CDOT INTERSECTION CONTROL ASSESSMENT TOOL (ICAT)

Version 1.0 Users Guide

The CDOT Intersection Control Assessment Tool (ICAT) is an open-source Excel workbook that includes 7 worksheets, each containing data inputs needed to complete an intersection control assessment. Computations rely on input from multiple worksheets, and the assessment results are continually updated as the worksheets are completed. Therefore, no results should be considered final until all worksheets are fully complete.

INTRODUCTION WORKSHEET

The **Introduction** worksheet provides information on the purpose and goals of the intersection control assessment, a description of the tool processes and responsibilities, answers to frequently asked questions, and documentation of ICAT version updates.

INTERSECTIONS WORKSHEET

The **Intersections** worksheet provides descriptions and graphics of each intersection type included for evaluation and links to national guides or publications that describe each intersection type in greater detail.

INTERSECTION DATA WORKSHEET

The **Intersection Data** worksheet begins the ICAT data entry process. **Figure 1** illustrates a blank worksheet and requested inputs for project, traffic, and safety data. Here and throughout the tool, orange text or boxes indicate **required** data inputs, and blue text or boxes indicate **optional** data inputs.

Project traffic and safety data input for a case study example project is illustrated in **Figure 2**, and requires the following:

- Project number and responsible person/agency
- County and CDOT region
- Major/Minor Road names and drop downs for roadway typology, turn lanes, right-of-way, speed limits and Major Road direction; note intersection lanes are determined by road typology, and if turn lanes are different by approach, choose the most conservative (most turn lanes) for entire street
- Area type, terrain, and existing intersection control
- Preparing agency name, date, and brief project description
- Project opening and design years and intersection K-factor (% of daily traffic occurring in the peak hour). While these factors are used to make traffic volume projection estimates, known traffic forecast data can be included using traffic data overrides tables.
- Crash history data (number of PDO, injury and fatal crashes) and LOSS factor obtained using DiExSys or state LOSS database.

Figure 3 illustrates the project example traffic data entry which is located outside the worksheet print border. Users can input data for up to two evaluation periods (typically AM and PM peak periods). The existing peak period volumes, approach growth rates, truck percentages and pedestrian volumes are input using the tables to the right (grey shaded area) and volume data is automatically copied onto the traffic diagrams. Based on input data, the worksheet will auto-calculate daily intersection entry volumes, approach volumes and Average Daily Traffic (ADT) volumes for existing, opening-year and design-year scenarios. If opening and design year traffic volumes and/or ADT volumes are known from other sources, the calculated volumes based on the input growth rate can be overwritten using the tables outside the worksheet print border.

Figure 1: Blank Intersection Data Worksheet

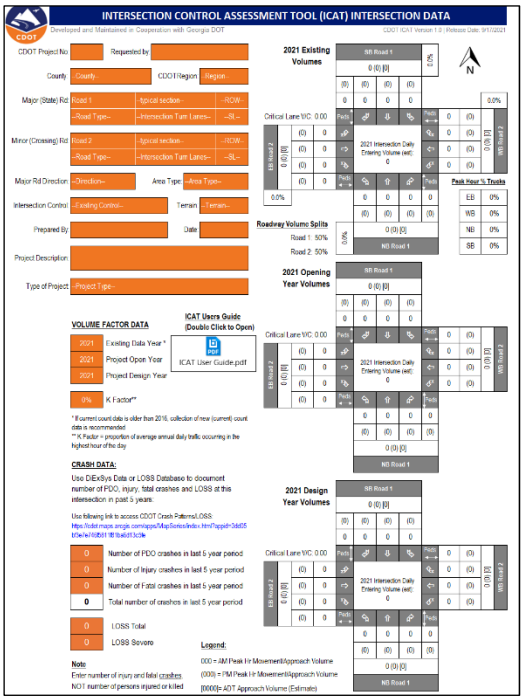


Figure 2: Project Information (Example Case)

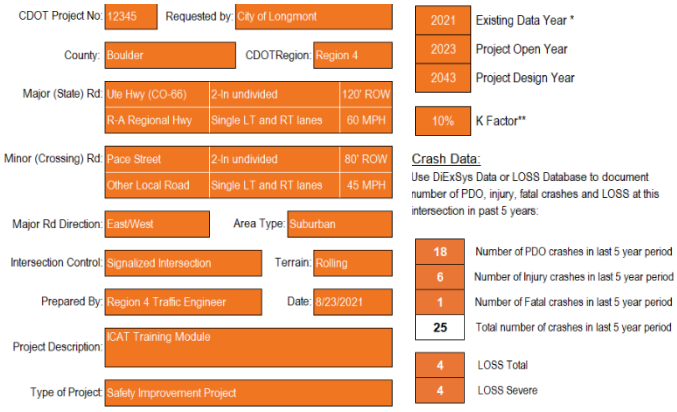
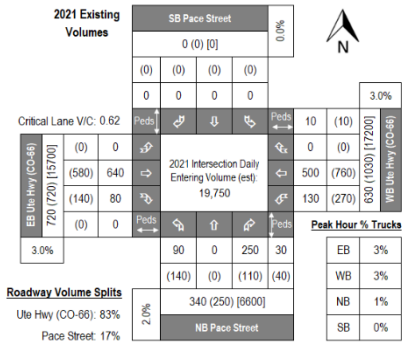
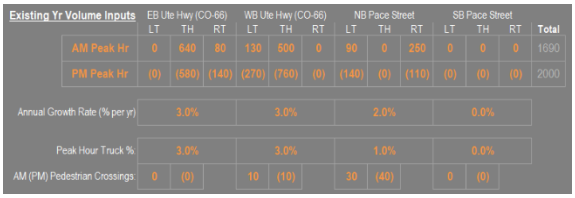


Figure 3: Traffic Data Entry





STAGE I WORKSHEET

The **Stage1** worksheet serves as a screening effort meant to eliminate non-competitive options and to identify which alternatives merit further considerations in Stage II based on their practical feasibility. **Figure 4** illustrates the Stage I worksheet where intersection screening evaluations and justifications are made.

The top left portion of the worksheet includes project information data carried forward from the Introduction worksheet. The user must select between two and five alternatives to be carried forward using the drop-down box in the upper right.

Users can create conventional alternatives (i.e. adding left or right turns and/or median and signal improvements) using the drop-down boxes to the right outside the print border and/or "write in" an improvement alternative not in the defined list of alternatives in the orange boxes. Selection of either results in automatic carryover to Stage II but selections will require additional steps to determine safety and cost estimate data required that would otherwise be auto populated in the Stage II worksheet (described in a later section).

Users should practice good engineering judgement in responding to the following 15 evaluation questions (listed in **Figure 5**) by selecting 0, 1, or 2 in the orange boxes below each question. Note that questions 4, 5, 7, 12 and 13 are auto populated based on previous data inputs.

1. Is ROW on major road constrained?
2. Is ROW on minor road constrained?
3. Are Intersection quadrants constrained?
4. Are there intersection safety issues?
5. Are there significant pedestrian crossings?
6. Is there significant bicycle activity?
7. Are one or more approach speeds high?
8. Do roadway contexts, characteristics transition at this intersection?
9. Are there numerous driveways near intersection? Assume future conditions (i.e. can/will driveways be closed as part of project?)
10. Is intersection isolated or part of network / dense network?
11. Is project location currently a T-intersection? Or can minor street thru or left turn movements be eliminated?
12. Based on V/C calculations, are design year no-build volumes high?
13. Are existing year left turning movement volumes high?
14. Is there a possibility to convert to interchange in next 20 years?
15. Are construction costs a primary decision factor?

These inputs are used to better understand the intersection context, impacts, and needs (illustrated in **Figure 6**), so that each intersection alternative is given an overall Stage I assessment score. Alternatives with the highest scores are highlighted in blue and become the shortlisted alternatives carried into Stage II for more detailed analysis.

Once the 15 questions are answered and overall scores are determined, users can either "deselect" an alternative or select an alternative not in the shortlist by placing an "X" or "Y", respectively, to the right of the total score. A justification for the selection/deselection must be entered in the column to the right. Final selected alternatives highlighted in blue are automatically carried forward into the Stage II worksheet.

Figure 4: Stage I Worksheet

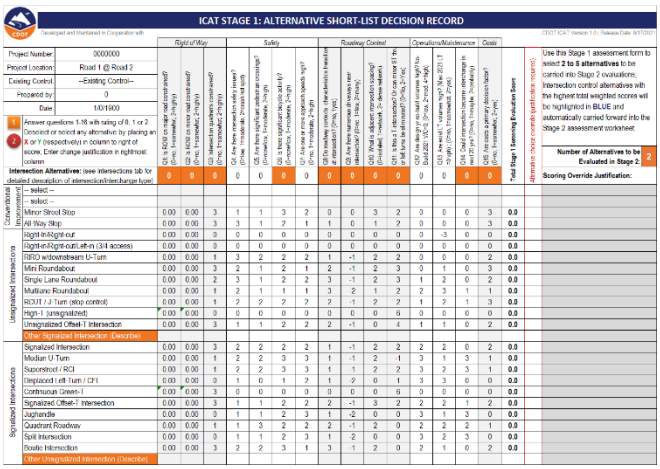


Figure 5: Evaluation Questions

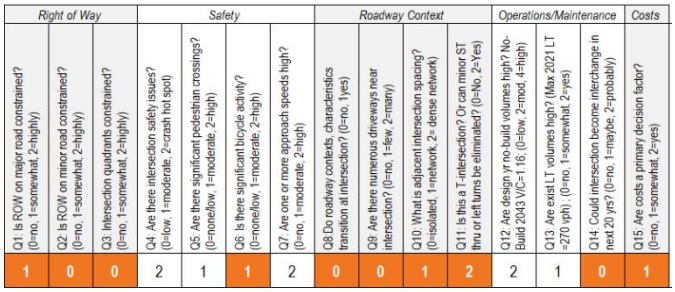
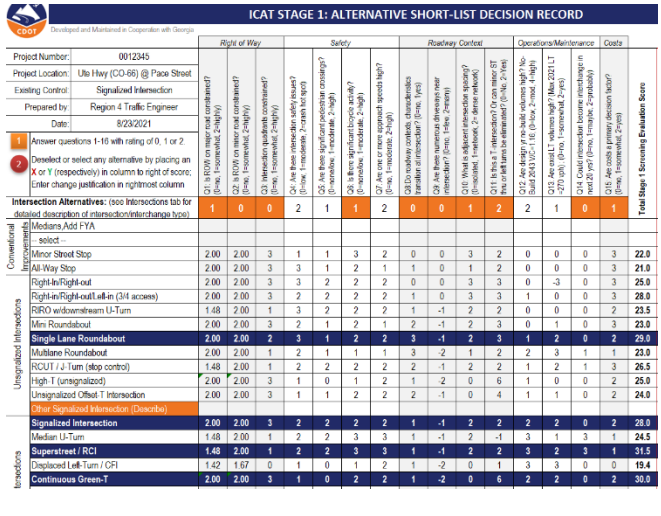


Figure 6: Example Stage I Selections (from Case Study)



Selecting/Deselecting Alternatives

Mini Roundabout	23.0		
Single Lane Roundabout	29.0	X	Does not meet plan for future widening
Multilane Roundabout	**23.0**	**Y**	**Locally preferred alternative**
RCUT / J-Turn (stop control)	26.5		

COSTS WORKSHEET

The **Costs** worksheet can be used to generate planning-level cost estimates when no independent cost estimates are available, or the project costs are anticipated to be different than shown in the tool. To begin, **Figure 7** illustrates the required input fields to identify existing intersection footprint, including number of lanes, turn bays and length, median width, and ROW.

Figure 8 illustrates the table used to identify specific elements for each alternative. Most of the input data can be determined from a mapping program image or GIS data and by using engineering judgement. The last row is used to identify any cost (in dollars) for ROW and structural impacts above and beyond the general ROW impacts of each alternative, which is automatically calculated by existing ROW inputs and expected alternative footprint. There are also inputs for drainage type and sidewalk / multi-use paths proposed at the intersection. Drop down selections also include site context and cost multipliers including topography, maintenance of traffic and project size (all drop-box choices). In the Environmental Impacts table, users must enter a cost to mitigate each moderate or significant impact (input in later in Stage II) that will be carried into the final cost estimate.

Lastly, users can select certain elements of each alternative using the alternative-dependent drop-down menu selections (highlighted in orange for only the short-listed alternatives) to better define project-specific values to improve cost-estimating accuracy.

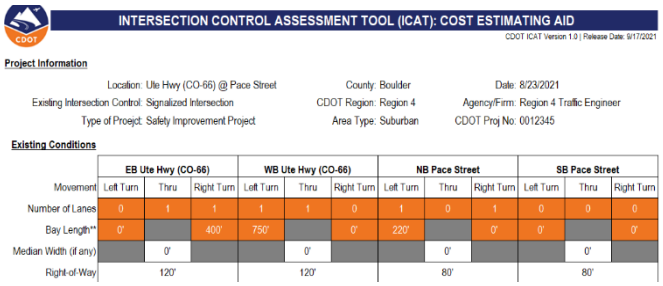
Figure 9 illustrates the table (on bottom of Costs worksheet) where assumptions for each alternative carried forward from Stage I are provided that were the basis of cost estimate. Cost estimate values for construction, right-of-way, environmental mitigation and utility costs and design and contingency cost are summarized in this table. If the worksheet-generated cost estimates do not seem reasonable, costs can be modified later in Stage II by either a) overriding costs data as described earlier or b) applying a percent multiplier to the overall costs. Note that user input and grade separated alternatives will not have cost estimates generated and thus users will have to provide own independent cost estimate(s) in Stage II.

Note that this cost worksheet is intended to generate a planning-level cost for comparative purposes and the ranking of selected alternatives only; a more detailed cost estimate should be prepared for the preferred alternative in the later project concept phase.

STAGE II WORKSHEET

The **Stage2** worksheet is used to assess the shortlisted alternatives in more detail and ultimately select a preferred alternative. **Figure 10** illustrates the top of the Stage II worksheet containing pre-populated project information. To the right, traffic measures of effectiveness are entered for existing year and future no-build conditions. Operational analysis must be performed for existing and design year no-build conditions using standard traffic analysis tools outside of the Stage II worksheet. The tool used and traditional delay and v/c measures (from HCM, Synchro, etc.) or network wide measure of effectiveness (MOEs) (from simulation model tools) are entered here for opening year and design year no-build conditions.

Figure 7: Existing Intersection Geometrics



INTERSECTION CONTROL ASSESSMENT TOOL (ICAT): COST ESTIMATING AID

CDOT ICAT Version 1.0 | Release Date: 9/17/2021

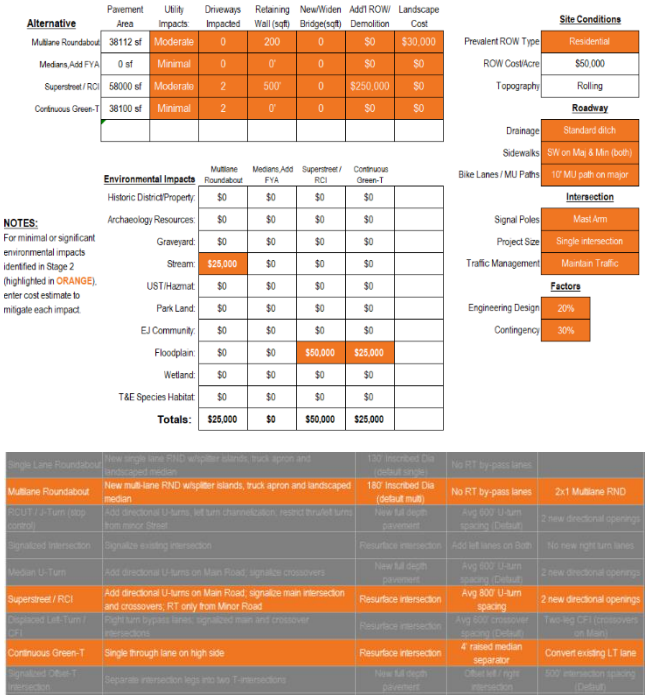
Project Information

Location: Ute Hwy (CO-66) @ Pace Street | County: Boulder | Date: 8/23/2021
Existing Intersection Control: Signalized Intersection | CDOT Region: Region 4 | Agency/Firm: Region 4 Traffic Engineer
Type of Project: Safety Improvement Project | Area Type: Suburban | CDOT Proj No: 0012345

Existing Conditions

	EB Ute Hwy (CO-66)			WB Ute Hwy (CO-66)			NB Pace Street			SB Pace Street		
Movement	Left Turn	Thru	Right Turn	Left Turn	Thru	Right Turn	Left Turn	Thru	Right Turn	Left Turn	Thru	Right Turn
Number of Lanes	0	1	1	1	1	0	1	0	1	0	0	0
Bay Length**	0'		400'	750'		0'	220'		0'	0'		0'
Median Width (if any)		0'			0'			0'			0'	
Right-of-Way		120'			120'			80'			80'	

Figure 8: Alternative Proposed Conditions



Alternative	Pavement Area	Utility Impacts	Driveways Impacted	Retaining Wall (sqft)	New/Widen Bridge(sqft)	Add'l ROW/ Demolition	Landscape Cost
Multilane Roundabout	38112 sf	Moderate	0	200	0	$0	$30,000
Medians,Add FYA	0 sf	Minimal	0	0'	0	$0	$0
Superstreet / RCI	58000 sf	Moderate	2	500'	0	$250,000	$0
Continuous Green-T	38100 sf	Minimal	2	0'	0	$0	$0

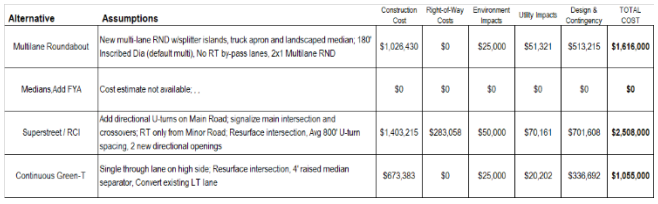
Environmental Impacts	Multilane Roundabout	Medians,Add FYA	Superstreet / RCI	Continuous Green-T
Historic District/Property:	$0	$0	$0	$0
Archaeology Resources:	$0	$0	$0	$0
Graveyard:	$0	$0	$0	$0
Stream:	$25,000	$0	$0	$0
UST/Hazmat:	$0	$0	$0	$0
Park Land:	$0	$0	$0	$0
EJ Community:	$0	$0	$0	$0
Floodplain:	$0	$0	$50,000	$25,000
Wetland:	$0	$0	$0	$0
T&E Species Habitat:	$0	$0	$0	$0
Totals:	$25,000	$0	$50,000	$25,000

NOTES:
For minimal or significant environmental impacts identified in Stage 2 (highlighted in ORANGE), enter cost estimate to mitigate each impact.

Site Conditions	
Prevalent ROW Type	Residential
ROW Cost/Acre	$50,000
Topography	Rolling
Roadway	
Drainage	Standard ditch
Sidewalks	SW on Maj & Min (both)
Bike Lanes / MU Paths	10' MU path on major
Intersection	
Signal Poles	Mast Arm
Project Size	Single intersection
Traffic Management	Maintain Traffic
Factors	
Engineering Design	20%
Contingency	30%

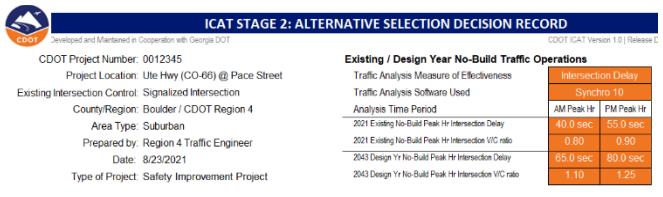
Single Lane Roundabout	New single lane RND w/splitter islands, truck apron and landscaped median	180' Inscribed Dia (default single)	No RT by-pass lanes	
Multilane Roundabout	New multi-lane RND w/splitter islands, truck apron and landscaped median	180' Inscribed Dia (default multi)	No RT by-pass lanes	2x1 Multilane RND
RCUT / J-Turn (stop-control)	Add directional U-turns; left turn channelization; restrict thru/left turns from minor Street	New full depth pavement	Avg 600' U-turn spacing (Default)	2 new directional openings
Signalized Intersection	Signalize existing intersection	Resurface intersection	Add left lanes on Both	No new right turn lanes
Median U-Turn	Add directional U-turns on Main Road; signalize crossovers	New full depth pavement	Avg 600' U-turn spacing (Default)	2 new directional openings
Superstreet / RCI	Add directional U-turns on Main Road; signalize main intersection and crossovers; RT only from Minor Road	Resurface intersection	Avg 800' U-turn spacing	2 new directional openings
Displaced Left-Turn / CFI	Right turn bypass lanes; signalized main and crossover intersections	Resurface intersection	Avg 600' crossover spacing (Default)	Two-leg CFI (crossovers on Main)
Continuous Green-T	Single through lane on high side	Resurface intersection	4' raised median separator	Convert existing LT lane
Signalized Offset-T Intersection	Separate intersection legs into two T-intersections	New full depth pavement	Offset left / right intersection	500' intersection spacing (Default)

Figure 9: Alternative Cost Summary



Alternative	Assumptions	Construction Cost	Right-of-Way Costs	Environment Impacts	Utility Impacts	Design & Contingency	TOTAL COST
Multilane Roundabout	New multi-lane RND w/splitter islands, truck apron and landscaped median; 180' Inscribed Dia (default multi), No RT by-pass lanes, 2x1 Multilane RND	$1,026,430	$0	$25,000	$51,321	$513,215	**$1,616,000**
Medians,Add FYA	Cost estimate not available; . .	$0	$0	$0	$0	$0	**$0**
Superstreet / RCI	Add directional U-turns on Main Road; signalize main intersection and crossovers; RT only from Minor Road; Resurface intersection, Avg 800' U-turn spacing, 2 new directional openings	$1,403,215	$283,058	$50,000	$70,161	$701,808	**$2,508,000**
Continuous Green-T	Single through lane on high side; Resurface intersection, 4' raised median separator, Convert existing LT lane	$673,383	$0	$25,000	$20,202	$336,892	**$1,055,000**

Figure 10: Project Type and No-Build Traffic Operations



ICAT STAGE 2: ALTERNATIVE SELECTION DECISION RECORD

Developed and Maintained in Cooperation with Georgia DOT

CDOT ICAT Version 1.0 | Release D

CDOT Project Number: 0012345
Project Location: Ute Hwy (CO-66) @ Pace Street
Existing Intersection Control: Signalized Intersection
County/Region: Boulder / CDOT Region 4
Area Type: Suburban
Prepared by: Region 4 Traffic Engineer
Date: 8/23/2021
Type of Project: Safety Improvement Project

Existing / Design Year No-Build Traffic Operations

Traffic Analysis Measure of Effectiveness	Intersection Delay	
Traffic Analysis Software Used	Synchro 10	
Analysis Time Period	AM Peak Hr	PM Peak Hr
2021 Existing No-Build Peak Hr Intersection Delay	40.0 sec	55.0 sec
2021 Existing No-Build Peak Hr Intersection V/C ratio	0.80	0.90
2043 Design Yr No-Build Peak Hr Intersection Delay	65.0 sec	80.0 sec
2043 Design Yr No-Build Peak Hr Intersection V/C ratio	1.10	1.25

Moving down the worksheet, **Figure 11** illustrates the input of cost data for each of the selected alternatives (alternative names are auto populated on the top row). The cost estimate data generated in the **Costs** worksheet is auto populated in this table. If cost estimates are independently generated for one or all or the selected alternatives, construction, ROW, environmental mitigation, utility, and design and contingency costs can be directly entered using the override table to right (lower half of Figure 8). The last row in this table can be used to adjust the costs by a percentage to better meet cost expectations.

Figure 12 illustrates data inputs for operational and safety analysis of the build conditions for each alternative. As for the design year no-build analyses, build condition alternative analyses must be performed using standard traffic analysis tools outside of the Stage II worksheet. The build analyses should use the design year traffic volumes (from the intersection data worksheet) and include the alternative intersection lanes and geometry. The tool uses traditional delay and v/c measures (from HCM, Synchro, etc.) or network wide MOEs from (from simulation model tools) and operational results are entered below each alterative.

Intersection safety performance measures are generated using Crash Modification Factors (CMF's) in FHWA's CMF clearinghouse (http://www.cmfclearinghouse.org). Most CMFs from known before-and-after intersection projects (i.e improvement from a 2-way stop to a single-lane roundabout) are auto-populated from the clearinghouse data, including source listings; however, when no CMF clearinghouse data exists, or the user feels that using a different clearinghouse data CMF is more appropriate, a table to the right can be used to define or override CMF data for PDO and injury/fatal crash types and source data. Note that leaving the field blank (CMF=0%) means that there are no perceived safety benefits (or disbenefits) of the alternative and the safety score will be zero for that alternative.

Figure 13 illustrates inputs of potential environmental impacts for each alternative (none, minimal & significant). If there are potential impacts, the Environmental score is decreased. Also, remember to return to the **Costs** worksheet to enter a cost estimate for each mitigation (highlighted in orange). Stakeholder support of alternatives (both local community and Region support) should be determined and entered using dropdowns (strong, positive, neutral, negative, opposition or unknown).

The final ICAT Stage II scores and rankings are provided at the bottom of the worksheet. The final score is based on cost, operations, safety, environmental and stakeholder input data and weighted percentages for each evaluation factor. Make sure all worksheet data has been completed before relying on any results. Lastly, use the data field at the bottom to provide comments or explain unique data input or results.

ENVIRONMENTAL DATA WORKSHEET

The **ENV** worksheet is only used when there are potential significant environmental impacts for one or more alternatives. **Figure 14** illustrates the ENV worksheet, where any potentially significant environmental impacts are to be documented (indicated in bold text as "significant" in the drop-down box in Stage II). The goal of this worksheet is to document that reasonable mitigation (or avoidance) can be achieved (that would otherwise disqualify this alternative) before that alternative is selected as a preferred solution.

Figure 11: Alternative Cost Data

Alternatives Analysis	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Proposed Control Type Improvement:	Multilane Roundabout	Medians,Add FYA	Superstreet / RCI	Continuous Green-T
Project Cost *(From Cost Worksheet)*	*Add addt'l description here*	*Add addt'l description here*	*Add addt'l description here*	*Add addt'l description here*
Construction Cost	$1,283,037	$400,000	$1,403,215	$673,383
ROW Cost	$0	$0	$283,058	$0
Environmental Cost	$31,250	$0	$50,000	$25,000
Reimbursable Utility Cost	$64,152	$25,000	$70,161	$20,202
Design & Contingency Cost	$641,519	$80,000	$701,608	$336,692
Cost Adjustment (justification req'd)	+25%	0%	0%	0%
Total Cost	$2,019,957	$505,000	$2,508,042	$1,055,277

Cost Data Override (if generated independent of CostEst Tool)	Multilane Roundabout	Medians,Add FYA	Superstreet / RCI	Continuous Green-T
Construction Cost	$0	$400,000	$0	$0
ROW Cost	$0	$0	$0	$0
Environmental Cost	$0	$0	$0	$0
Reimbursable Utility Cost	$0	$25,000	$0	$0
Design/Contingency Cost	$0	$80,000	$0	$0
Cost Adjustment (justification required)	+25%	0%	0%	0%

Figure 12: Alternative Traffic Operations and Safety

Alternatives Analysis	Alternative 1		Alternative 2		Alternative 3		Alternative 4	
Proposed Control Type Improvement:	Multilane Roundabout		Medians,Add FYA		Superstreet / RCI		Continuous Green-T	
Traffic Operations								
Traffic Analysis Software Used	SIDRA 7		Synchro 10		Synchro 10		Synchro 10	
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
2043 Design Yr Build Intersection Delay	30.0 sec	35.0 sec	55.0 sec	65.0 sec	40.0 sec	48.0 sec	35.0 sec	45.0 sec
2043 Design Yr Build Intersection V/C	0.65	0.75	0.95	1.10	0.75	0.90	0.60	0.85
Safety Analysis								
Predefined CRF: PDO	26%		0%		15%		4%	
Predefined CRF: Fatal/Inj	71%		0%		15%		4%	
Predefined CRF Source:	FHWA Clearinghouse IDs: 4196 / 4195		-		FHWA Clearinghouse ID:9984		CDOT Study ID:8655	
User Defined CRF: PDO			8%					
User Defined CRF: Fatal/Inj			8%					
User Defined CRF Source (write in if applicable):			CMF Clearinghouse					

Figure 13: Environmental/Stakeholder Data &Final Results

Environmental Impacts				
Historic District/Property:	None	None	None	None
Archaeology Resources:	None	None	None	None
Graveyard:	None	None	None	None
Stream:	Minimal	None	None	None
UST/Hazmat:	None	None	None	None
Park Land:	None	None	None	None
EJ Community:	None	None	None	None
Floodplain:	None	None	**Significant**	Minimal
Wetland:	None	None	None	None
T&E Species Habitat:	None	None	None	None
Stakeholder Support:	**Note:** Be sure to go back to **Costs** worksheet to enter mitigation costs for each noted impact			
Local Community Support	Supportive	Neutral	Negative	Neutral
CDOT Region Support	Supportive	Negative	Supportive	Neutral
Final ICAT Stage 2 Score:	6.1	3.1	3.0	3.8
Rank of Control Type Alternatives:	1	3	4	2

Figure 14: Environmental Impacts Worksheet

INTERSECTION CONTROL ASSESSMENT TOOL (ICAT): ENVIRONMENTAL FACTORS

Developed and Maintained in Cooperation with Georgia DOT — CDOT ICAT Version 1.0 | Release Date: 9/17/2021

Project Information

Project Location: Ute Hwy (CO-66) @ Pace Street — Area Type: Suburban
County: Boulder — Prepared By: Region 4 Traffic Engineer
CDOT Region: Region 4 — Date: 8/23/2021

Environmental Factors

In the box below, document any significant environmental factors for any alternative considered. Include a plan and costs for mitigation that retains the proposed intersection type as a viable alternative. Include in ICAT documentation package only if one or more alternatives have significant impacts.

Proposed Intersection Control #1: Multilane Roundabout

None

Proposed Intersection Control #2: Medians,Add FYA

None