median not wide enough
Partial Median U -Turn	28	No	-	-	-			No	Median not wide enough
Bowtie	24	No	-	-	-			No	Not necessary for volumes
Split Intersection	36	No	-	-	-			No	Not necessary for volumes
Roundabout	8	Yes	Yes	Yes	Yes	0.25	0.30	Yes	Should proceed to Stage II
Other (provide description)		-	-	-	-			-	
Grade-Separated Intersection	Safety	Q1	Q2	Q3	Q4	CAP-X		Decision	Screening Decision Justification
Echelon	28	No	-	-	-			No	Not necessary for volumes
Center Turn Overpass	32	No	-	-	-			No	Not necessary for volumes
Interchange	Safety	Q1	Q2	Q3	Q4	CAP-X		Decision	Screening Decision Justification
Diamond	28	No	-	-	-			No	Not necessary for volumes
Partial Cloverleaf	20	No	-	-	-			No	Not necessary for volumes
Displaced Left Turn Interchange	28	No	-	-	-			No	Not necessary for volumes
Contraflow Left Interchange	32	No	-	-	-			No	Not necessary for volumes
DDI	20	No	-	-	-			No	Not necessary for volumes
Single Point	32	No	-	-	-			No	Not necessary for volumes
Single Point with Roundabout	12	No	-	-	-			No	Not necessary for volumes
Other (provide description)		-	-	-	-			No	Not necessary for volumes

Figure 2-7: IIE Stage I – Scoping Form (Sample Data)

TDOT ICE Stage II

- Project Cost
- Life-cycle Cost (Optional)
- Traffic Operations
  - LOS
  - Delay
  - V/C Ratio
  - Queue Results
- Predictive Crash Analysis (Optional)
- Multimodal Qualitative Assessment
- Stakeholder Posture
- TDOT Approval

TN TDOT Department of Transportation	Intersection Location:	SR-6 at SR-248 in Williamson County								
	Number of Intersection I	3		PIN:	124792.00			Date:	5/6/21	
	TDOT IIE Stage II Form - Selecti			Analyst	Arcadis			Version: 09142020		
	Existing Control	Option 1		Option 2		Option 3		Option 4		
DOT IIE Stage II Form - Selecti	Other (provide descriptio	Traffic Signal		Continuous Green T		-Turn (Unsignalized RCU		Other (provide descriptio		
Project Cost										
Tool Used	Not Applicable	Other		Other		Other		Other		
Total Project Cost	Not Applicable	$250,000		$950,000		$650,000		$3,500,000		
Life Cycle Cost										
Tool Used	-	-		-		-		-		
Analysis Period	2025 to 2045	2025 to 2045		2025 to 2045		2025 to 2045		2025 to 2045		
Total Life Cycle NPV Cost	-	-		-		-		-		
Traffic Operations										
Traffic Analysis Software Used	-	-		-		-		-		
2025 Opening Year	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
LOS	-	-	A	B	B	B	A	B	A	A
Delay (s/veh)			7.1	13.7	10.1	18.5	7.1	13.7	1.3	1.5
v/c			0.41	0.58	0.48	0.62	0.41	0.58	0.05	0.1
Queues Accommodated?	-	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2045 Design Year	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
LOS	-	-	B	F	C	F	B	F	A	A
Delay (s/veh)			15.2	86.1	32.9	106.7	15.2	86.8	1.8	2.1
v/c			0.86	1.21	0.99	1.21	0.86	1.21	0.1	0.13
Queues Accommodated?	-	-	Yes	No	Yes	No	Yes	No	Yes	Yes
Predictive Crash Analysis										
Tool Used	Other	Other		Other		Other		Other		
Analysis Period	2025 to 2045	2025 to 2045		2025 to 2045		2025 to 2045		2025 to 2045		
Total Crashes		5		4		5		1		
Fatal & Injury Crashes		2		1		3		0		
Multimodal										
Are peds, bicyclists, and transit riders accommodated?	-	Well		Adequately		Well		Well		
Stakeholder Posture										
Local Community Support	Not Applicable	Unknown		Unknown		Unknown		Unknown		
TDOT Support	Not Applicable	Unknown		Unknown		Unknown		Unknown		
TDOT Approval										
Preferred Option?	Not Applicable	-		-		-		-		

NCDOT "SaFID" Charts

			Minor Street									
			Thru Lanes	2			4				6	8
Major Street			Low AADT	0	5,000	7,500	10,000	10,000	15,000	20,000	25,000 and above	Any	Any
Thru lanes	Low AADT	High AADT	High AADT	5,000	7,500	10,000	15,000	15,000	20,000	25,000			
2	0	5,000	**Safest**	**All-Way Stop**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			CMF	0.3									
			Compare to	Two-way stop									
	5,000	7,500	**Safest**	**All-Way Stop**	**All-Way Stop**	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			CMF	0.3	0.3								
			Compare to	Two-way stop	Two-way stop								
	7,500	10,000	**Safest**	**One-Lane Roundabout**	**One-Lane Roundabout**	**One-Lane Roundabout**	n/a	n/a	n/a	n/a	n/a	n/a	n/a
			CMF	0.5	0.6	0.6							
			Compare to	Two-way stop	Signal	Signal							
	10,000	15,000	**Safest**	**One-Lane Roundabout**	**One-Lane Roundabout**	**One-Lane Roundabout**	**One-Lane Roundabout***	n/a	n/a	n/a	n/a	n/a	n/a
			CMF	0.5	0.6	0.6	0.6						
			Compare to	Two-way stop	Signal	Signal	Signal						
4	10,000	15,000	**Safest**	**Unsignalized RCI**	**Unsignalized RCI**	**Unsignalized RCI**	**Signalized RCI**	**Signalized RCI**	n/a	n/a	n/a	n/a	n/a
			CMF	0.6	0.8	0.8	0.8	0.8					
			Compare to	Two-way stop	Signal	Signal	Signal	Signal					
	15,000	20,000	**Safest**	**Unsignalized RCI**	**Unsignalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	n/a	n/a	n/a	n/a
			CMF	0.6	0.8	0.8	0.8	0.8	0.8				
			Compare to	Two-way stop	Signal	Signal	Signal	Signal	Signal				
	20,000	25,000	**Safest**	**Unsignalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	n/a	n/a	n/a
			CMF	0.6	0.8	0.8	0.8	0.8	0.8	0.8			
			Compare to	Two-way stop	Signal	Signal	Signal	Signal	Signal	Signal			
	25,000	30,000	**Safest**	**Unsignalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Median U-Turn**	n/a	n/a
			CMF	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8		
			Compare to	Two-way stop	Signal	Signal	Signal	Signal	Signal	Signal	Signal		
	30,000 and above		Safest	**Unsignalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Median U-Turn**	n/a	n/a
			CMF	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8		
			Compare to	Two-way stop	Signal	Signal	Signal	Signal	Signal	Signal	Signal		
6	Any		Safest	**Unsignalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Median U-Turn**	**Median U-Turn**	n/a
			CMF	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	
			Compare to	Two-way stop	Signal	Signal	Signal	Signal	Signal	Signal	Signal	Signal	
8	Any		Safest	**Unsignalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Signalized RCI**	**Median U-Turn**	**Median U-Turn**	**Median U-Turn**
			CMF	0.6	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
			Compare to	Two-way stop	Signal	Signal	Signal	Signal	Signal	Signal	Signal	Signal	Signal

NCDOT "POFID" Charts

				Minor street						
			Number through lanes:	2				4		6 or 8
Major street			Low AADT:	0	5,000	7,500	10,000	10,000	25,000 and above	Any
Number through lanes	Low AADT	High AADT	High AADT:	5,000	7,500	10,000	15,000	25,000		
2	0	7,500		1) AWSC	2) AWSC	n/a	n/a	n/a	n/a	n/a
	7,500	15,000		3) Roundabout	4) Roundabout	5) Roundabout	6) Roundabout or signal	n/a	n/a	n/a
4	10,000	15,000		7) TWSC or signal	8) Bowtie or MUT	9) Bowtie or MUT	10) Bowtie or MUT	11) Bowtie or MUT	n/a	n/a
	15,000	20,000		12 TWSC or signal	13) Bowtie or MUT	14) Bowtie or MUT	15) Bowtie or MUT	16) Bowtie or MUT	n/a	n/a
	20,000	25,000		17) TWSC or signal	18) Bowtie or MUT	19) Bowtie or MUT	20) Bowtie or MUT	21) Bowtie or MUT	n/a	n/a
	25,000 and above			22) TWSC or signal	23) Bowtie or MUT	24) Bowtie or MUT	25) Bowtie or MUT	26) Bowtie or MUT	27) MUT	n/a
6 or 8	Any			28) TWSC or signal	29) Bowtie or MUT	30) Bowtie or MUT	31) Bowtie or MUT	32) Bowtie or MUT	33) MUT	34) MUT

Pedestrian Optimum Feasible Intersection Design **(POFID)** Table

NCDOT "BOFID" Charts

				Minor street						
			Number through lanes:	2				4		6 or 8
Major street			Low AADT:	0	5,000	7,500	10,000	10,000	25,000 and above	Any
Number through lanes	Low AADT	High AADT	High AADT:	5,000	7,500	10,000	15,000	25,000		
2	0	7,500		1) AWSC	2) AWSC	n/a	n/a	n/a	n/a	n/a
	7,500	15,000		3) Roundabout	4) Roundabout	5) Roundabout	6) Roundabout or signal	n/a	n/a	n/a
4	10,000	15,000		7) Unsignalized RCI or TWSC	8) Bowtie or MUT	9) Bowtie or MUT	10) Bowtie or MUT	11) Signalized RCI	n/a	n/a
	15,000	20,000		12) Unsignalized RCI or TWSC	13) Bowtie or MUT	14) Bowtie or MUT	15) Bowtie or MUT	16) Signalized RCI	n/a	n/a
	20,000	25,000		17) Unsignalized RCI or TWSC	18) Bowtie or MUT	19) Bowtie or MUT	20) Bowtie or MUT	21) Signalized RCI	n/a	n/a
	25,000 and above			22) Unsignalized RCI or TWSC	23) Bowtie or MUT	24) Bowtie or MUT	25) Bowtie or MUT	26) Signalized RCI	27) MUT	n/a
6 or 8	Any			28) Unsignalized RCI or TWSC	29) Signalized RCI	30) Signalized RCI	31) Signalized RCI	32) Signalized RCI	33) MUT	34) MUT

Bicycle Optimum Feasible Intersection Design (**BOFID)** Table

Conclusions

- States beginning to develop ICE polices at greater pace; more states expressing interest
- More validated policies / tools available from current ICE programs
- Need for more qualitative processes to reduce user bias
- Need for methods to select and weight competing factors
- Enhancement tools (big data / SSI) may enter processes
- NCHRP 17-98 (Summer 2023) will help fill some gaps

Questions



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