ISOAP Workshop

Intersection Safety and Operational Assessment Process

LMS Course Code 102700 for Caltrans Employees

California LTAP

June 16-17, 2025

John Liu, Deputy District Director
Caltrans District 6 Division of Maintenance and Operations
Jerry Champa
Caltrans HQ Division of Safety Programs

Schedule – June 16

12:30 Introductions and background – John Liu

12:40 Stages and steps of ISOAP – John Liu

1:00 Integrating Pedestrian and Bicyclist Safety in the Intersection Development and Design Process – Bastian Schroeder, Kittelson & Associates

2:00 Safe System Intersections/intersection control strategies – Jerry Champa

2:40 Break (10 minutes)

Schedule – June 16

2:50 Turbo roundabouts – Bing Yu and Sam Toh, District 5

3:05 Affordable roundabouts – Jerry Champa, Phil Rust, City of San Diego, and John Liu

3:45 Performance-based practical design – Gina Lopez, HQ Design

4:15 Truck and OSOW vehicles – John Liu

4:20 Stage 1 (District 6) case study – John Liu

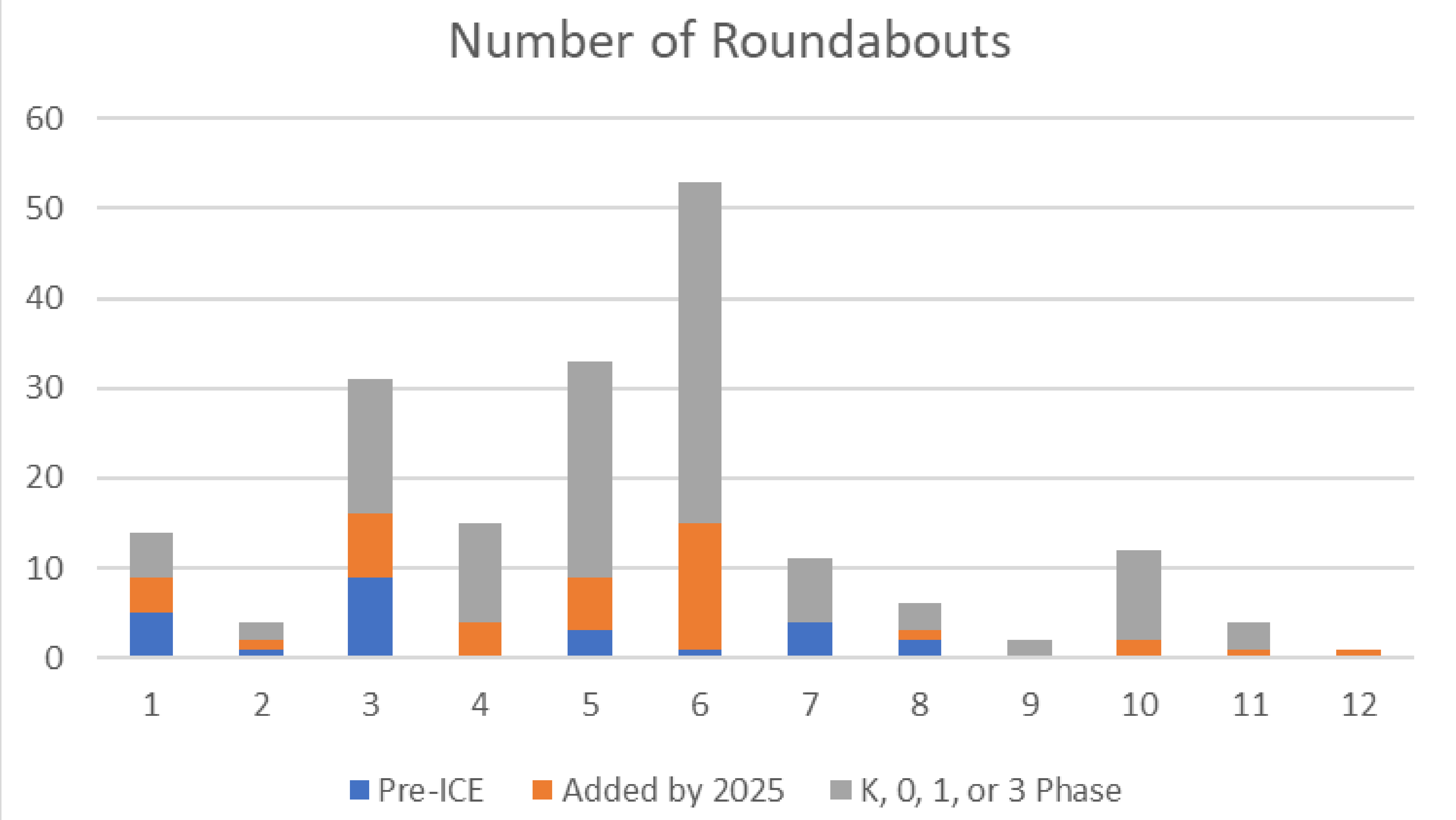
4:30 Conclude

Schedule – June 17

12:30	Review and questions and answers
12:50	Saving time, money, and lives through performance-based intersection evaluation and design – Brian Ray, Sunrise Transportation Strategies
1:35	Calculating safety performance – Gina Lopez and Bernice Chan, HQ Design, and Jerry Champa
2:20	Calculating mobility performance – Lilian Wu, HQ Traffic Ops
2:50	Break (10 minutes)

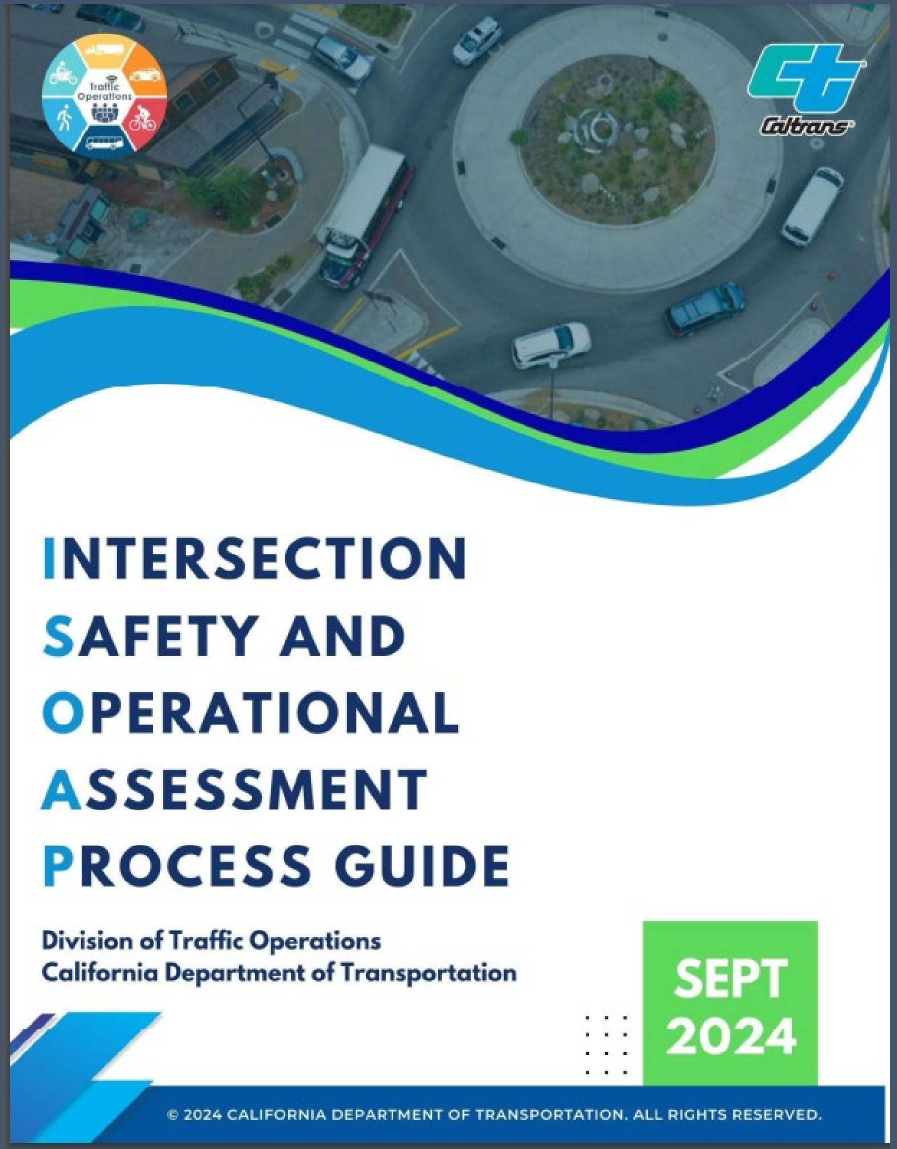
Schedule – June 17

3:00 Intersection pavement design – Mohammad Al-Assi, District 6
3:15 Stage 1 & 2 (District 9) case study – John Liu
3:25 Local sponsored projects and Local Development Review (LDR), roles and responsibilities – John Liu
3:45 Public outreach – John Liu
4:00 ISOAP Exercise – Jerry Champa
4:15 Questions and answers
4:25 Resources and concluding remarks – John Liu
4:30 Conclude


Number of Roundabouts
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Pre-ICE
Added by 2025
K, 0, 1, or 3 Phase

Background

- Intersection Control Evaluation (ICE) was established in a Traffic Operations Policy Directive (TOPD) in 2013
- Began update process in late 2021 with FHWA and VHB
- 2022 Director's Policy 36 on Road Safety
- ICE rebranded to ISOAP, and memo signed on September 10, 2024



Stage 1 Screening and Initial Assessment

- Step 1.1 – Is ISOAP required?
- Step 1.2 – Determine intended project outcome, place type, design vehicle, and gather data
- Step 1.3 – Ped and bike planning and feasibility assessment
- Step 1.4 – General R/W and operational feasibility assessment
- Step 1.5 – Transit and freight assessment
- Step 1.6 – Initial safety assessment
- Step 1.7 – Eliminate infeasible strategies
- Step 1.8 – Findings and recommendations

Stage 2 Detailed Analysis

- Step 2.1 – Detailed safety analysis using Highway Safety Manual (HSM) if applicable
- Step 2.2 – Detailed operational analysis
- Step 2.3 – Functional sketches and performance checks
- Step 2.4 – Cost estimate, life-cycle costs
- Step 2.5 – Performance-based analysis matrix
- Step 2.6 – Findings and recommendation

Key Changes from ICE to ISOAP

- More guidance as to what to include in the analysis, including bikes, peds, transit, and freight
- Standardized forms – optional
- Required use of Highway Safety Manual (HSM) in Stage 2 if applicable
- If short of funding for the recommended strategy, need to consider phased or interim improvements or finding additional funding

Key Changes from ICE to ISOAP

- Recommended strategy needs to support the Safe System Approach (may or may not have the highest B/C)
- District Traffic Safety Engineer concurrence for recommended strategy
- New streamlined processes for certain conditions

Streamlined Processes

1. Stop sign at new low-volume public road connection where signal warrants are not expected to be met within 20 years
2. Single lane roundabout where:
   - ADT of all approaches is less than 25,000, and
   - Signal warrants are projected to be met within 10 years or there is a high number of broadside crashes, and
   - Cost of a roundabout is comparable to signalization
   - If public concern is anticipated, evaluating alternative strategies may be required for the environmental process

Applicability

ISOAP is required for the following:

- New public road, private road, or high-volume (1,000 ADT) driveway
- New freeway interchange
- Change in type of traffic control (stop, yield, signal)
- Pedestrian hybrid beacon (PHB) at an intersection
- Major physical changes to intersection approaches, such as adding a leg to an intersection or widening to provide an additional through or turn lane

Applicability

ISOAP is not required for the following:

- Changing lane configurations without pavement widening
- Minor modifications to existing traffic signals (adding or removing signal heads, modifying detection, etc.)
- Changing signal software, phasing, or timing
- Restricting movements at an existing intersection, such as prohibiting left turns or through movements

ISOAP and Project Delivery

Pre-PID (Traffic Investigation Report (TIR), local development review (LDR), walk assessment, conceptual report/Project Initiation Proposal)

PID

PA&ED

PS&E

Stage 1

Stage 2

ISOAP and Project Delivery

ISOAP

- Is done in parallel to other project delivery activities
- Can be done early if the information is available and there are available resources to perform it
- Can be updated if there is new information
- Stage 1 should eliminate poor performing strategies; a single project alternative besides the no build would facilitate the environmental process

ISOAP and Project Delivery

ISOAP

- Makes a recommendation, but the PDT or the District Director makes the decision on the appropriate intersection control strategy
- Recommendations should also be documented in the approval document, such as the Project Report

ISOAP Documentation

- Fillable Word forms for Stage 1 and 2.
- Stage 1 long form provides step-by-step guidance. Stage 1 short form is more of a summary.
- Use of the forms is optional. A traditional report containing all relevant information is acceptable.
- District ISOAP Coordinators approve completion of each stage of ISOAP and can use a memo for documentation.

ISOAP Stage 1 (Screening and Initial Assessment) Long Form

Prepared by: Enter text
Checked by: Enter text
Cty-Rte-PM: Enter text
Major Street: Enter text
Minor Street: Enter text
Project EA: Enter text
Date: Enter date

Step 1.1 Is ISOAP Required?

Applicability criteria

☐ New public road, private road, or high-volume (1,000 ADT) driveway
☐ New freeway interchange
☐ Change in type of traffic control (stop, yield, signal)
☐ Pedestrian hybrid beacon (PHB) at an intersection
☐ Major physical changes to intersection approaches (including ramp terminals), such as adding a leg to an intersection or widening to provide an additional through or turn lane

Step 1.2 Determine Intended Project Outcome, Place Type, Design Vehicle, and Gather Data

Determine desired result of project, collaborating with functional units and stakeholders as needed (for example, safety improvement, improve walkability, reduced queuing): Enter text

Gather available existing traffic data

Major street:

- Route classification: Choose an item
- Lane configuration: Enter text
- Existing ADT: Enter text
- Future ADT: Enter text
- Speed limit: Choose an item

Minor street:

- Route classification: Choose an item
- Lane configuration: Enter text
- Existing ADT: Enter text
- Future ADT: Enter text

Step 1.1 Is ISOAP Required?

- Use applicability criteria
- Exceptions from conducting ISOAP for a proposed new or modified intersection meeting the applicability criteria
  - Requires approval from the Divisions of Traffic Operations and Safety Programs
  - District ISOAP Coordinator will process any exceptions

Step 1.2 Determine Intended Project Outcome, Place Type, Design Vehicle, and Gather Data

Determine desired result of project

- Collaborate with functional units and stakeholders
- Examples
  - Address collision pattern
  - Address excessive queuing
  - Calm traffic
  - Improve walkability

Step 1.2 Determine Intended Project Outcome, Place Type, Design Vehicle, and Gather Data

Gather available existing traffic data

- Traffic counts (ADT, peak hour, turning movement, truck, bicycle, pedestrian, etc.), roadway geometrics
- Collision data

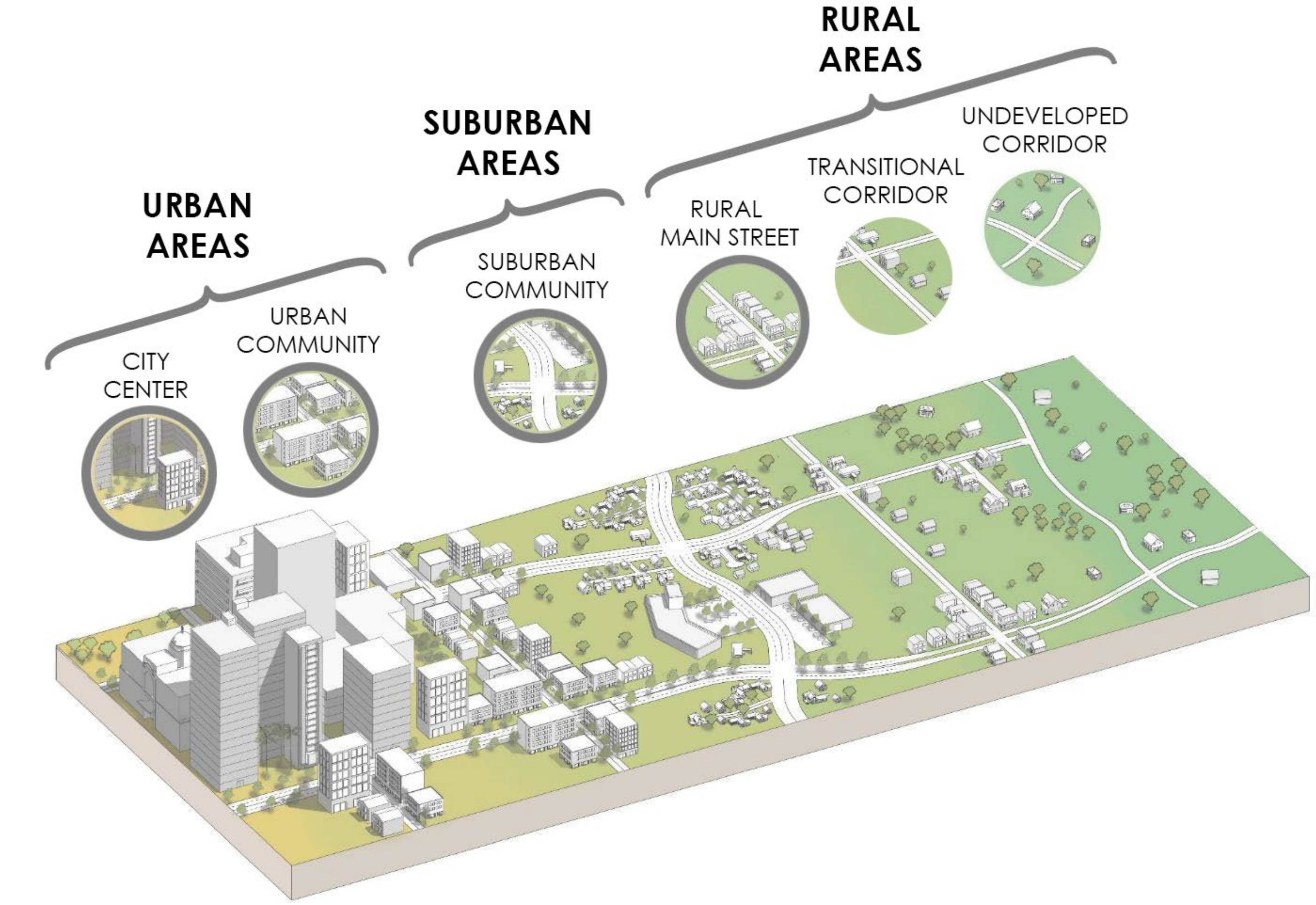
Gather planning information

- Route Concept Report, Transportation Concept Report, or Multimodal Corridor Plan
- Active Transportation Plan
- General Plan or Specific Plan

Step 1.2 Determine Intended Project Outcome, Place Type, Design Vehicle and Gather Data

Determine place type

- Urban areas
  - Center cities
  - Urban communities
- Suburban areas
- Rural areas
  - Rural main streets
  - Transitional corridors
  - Undeveloped corridors
- Special use areas and protected lands



Step 1.2 Determine Intended Project Outcome, Place Type, Design Vehicle, and Gather Data

Determine design vehicle

- Truck network – STAA, Terminal Access
- Consult with District Truck Access Manager (DTAM) if lesser than STAA trucks may be accommodated

Step 1.3 Ped and Bike Planning and Feasibility Assessment

- Qualitative assessment for the needs of bicyclists and peds
- Consider land use and connectivity
- Take note of schools and senior centers or housing
- Determine appropriate type of bicycle facility

Step 1.4 General R/W and Operational Feasibility Assessment

- Consider appropriate strategies to analyze
- Right of way
  - Footprint based on typical designs
  - Use Highway Design Manual (HDM) or DIB 94
  - Look for constraints
- Operational assessment
  - Use CAP-X or rules of thumb for lane configurations
  - Use more advanced tools (Synchro, Sidra) if turning movement counts are available

Step 1.5 Transit and Freight Assessment

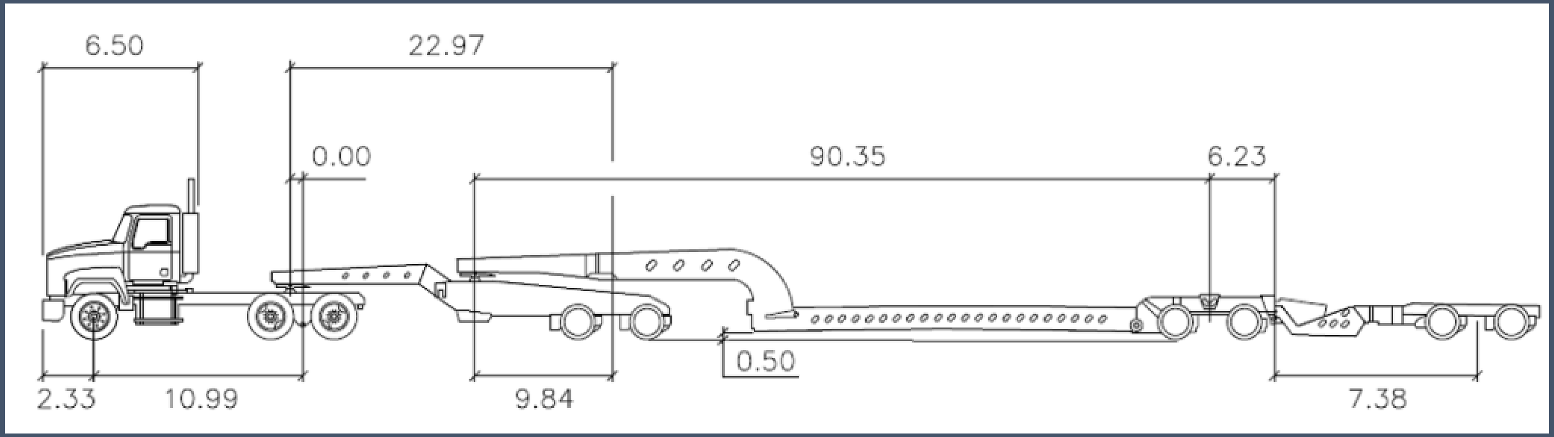
<u>Transit considerations</u>

- Existing and potential future transit needs
- Shelters and passenger queuing
- Bus bays, far side/near side, vehicle queuing

Step 1.5 Transit and Freight Assessment

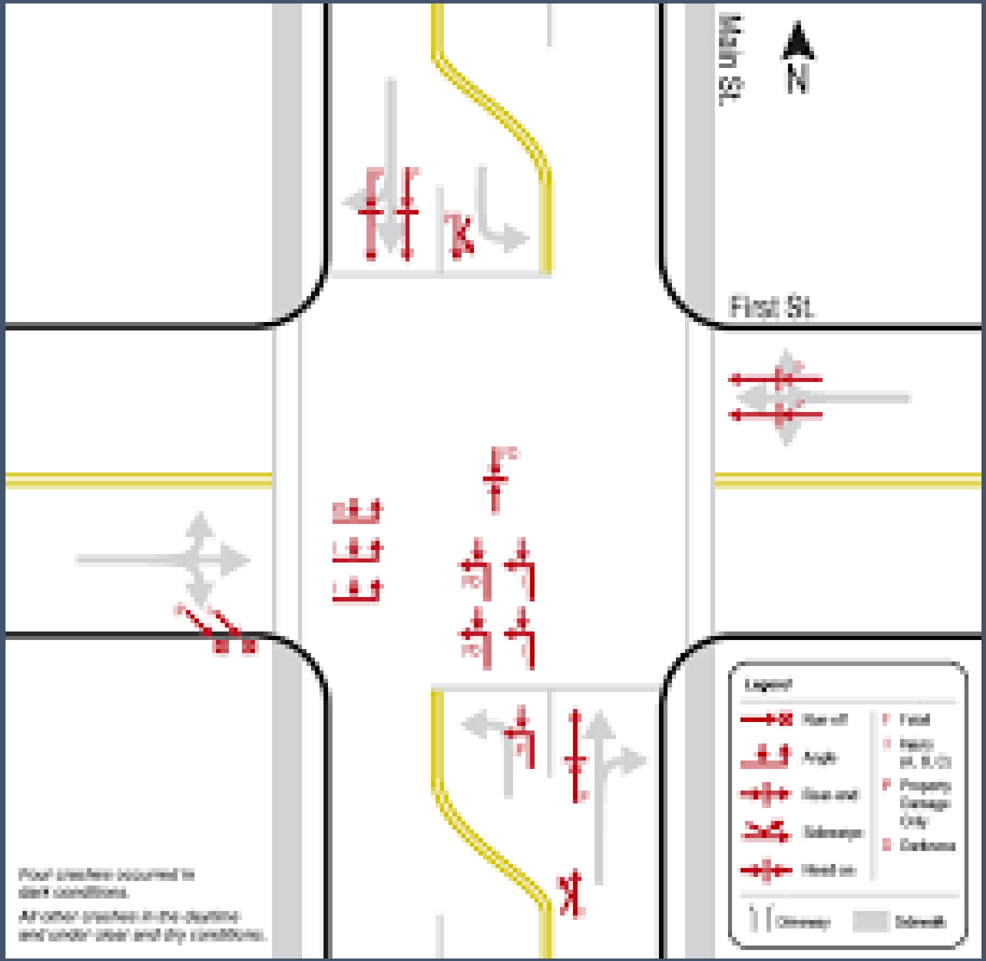
Freight considerations

- Design vehicle determined in Step 1.2
- Consider oversize vehicles
- Determine which movements trucks make, any potential alternate routes



Step 1.6 Initial Safety Assessment

- Consider relative safety among strategies
- Analyze existing collision history
- Can use SPICE tool, SSI methodology



Step 1.7 Eliminate Infeasible Strategies

Eliminate strategies that:

- Do not satisfy the need
- Have unmitigable environmental impacts
- Inadequately address safety
- Exceed available and potentially available funding

Step 1.8 Findings and Recommendations

- Document findings on Stage 1 ISOAP form and submit to District ISOAP Coordinator for review
- If there is only one viable strategy but funding is insufficient, consider:
  - Other potential funding sources (SHOPP, CMAQ, Minor, ATP, measure, developer fees)
  - Phased implementation
  - Interim improvements

Step 1.8 Findings and Recommendations

- District ISOAP Coordinator and designated Traffic Operations functional manager, if applicable, reviews ISOAP forms
- If ISOAP form is satisfactory and there is only one viable strategy, ISOAP form is submitted to the District Traffic Safety Engineer for review and concurrence of recommendation
- District ISOAP Coordinator responds with comments or approval memo
- If there is more than one viable strategy, proceed to Stage 2; otherwise ISOAP concludes

Step 2.1 Detailed Safety Analysis

- Quantitative safety analysis to show predicted crash frequency and severity for each strategy
- The Highway Safety Manual (HSM) is to be used where applicable
- Use Caltrans crash costs with the predicted crashes and severities to convert to a dollar amount to be used in an economic analysis
- Where the HSM cannot be used, a qualitative safety analysis may be performed by describing the safety benefits rather than doing an economic analysis

Step 2.2 Detailed Operational Analysis

- Use analysis tools such as Synchro/SimTraffic, VISSIM, Highway Capacity Software (HCS), Sidra, and Rodel
- Study area should be large enough to capture all potential impacted facilities
- Data collected during appropriate time periods, days of the week, and time of year, include pedestrians, bicyclists, transit, and freight movements

Step 2.2 Detailed Operational Analysis

- As LOS is no longer the standard performance metric, the measure of effectiveness (MOE) should be documented and may be daily person hour delay (DPHD), volume/capacity ratio, queuing, or other measure as directed by the district Traffic Operations functional manager
- The operational analysis should address accommodating queues

Step 2.3 Functional Sketches and Performance Checks

- Conceptual layout for each feasible strategy showing pedestrian, bicycle, and transit facilities
- Sufficient detail to develop a cost estimate and evaluate right-of-way and potential environmental impacts
- Performance checks for roundabouts and verifying sight distance
- Can use NCHRP 948 Design Flags Tool to evaluate bike and ped facilities

Step 2.4 Cost Estimate and Lifecycle Costs

- Cost estimate for construction and right of way for each viable strategy
- Consider traffic handling and detours
- Life-cycle costs using annual maintenance costs, including for electricity, and other periodic maintenance costs
- Crash costs

Step 2.5 Performance-Based Analysis Matrix

- Matrix showing operational and safety performance, life-cycle cost estimate, and benefit-cost ratio of each viable strategy
- Cost to State, which is the sum of the construction cost and all crashes for 20 years after opening to traffic, may be used as an alternative to the benefit-cost ratio for new construction

Step 2.5 Performance-Based Analysis Matrix

			Performance Metrics					
Improvement Strategy (Alternative)	**Capital Cost** ($)	**Service Life** (years)	***Mobility*** **Delay Benefit ($)**	***Safety*** **Crash Benefit ($)**	***Maint.*** **Cost ($)**	***Life-Cycle*** **Cost ($)**	***Other*** **Cost ($)**	**Benefit / Cost Ratio*** (BCR)
Traffic Signal								
Roundabout								
Mini-Roundabout								
RCUT								
No Build (do nothing Alt.)								

Step 2.6 Findings and Recommendations

- Highest performing strategy supporting the principles of the Safe System Approach becomes the recommended strategy, may or may not be the strategy with the highest benefit-cost ratio
- Bicycle and pedestrian accommodations and description how the Safe System Approach is supported are documented

Step 2.6 Findings and Recommendations

- Cost may exceed the available funding, and additional funding sources and phased implementation or interim improvements should be considered in such cases
- Completed Stage 2 ISOAP form is submitted to the District ISOAP Coordinator for review and approval by the designated Traffic Operations functional manager
- If satisfactory, Stage 2 ISOAP form is submitted to the District Traffic Safety Engineer for review and concurrence

Step 2.6 Findings and Recommendations

- District ISOAP Coordinator responds with comments or approval memo, and ISOAP concludes

Integrating Pedestrian and Bicyclist Safety in the Intersection Development and Design Process

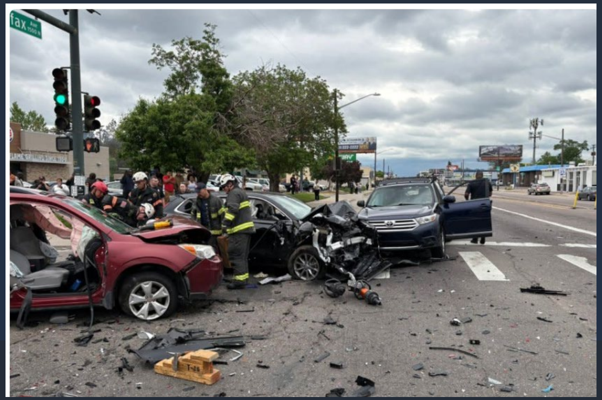
Bastian Schroeder

Kittelson & Associates

Safe System Intersections & Control Strategies

Jerry Champa
Office of Safe Systems Approach Integration
Caltrans HQ Division of Safety Programs

Crash Data
(Intersection-related)



- **28.3%** of all fatalities
- **50%** of fatalities and injuries
- **25%** of fatalities at signalized intersections are pedestrians

Intersection Crash Trend

U.S. Department of Transportation
Federal Highway Administration

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Year	Total Traffic Fatalities	Total Traffic Fatalities Involving an Intersection
2018	36,835	10,148
2019	36,355	10,273
2020	39,007	10,720
2021	42,939	11,799
2022	**42,514**	**12,036** (**+19%** since 2018)
	(+15% since 2018)	

Intended ISOAP Outcomes

- **Improved safety, mobility and convenience for motorists, bicyclists, and pedestrians**
- **Greater implementation of cost-effective intersection improvements**
- **More consistent application across districts**
- **Improved utilization of support resources**

  - **Identification of the optimal strategy / *solution***
    - in consideration of the expected reduction in conditions & crashes known to result in fatalities and serious injuries

Intersection Types & Control Strategies

AT-GRADE intersections	GRADE-SEPARATED Intersections
▪ Minor road stop ▪ Right in/right out ▪ ¾ Movements ▪ Thru-cut ▪ All-way stop ▪ Traffic signal ▪ Continuous Tee signal ▪ **Pedestrian hybrid beacon** ▪ **Roundabout** (All-Way Yield) ▪ **Restricted Crossing U-Turn (RCUT)** ▪ **Median U-Turn (MUT)** ▪ Jughandle ▪ Quadrant Roadway	○ **Non-freeway** ▪ Center Turn Overpass ▪ Echelon • **Freeway** (interchange configurations) ▪ **Diverging Diamond Interchange** ▪ Diamond, partial cloverleaf ▪ Single Point ▪ Various with **roundabouts** at ramp termini

How many of these strategies do we need to evaluate / assess during an ISOAP study?

Principles of a Safe System Approach

A Safe System Approach incorporates the following principles:

1. Death & Serious Injuries are Unacceptable, so …

A Safe System Approach prioritizes the elimination of crashes that result in death and serious injuries

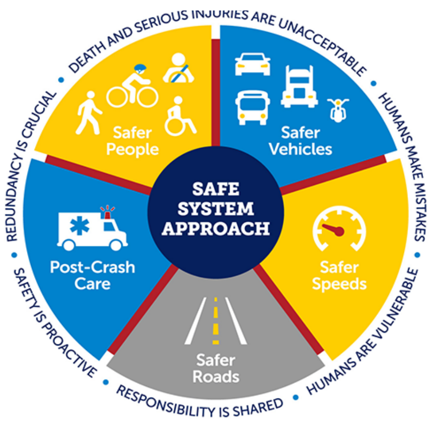
2. Humans Make Mistakes

People will inevitably make mistakes and decisions that can lead or contribute to crashes, but the **transportation system can be designed and operated to accommodate and reduce certain types of human mistakes which lead to death and serious injuries when a crash occurs.**

3. Humans Are Vulnerable

Human bodies have physical limits for tolerating crash forces before death or serious injury occurs

Principles of a Safe System Approach



A Safe System Approach incorporates the following principles:

4. Responsibility is Shared

All stakeholders – including government at all levels, industry, non-profit / advocacy, researchers, and the general public are vital to preventing fatalities and serious injuries on our roadways.

5. Safety is Proactive and Reactive

Proactive tools and investments must supplement reactive investments. Every activity and project presents an opportunity to identify and address safety issues in the transportation system.

6. Redundancy is Critical

If one part of the system fails, overlapping parts are in place and work as designed to protect people. **Double-down on investment in strategies that have built-in redundancy.**

How do the Safe System Approach (SSA) and ISOAP produce optimal investment decisions?

TRADITIONAL APPROACH [1]	*SAFE SYSTEM and ISOAP Approaches*
Nominal Safety	**Data-driven Safety Performance Analysis**
Reduce Crashes	**Prevent crashes that result in & serious injuries**
Speed Enforcement / Traffic Calming	**Reduce Kinetic Energy** (Self-Enforcing Roads) [2]
Design for Peak Period	**Also Design for Non-Peak and Dark Conditions**
Warrant Studies	**Performance Analysis**
***Accommodate* Pedestrians & Cyclists**	**Provide Complete Infrastructure to protect VRUs**

NOTES:

1. **Standard design does not equate to "complete scope" (i.e. inclusion of Safe System strategies)**
2. **Speeds are typically higher and 60% of fatal crashes occur during darkness, dawn and dusk**

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Warrant Studies	**Performance Analysis**
***Accommodate* Pedestrians & Cyclists**	Provide Complete Infrastructure to protect VRUs
OBJECTIVES FOR CAPITAL PROJECT EXPENDITURES ON INTERSECTIONS & INTERCHANGES	
Acceptable Level of Service →	**Reduce Person Hours of Delay** (MOE for throughput)
PDT selects any Alt which meets P & N (often the lowest cost Alt) →	**PDT selects Alt which provides greatest performance benefits and value (Optimal)**

NOTES:

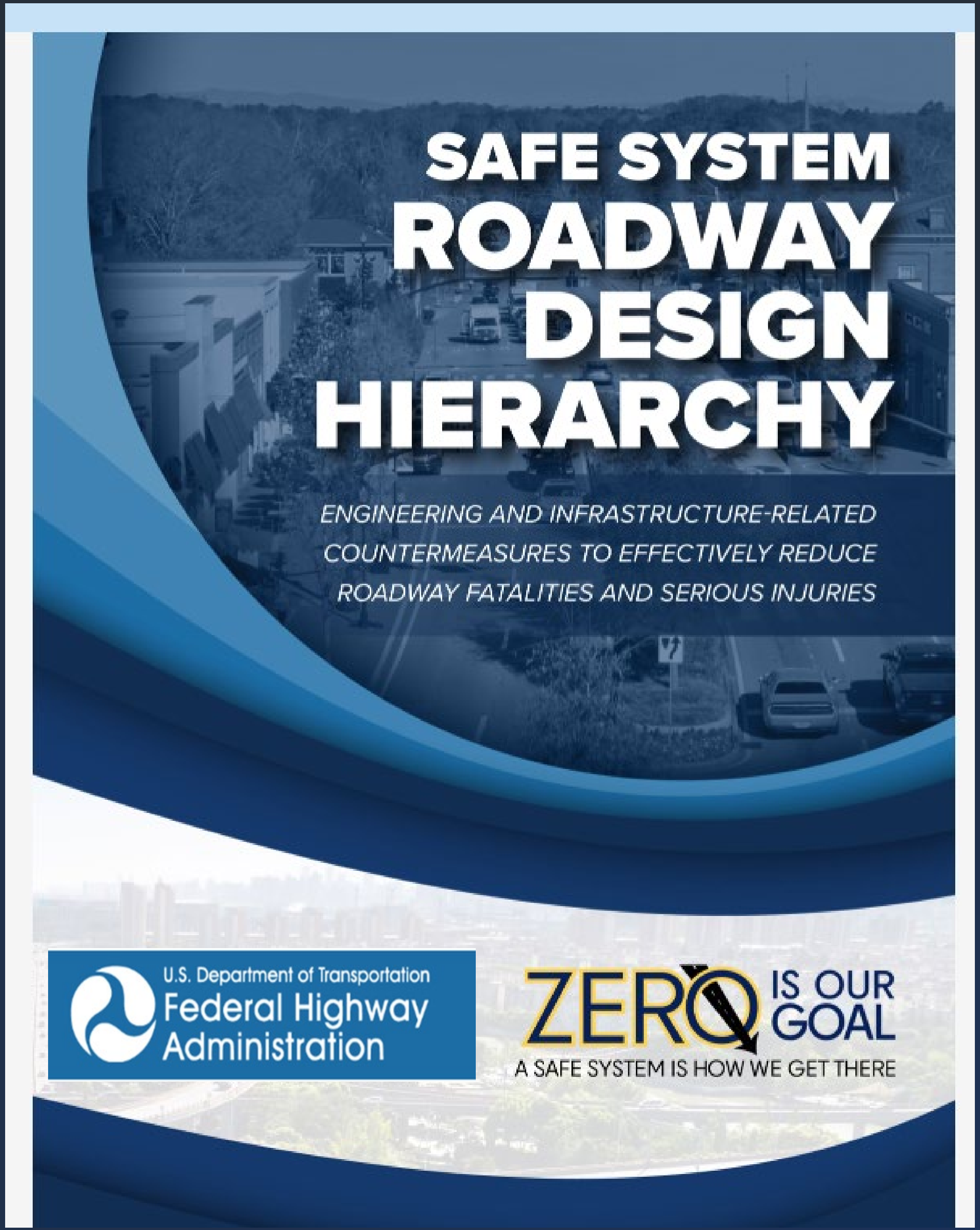
1. **Standard design does not equate to "complete scope" (i.e. inclusion of Safe System strategies)**
2. **Speeds are typically higher and 60% of fatal crashes occur during darkness, dawn and dusk**
3. See next slide for source document containing a prioritized list of strategies / solutions

Resources and Tools

for planning & engineering practitioners during ISOAP studies

FHWA publication (2024) containing hierarchy of:

ENGINEERING & INFRASTRUCTURE-RELATED COUNTERMEASURES TO EFFECTIVELY REDUCE ROADWAY FATALITIES & SERIOUS INJURIES



https://highways.dot.gov/sites/fhwa.dot.gov/files/2024-01/Safe_System_Roadway_Design_Hierarchy.pdf

Safe System Solution Hierarchy

→ founded in the 28 *Proven Safety* Countermeasures

Strategies organized under 4 *Tiers based on:*

- **proven ability to meet SSA objectives**
- **effectiveness at severe crash reduction**
- **arranged from most to least aligned with the Safe System Approach Principles**

Note: Tier 1 strategies are the *most aligned, and Tier 4 strategies are the least aligned*

Safe System Solution Hierarchy

→ founded in the 28 *Proven* Safety Countermeasures

PURPOSE, ROLE & VALUE:

- **help agencies & practitioners to identify and prioritize strategies when initiating and developing all types of transportation infrastructure projects *(not just safety)***

https://highways.dot.gov/sites/fhwa.dot.gov/files/Proven%20Safety%20Countermeasures%20Booklet.pdf

Safe System *Solution* Hierarchy

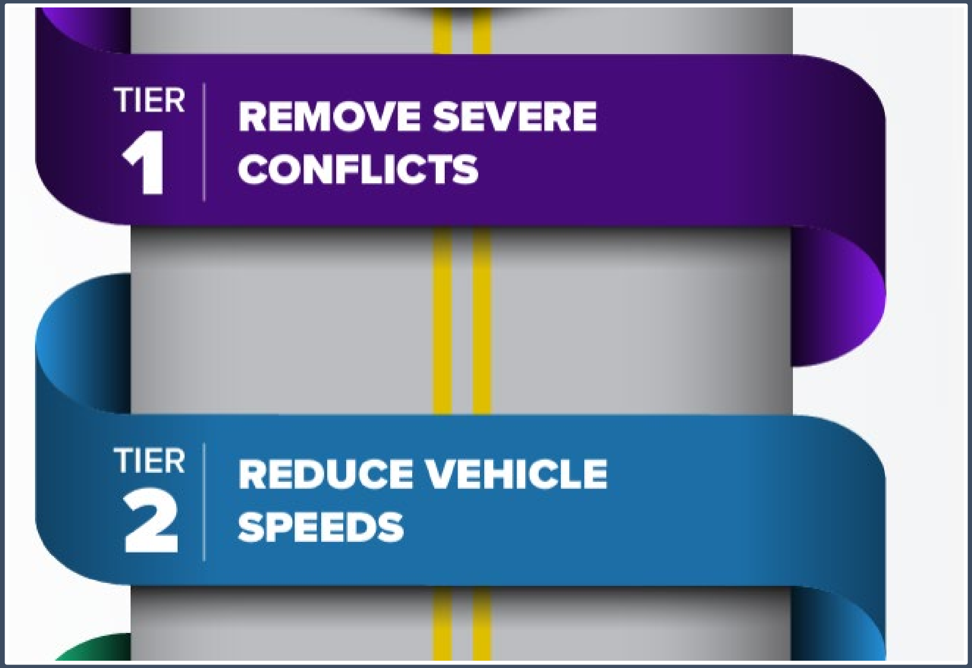
How to use …

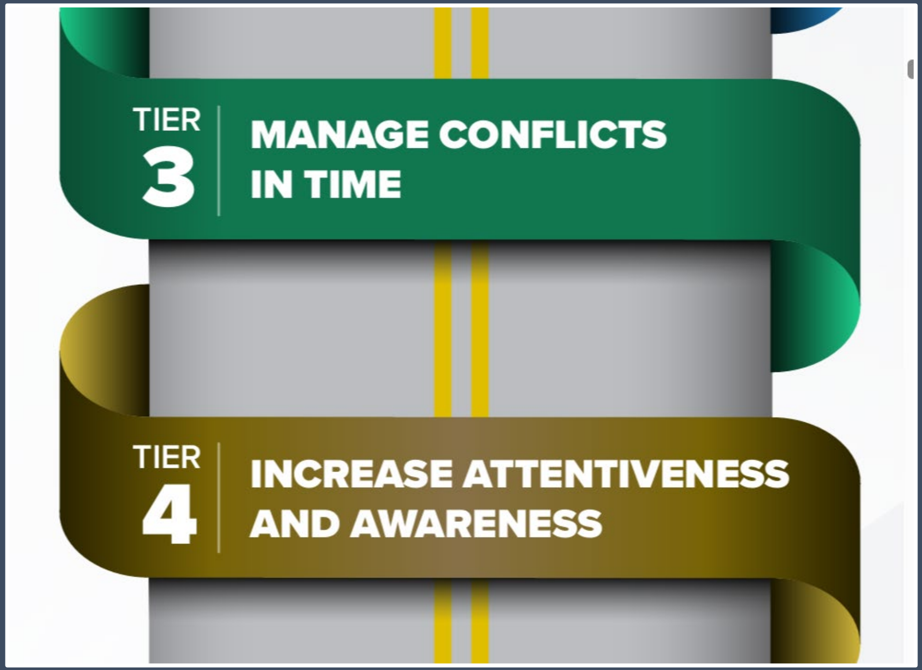
- first consider strategies under Tier 1
    - especially when also identified under multiple tiers
    - if not feasible, select solutions from subsequent Tiers

- a combination of strategies can provide the redundancy required of a *Safe System*

Strategies are organized and prioritized within Tiers (1-4) based on

- alignment with Safe System Principles
- ability to meet Safe System Objectives (below)





ISOAP also emphasizes strategies which provide space & protection for vulnerable road users: pedestrians, cyclists, disabled travelers, older drivers, etc.

SAFE SYSTEM HIERARCHY: Proven Countermeasures for *INTERSECTIONS*

Intersection PSC	TIER 1	TIER 2	TIER 3	TIER 4
Backplates with Reflective Borders				✓
Corridor Access Management	✓			
Dedicated Left and Right Turn Lanes at Intersections	✓			
Reduced Left Turn Conflict Intersections	✓			
Roundabouts	✓	✓	Yes [1]	Yes [2]
Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections				✓
Yellow Change Intervals			✓	

[1] All-Way Yield Control *manages conflicts in time*;

[2] Roundabouts are highly conspicuous and serve as gateway treatments

SAFE SYSTEM HIERARCHY: Proven Countermeasures for *PEDS / CYCLISTS*

Intersection PSC	TIER 1	TIER 2	TIER 3	TIER 4
Bicycle Lanes	✓			
Crosswalk Visibility Enhancements				✓
Leading Pedestrian Interval			✓	
Medians and Pedestrian Refuge Islands	✓	✓		
Pedestrian Hybrid Beacons			✓	
Rectangular Flashing Beacons (RRFB)				✓
Road Diets	✓	✓		
Walkways	✓			

Intersection Types & Control Strategies

AT-GRADE intersections	SS Tiers
▪ Minor road stop	
▪ Right in/right out	
▪ ¾ Movements	
▪ Thru-cut	
▪ All-way stop	
▪ Traffic signal	
▪ Continuous Tee signal	
▪ **Pedestrian hybrid beacon**	**3**
▪ **Roundabout** (All-Way Yield)	**1 2 3 4**
▪ **Restricted Crossing U-Turn**	**1**
▪ **MUT**	**1**
▪ Jughandle	
▪ Quadrant Roadway	

GRADE-SEPARATED Intersections	SS Tiers
○ **Non-freeway**	
▪ Center Turn Overpass	
▪ Echelon	
• **Freeway Interchange Configurations**	
▪ **Diverging Diamond I/C**	
▪ **Diamond, partial cloverleaf**	
▪ Single Point	
▪ Various with **roundabouts** at ramp termini	**1 2 3 4**

Safe System Intersections and Proven Safety Countermeasures are **highlighted**

Intersection Types & Control Strategies

AT-GRADE intersections	SS Tiers
▪ Minor road stop	
▪ Right in/right out	
▪ ¾ Movements	
▪ Thru-cut	
▪ **All Way Stop**	
▪ **Traffic Signals**	
▪ Continuous Tee signal	
▪ **Pedestrian hybrid beacon**	3
▪ **Roundabout** (All-Way Yield)	1 2 3 4
▪ **Restricted Crossing U-Turn**	1
▪ **MUT**	1
▪ Jughandle	
▪ Quadrant Roadway	

GRADE-SEPARATED Intersections	SS Tiers
○ **Non-freeway**	
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• **Freeway Interchange Configurations**	
▪ **Diverging Diamond I/C**	
▪ **Diamond, partial cloverleaf**	
▪ Single Point	
▪ Various with **roundabouts** at ramp termini	1 2 3 4

These are Traffic Control Devices which can reduce severe crashes, but they are not:
- **Proven Safety Countermeasures**
- **Safe System Intersection strategies**

Safe System Intersections and Proven Safety Countermeasures are **highlighted**

U.S. Department of Transportation Federal Highway Administration

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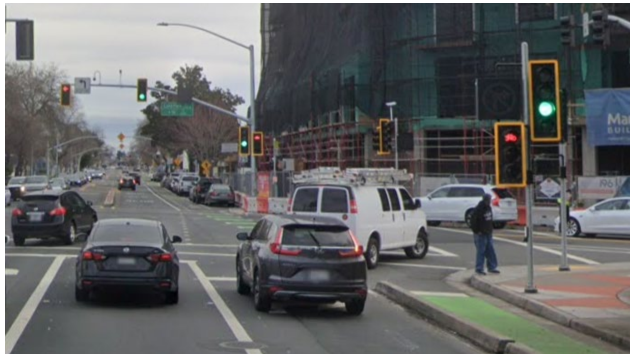
Signalized Intersection Crashes

Traffic signals are often chosen for operational reasons, and may involve trade-offs between safety and mobility. **Signalized intersections represent about one-third of ALL intersection fatalities,** including a large proportion that involve red-light-running.



Fatalities at Signalized Intersections have increased by 26% since 2018

Year	Total Traffic Fatalities	Total Traffic Fatalities involving an intersection	Total Traffic Fatalities involving a *Signalized* intersection
2018	36,835	10,148	3,347
2019	36,355	10,273	3,296
2020	39,007	10,720	3,577
2021	42,939	11,799	4,047
2022	42,514	**12,036 (+19%** since '18)	**4,204 (+26% since '18)**

Note: table values include records coded as Intersections, Intersection-Related, Driveway Access, and Driveway Access Related

Select Solutions for Intersection & Interchange Needs

Safe System Intersections & Control Strategies	○ PEDESTRIAN HYBRID BEACONS

Pedestrian Hybrid Beacon (PHB) …

… is used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk

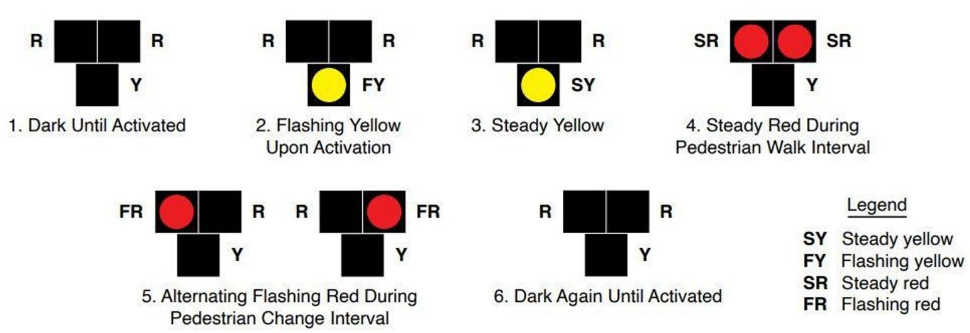
Source: CA MUTCD, Chapter 4F

OFFICE OF SAFETY

Proven Safety Countermeasures

Pedestrian Hybrid Beacons (PHB)

The pedestrian hybrid beacon (PHB) is traffic control device designed to help pedestrians safely cross higher-speed roads at midblock crossings & uncontrolled intersections. The beacon head consists of two red lenses above a single yellow lens. The lenses remain "dark" until a pedestrian desiring to cross the street pushes the call button to activate the beacon, which then initiates a yellow to red lighting sequence consisting of flashing and steady lights that directs motorists to slow and come to a stop, and provides the right-of-way to the pedestrian to safely cross the roadway before going dark again.



Source: MUTCD

Safety Benefits

55% reduction in pedestrian crashes.[2]

29% reduction in total crashes.[3]

15% reduction in fatal and serious injury crashes.[3]

 # = Crash Reduction Factors (%)

Pedestrian Hybrid Beacon (PHB)

California MUTCD 2014 Edition — Page 973
(FHWA's MUTCD 2009 Edition, including Revisions 1,2, &3, as amended for use in California)

CHAPTER 4F. PEDESTRIAN HYBRID BEACONS

Section 4F.01 Application of Pedestrian Hybrid Beacons

Support:

01 A pedestrian hybrid beacon is a special type of hybrid beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk.

01a A conventional traffic control signal operation with a standard signal face displaying green, yellow and red (steady and/or flashing red) indications, at a mid-block crosswalk is an alternative to the pedestrian hybrid beacon.

Option:

02 A pedestrian hybrid beacon may be considered for installation to facilitate pedestrian crossings at a location that does not meet traffic signal warrants (see Chapter 4C), or at a location that meets traffic signal warrants under Sections 4C.05 and/or 4C.06 but a decision is made to not install a traffic control signal.

Standard:

03 If used, pedestrian hybrid beacons shall be used in conjunction with signs and pavement markings to warn and control traffic at locations where pedestrians enter or cross a street or highway. A pedestrian hybrid beacon shall only be installed at a marked crosswalk.

A pedestrian hybrid beacon may be considered for installation … at a location that does not meet signal warrants (see Chapter 4C), or at a location that meets … but a decision is made to not install a traffic control signal.

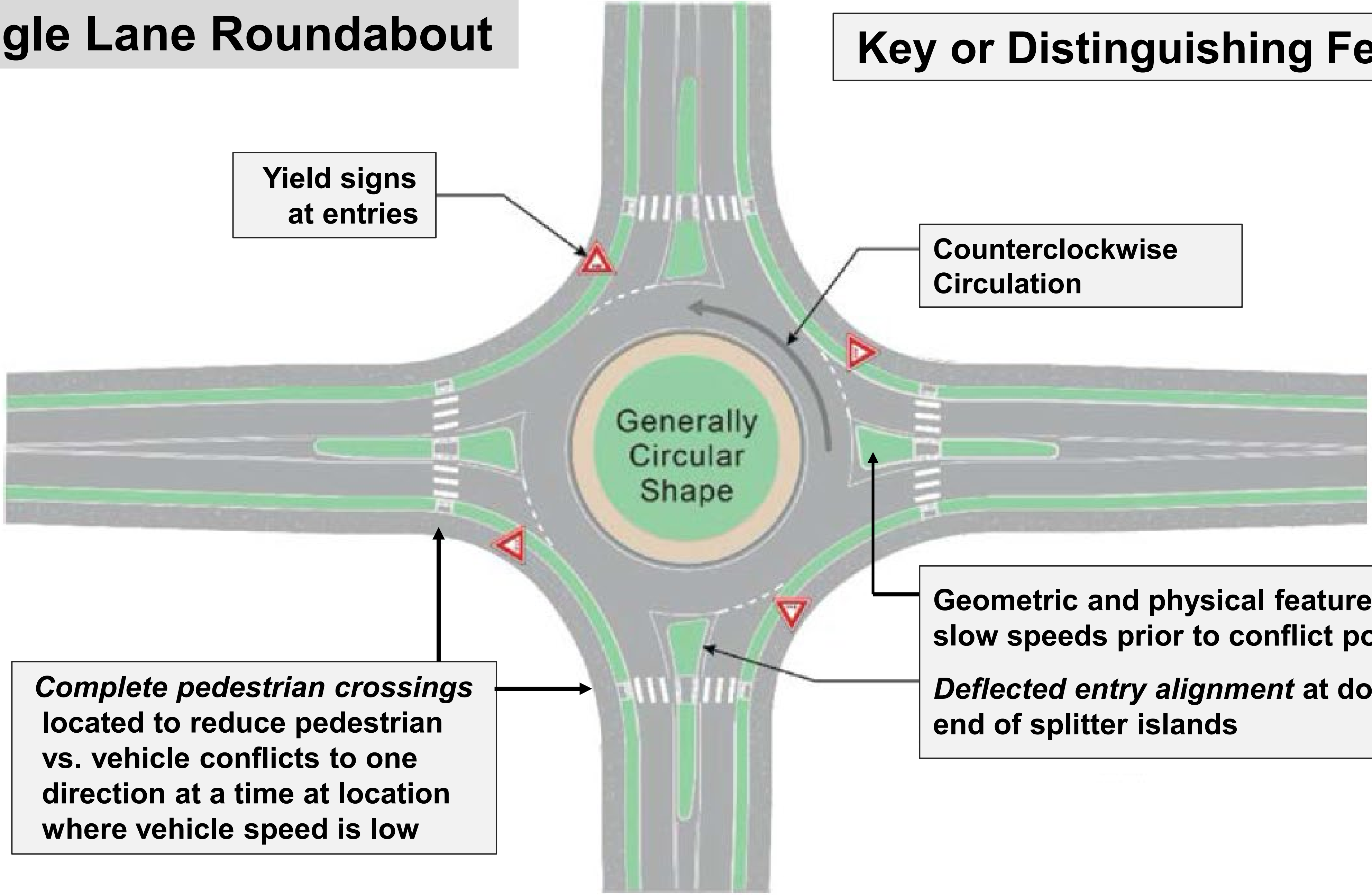
When an engineering study finds that installation of a PHB is justified … The PHB should be installed ***at an intersection, or at the junction of a roadway with a driveway, or at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs***

Safe System Intersections & Control Strategies *which significantly improve mobility*:

1. **improve operations & travel times**
2. **increase throughput**
3. **reduce delay & congestion without adding capacity**

Single Lane Roundabout

Key or Distinguishing Features

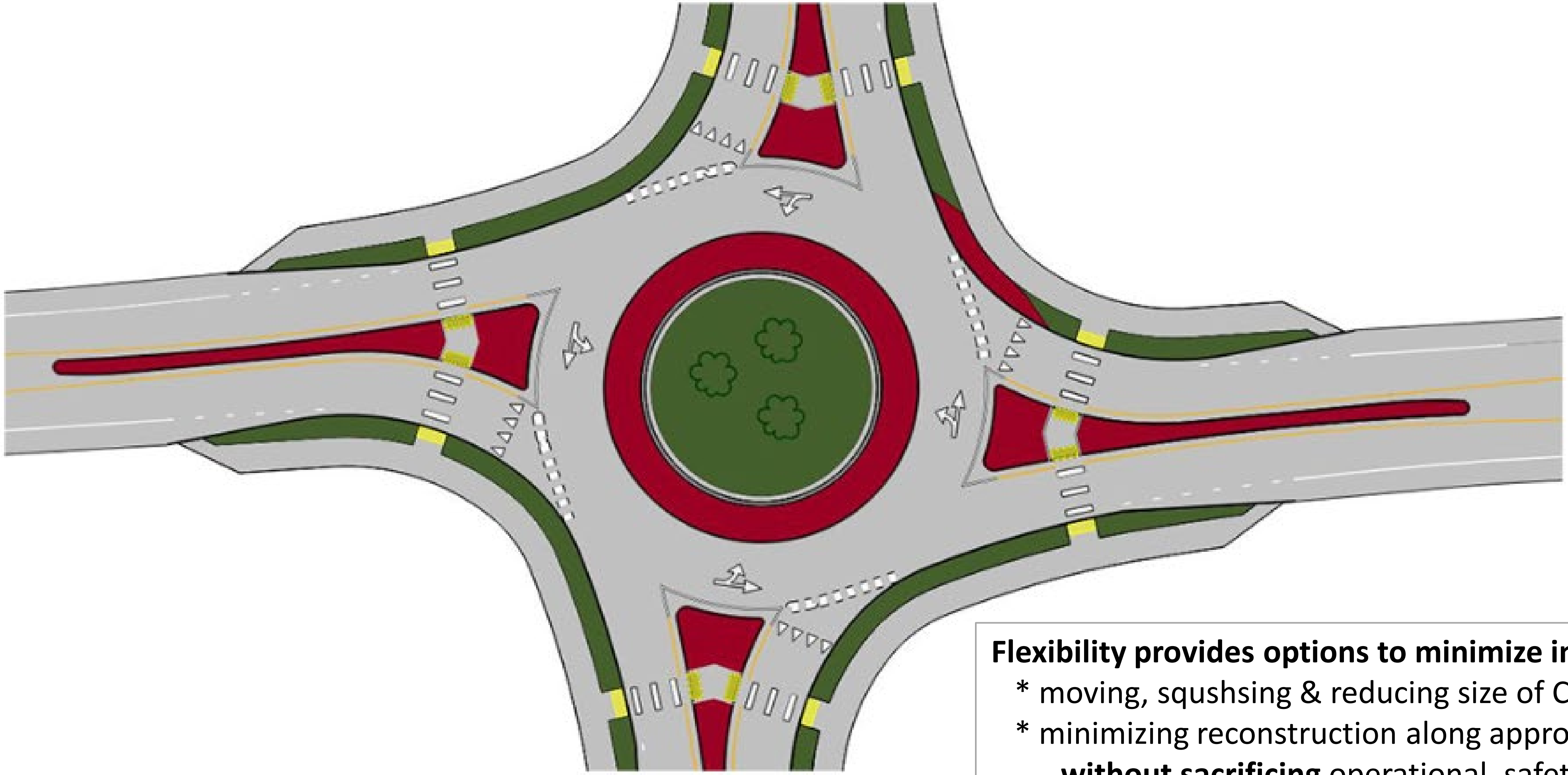


Roundabout Sizes …

… range from a minimum *inscribed circle* diameter of 50’ (for minis) to 200’ or more to accommodate multiple circulating lanes and turning movements by design vehicles

Design characteristics and Flexibility

Roundabouts are a versatile choice for intersection control because the geometry can be modifed to suit the constraints of each intersection …



Flexibility provides options to minimize impacts & cost by:
* moving, squshsing & reducing size of Circular Roadway
* minimizing reconstruction along approaches
… **without sacrificing** operational, safety & calming **benefits**

Roundabout Safety Performance

U.S. Department of Transportation
Federal Highway Administration
FHWA-SA-21-042

Roundabouts_508.pdf (PDF, 647.13 KB)

The modern roundabout is an intersection with a circular configuration that safely and efficiently moves traffic. Roundabouts feature channelized, curved approaches that reduce vehicle speed, entry yield control that gives right-of-way to circulating traffic, and counterclockwise flow around a central island that minimizes conflict points. The net result of lower speeds and reduced conflicts at roundabouts is an environment where crashes that cause injury or fatality are substantially reduced.

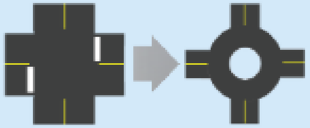
Illustration of a multi-lane roundabout. Source: FHWA

Example of a single-lane roundabout. Source: FHWA

Roundabouts can be implemented in both urban and rural areas under a wide range of traffic conditions. They can replace signals, two-way stop controls, and all-way stop controls. Roundabouts are an effective option for managing speed and transitioning traffic from high-speed to low-speed environments, such as freeway interchange ramp terminals, and rural intersections along high-speed roads.

Golden Hill and Union Road (Paso Robles)

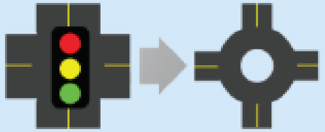
Two-Way Stop-Controlled Intersection to a Roundabout



82%

Reduction in fatal and injury crashes[1]

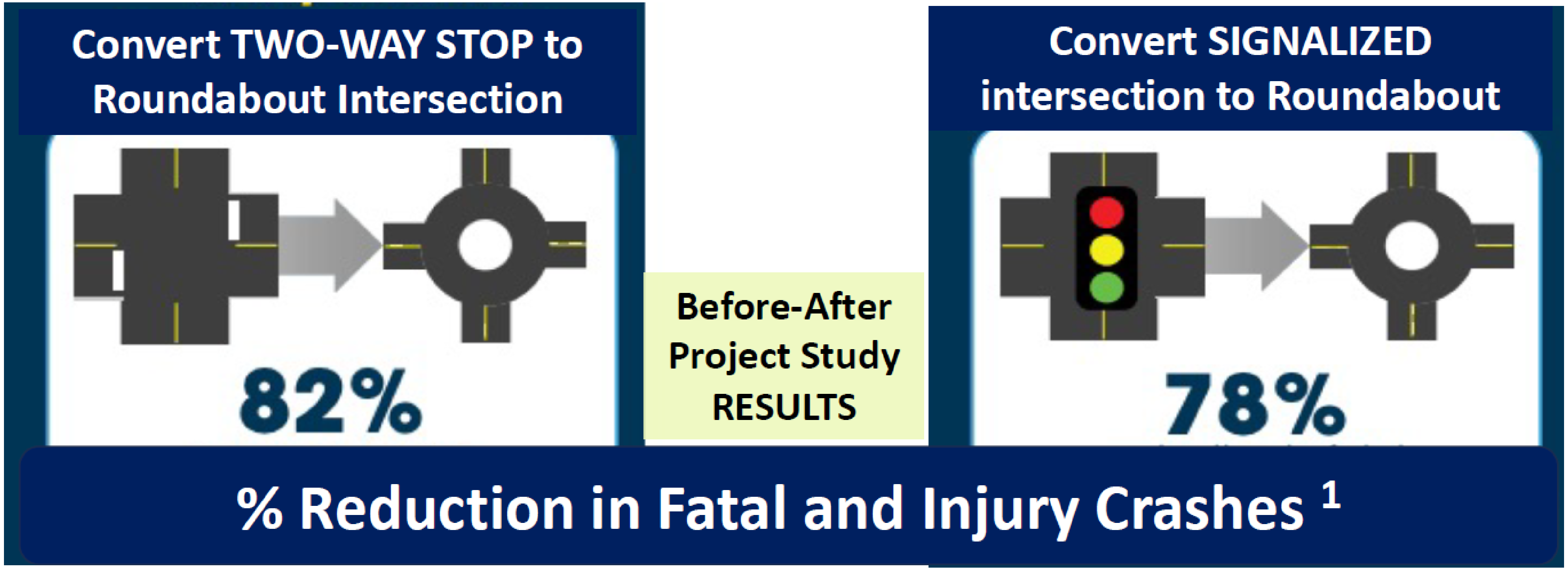
Signalized Intersection to a Roundabout



78%

Reduction in fatal and injury crashes[1]

Crash Reduction Factors for Roundabouts



But are roundabouts also safer for Peds & Cyclists?

[1] SOURCE: *Making our Roads Safer, One Countermeasure at a Time; see page 18, FHWA Publication*

- https://safety.fhwa.dot.gov/provencountermeasures/pdf/FHWA-SA-21-071_PSC%20Booklet_508.pdf

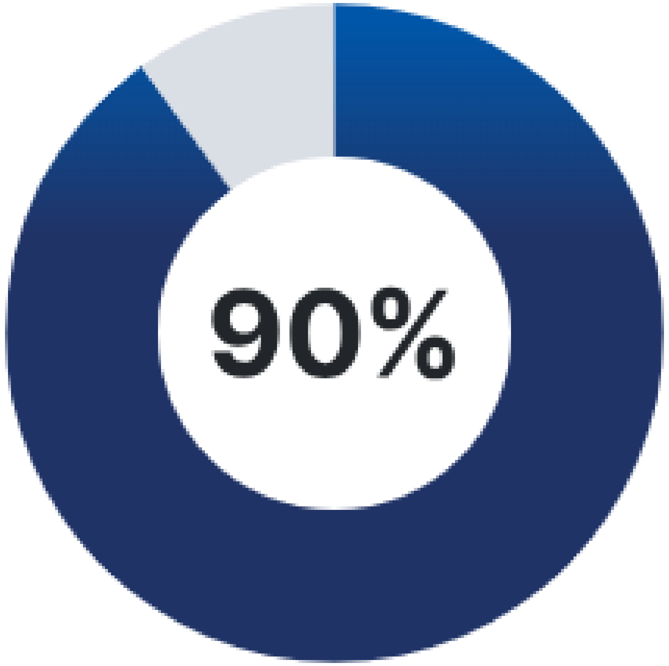
Crash Reduction Ability of Roundabouts

Enhanced safety

Reduced number of conflict points.

- **Roundabouts reduce fatalities by 90%** by eliminating crossing conflict points and head-on crashes.
- Roundabouts significantly reduce the total number of conflict points in an intersection, which means fewer opportunities for crashes.

Source: National Academy of Sciences (NAS)



ROUNDABOUTS: Slower & Safer for all Road Users

“since the early 1990’s … there have been only 10 vulnerable road user fatalities …”

STREETSBLOG USA

BICYCLE INFRASTRUCTURE

Opinion: America Should ‘Think Round’ For Safety for Vulnerable Road Users

By Kea Wilson Sept 19, 2022 (Excerpt)

The actual safety record for roundabouts for vulnerable road users, though, speaks for itself — regardless of any conjecture otherwise.

Although there is no known, official collection of crash data for roundabouts nationwide, Scott Batson, a traffic engineer from the Portland Bureau of Transportation, has been unofficially tracking fatalities at roundabouts since the early 2000s from publicly known crashes. From that data, there have been only 10 vulnerable road user fatalities at roundabouts — six pedestrians and four cyclists — since they were first installed in the US in the early 1990s. **None of those fatalities are known to have occurred in a marked crosswalk located along one of those roundabouts, either.**

https://usa.streetsblog.org/2022/09/19/opinion-america-should-think-round-for-vulnerable-road-user-safety

Mini-roundabout - 62’ Diameter, Source: FHWA

STREETSBLOG USA

BICYCLE INFRASTRUCTURE

Opinion: America Should 'Think Round' For Safety for Vulnerable Road Users

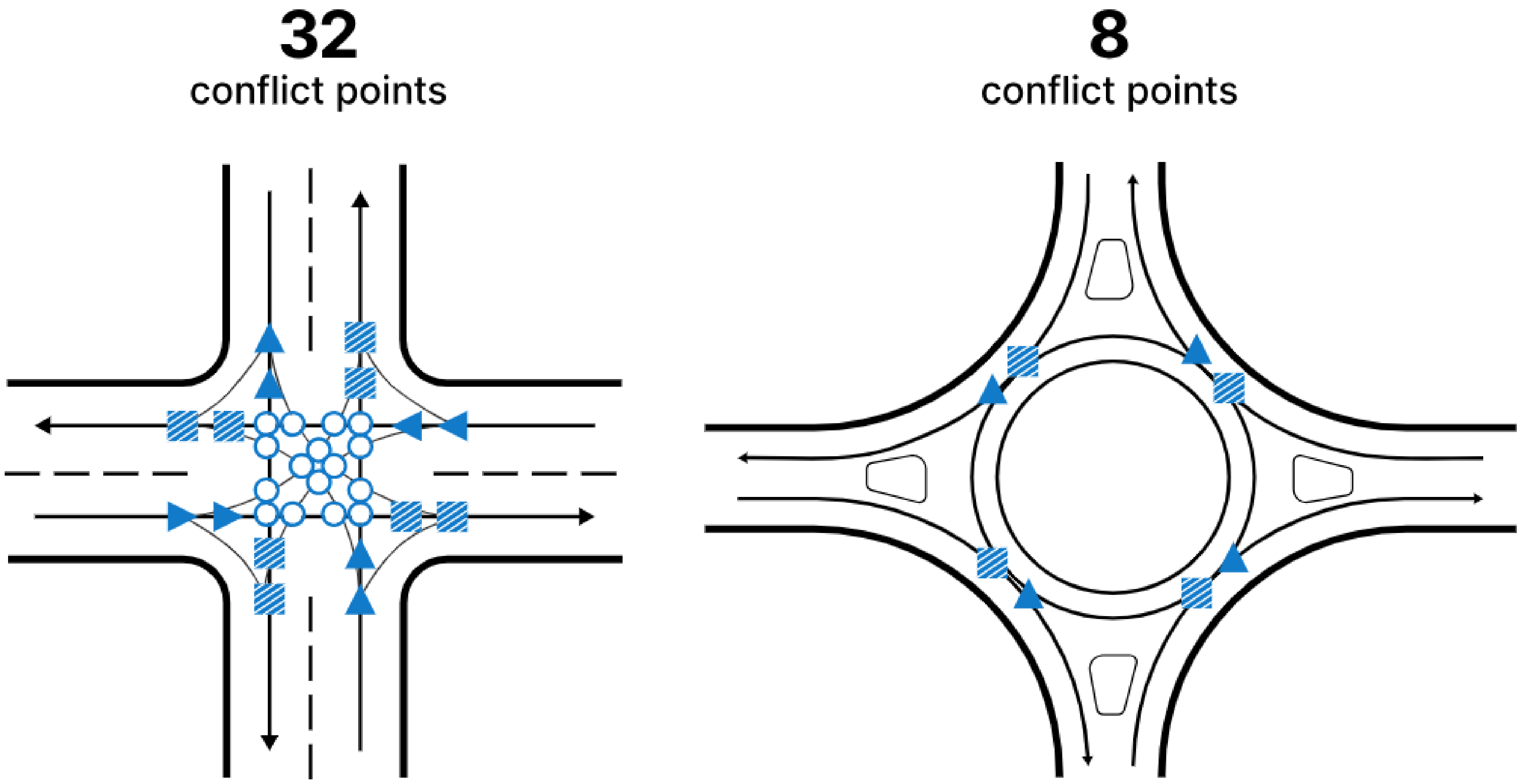
There's also one clause in the Bipartisan Infrastructure Law that doesn't stand out much, but the very fact it is included in the law is groundbreaking. The clause is under the Highway Safety Improvement Program section, and updates Section 148 of Title 23, US Code to make it clear that such a project can include "an intersection safety improvement that provides for the safety of all road users, as appropriate, *including a multimodal roundabout.*" (Emphasis ours.)

Here's why this is huge: Congress has not only codified roundabouts into federal law for the first time, *and* put them at the top of the list of examples of highway safety improvement projects. They've also defined them as providing "for the safety of all road users," including pedestrians, cyclists and people who use assistive devices like wheelchairs — not just vehicle drivers.

It is also why constructing more roundabouts instead of signalized intersections should be a key component of a Safe System Approach, which requires road designers to accept the inevitability of human error. As seen from the data and the basic physics, roundabouts are much more forgiving to vulnerable road users if people make mistakes and a crash occurs.

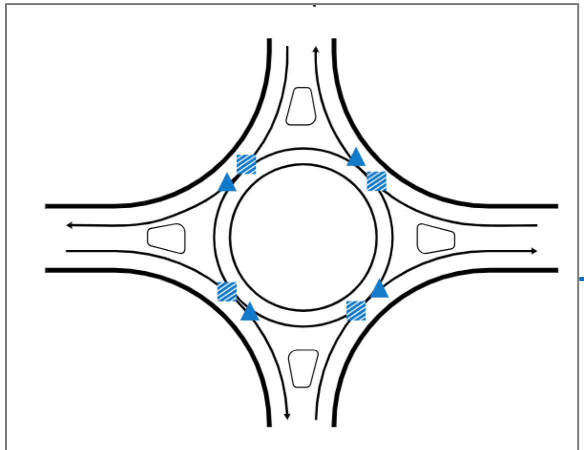
Mini-roundabout - 62' Diameter, Source: FHWA

https://usa.streetsblog.org/2022/09/19/opinion-america-should-think-round-for-vulnerable-road-user-safety



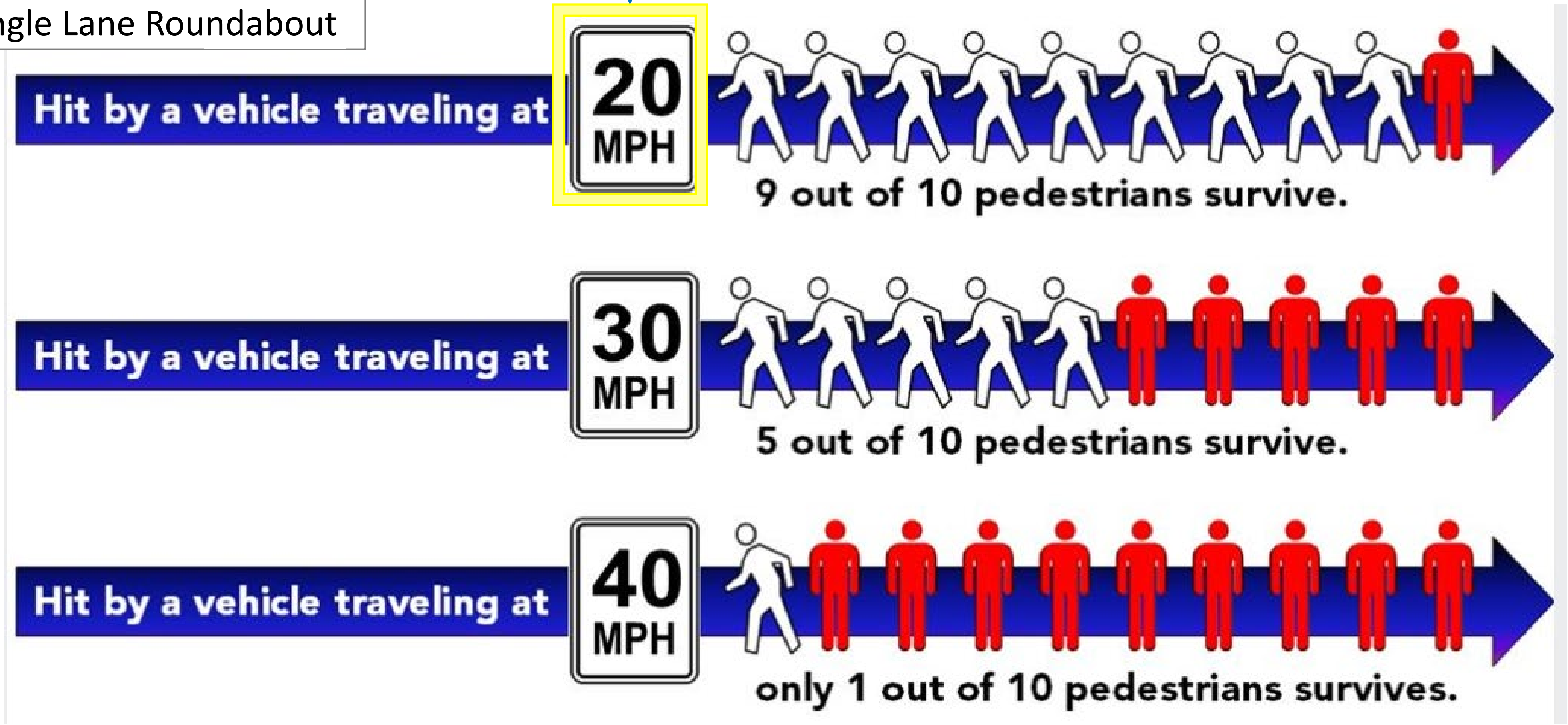
Conventional vs Roundabout Intersections

Diverging
Merging
Crossing



Why Roundabouts are Safer :

- 8 low speed Veh-Veh Conflict Points (with low *speed differential)*
- 8 low speed Pedestrian Crossing Conflict Points



ROUNDABOUTS: *More than a TIER 1 SAFE SYSTEM INTERSECTION*

Proven Safety Countermeasure	TIER 1 Remove Severe Conflicts	TIER 2 Reduce Vehicle Speeds	TIER 3 Manage Conflicts in Time	TIER 4 Increase Attention / Awareness
Roundabouts:	✓	✓	✓ [1]	✓ [2]

- **Remove crossing & left turn conflicts** from intersections **(Tier 1)**
  - Reduce number of intersection crossing conflicts
- **Reduce vehicle speeds** prior to conflict points **(Tier 2)**
- Reduce kinetic energy involved in vehicle crashes
  - Create self-enforcing roads when installed in series
- All-Way Yield Control regulates entry to “gaps” in circulating flow **(Tier 4)**
- are Intentionally conspicuous and used as a Gateway Treatment **(Tier 3)**

Provides numerous other advantages & measurable benefits for all road users …

https://highways.dot.gov/safety/zero-deaths/safe-system-roadway-design-hierarchy

Roundabouts provide numerous other advantages & benefits for all road users …

Greater Operational Efficiency → More Capacity → fewer lanes required at entry …

facilitates implementation of Road Diets …

Case Study: College Street in Ashville, NC
An *Intersection* Diet within RD Corridor
6 lanes (one leg) to 2 lanes

Operational efficiency means that fewer lanes are needed along approaches (about half)

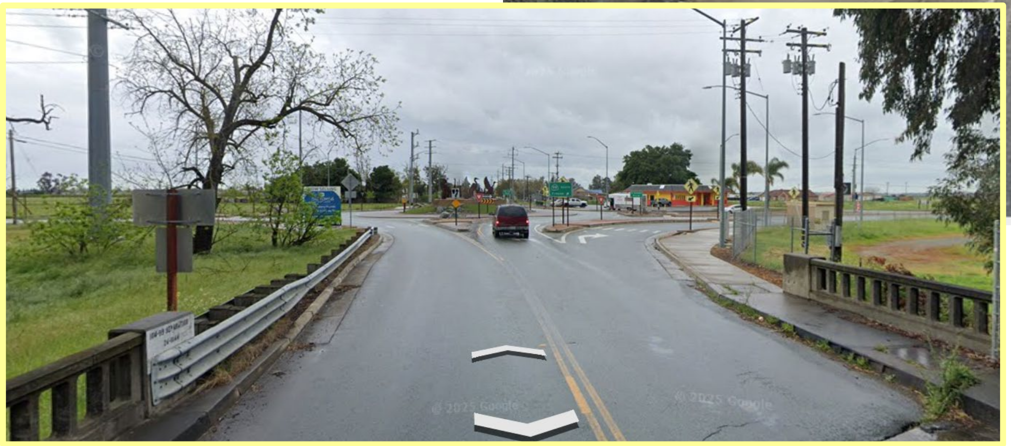
Note RR tracks passing thru the roundabout

SR 99 / Twin Cities Road Freeway Interchange

City of Galt (District 3)

SR 99 Interchange at Twin Cities Road (SR 104)

City of Galt - District 3



Widening for WB Bypass Lane begins downstream of O/C structure

Roundabouts provide numerous other advantages & benefits for all road users …

- Traffic Calming / Speed Reduction
- Improve Circulation: Provide U-Turns

Slow vehicles prior to entering:

- a community (Main Street along a rural corridor)
- a complex (high-risk) intersection / interchange:
  - speed differential prevails, and
  - multiple decisions are required

Safe System Intersections & Control Strategies

- ROUNDABOUTS
- PED HYBRID BEACONS
- REDUCED LEFT TURN CONFLICT INTERSECTIONS (RCUT and MUT)

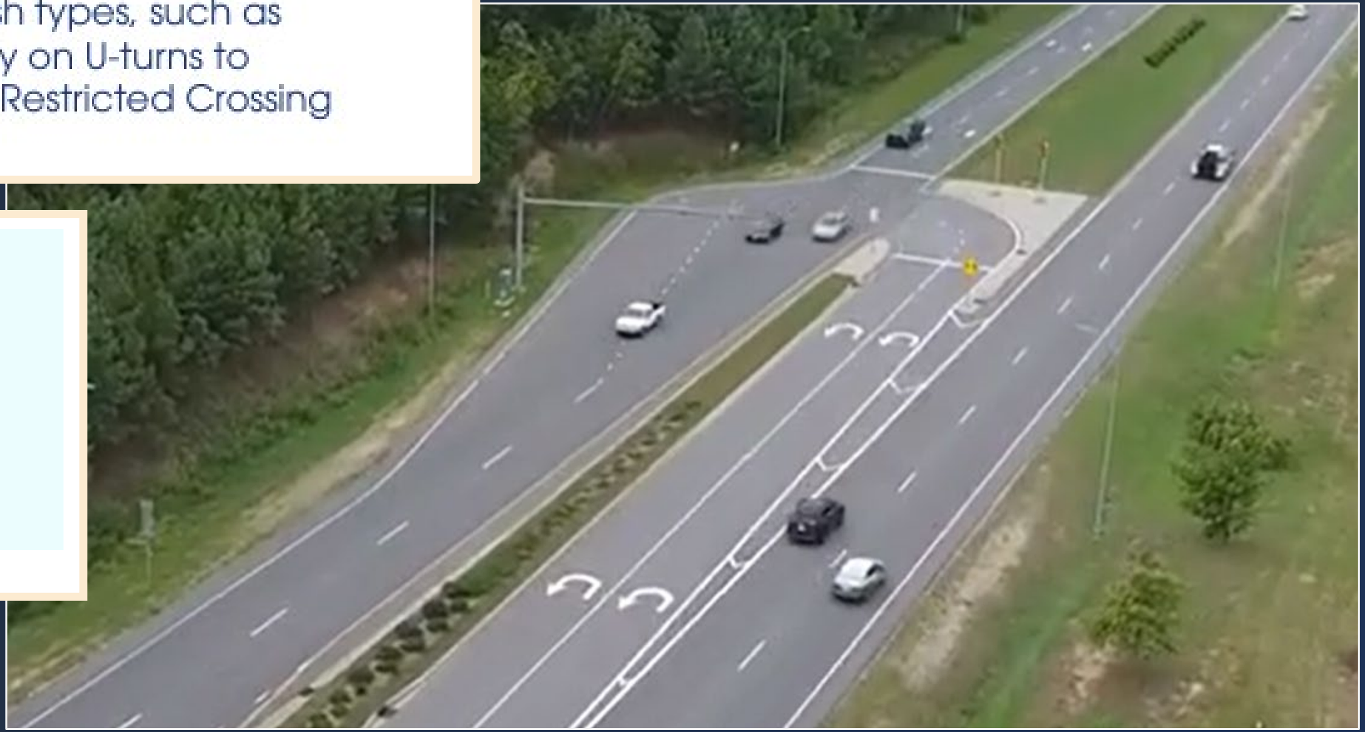
OFFICE OF SAFETY

Proven Safety Countermeasures

Reduced Left-Turn Conflict Intersections

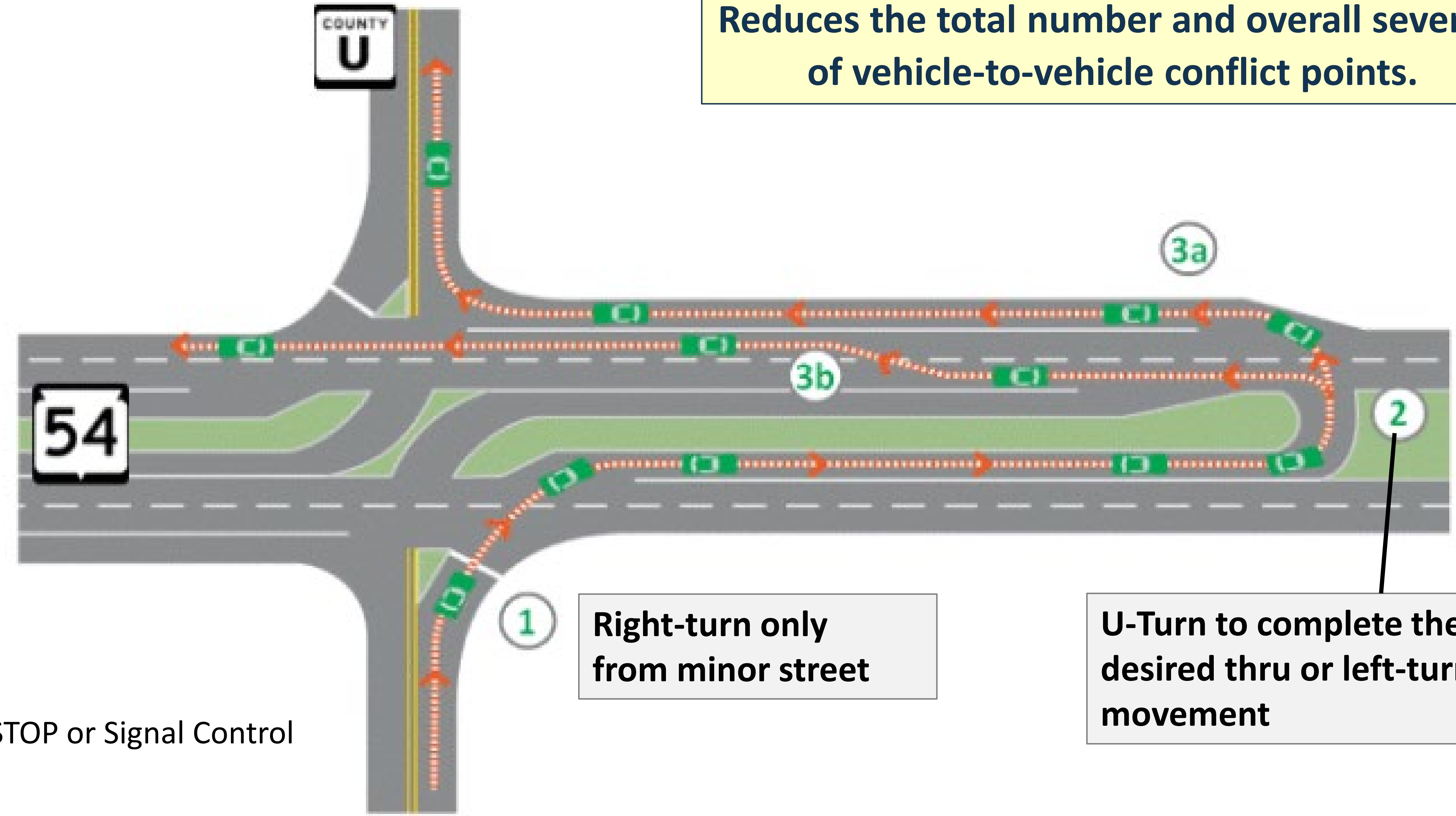
Reduced left-turn conflict intersections are geometric designs that alter how left-turn movements occur. These intersections simplify decision-making for drivers and minimize the potential for higher severity crash types, such as head-on and angle. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the Restricted Crossing U-turn (RCUT) and the Median U-turn (MUT).

- **Restricted Crossing U-Turn (RCUT)**
- **Median U-Turn (MUT)**
- **Displaced Left Turn**
- **Continuous Green T intersection**



Restricted Crossing U-Turn (RCUT) Intersection

Reduces the total number and overall severity of vehicle-to-vehicle conflict points.

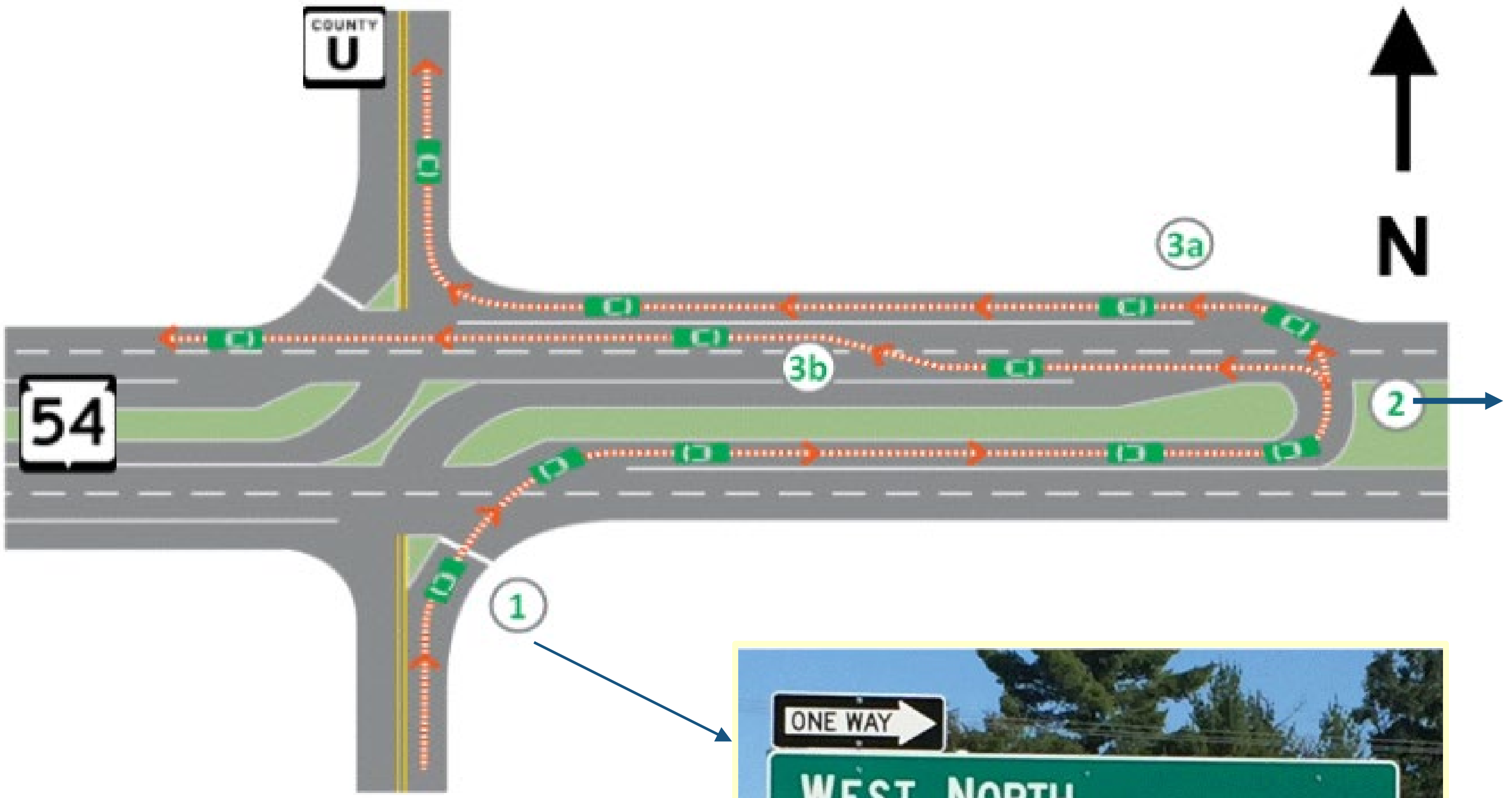


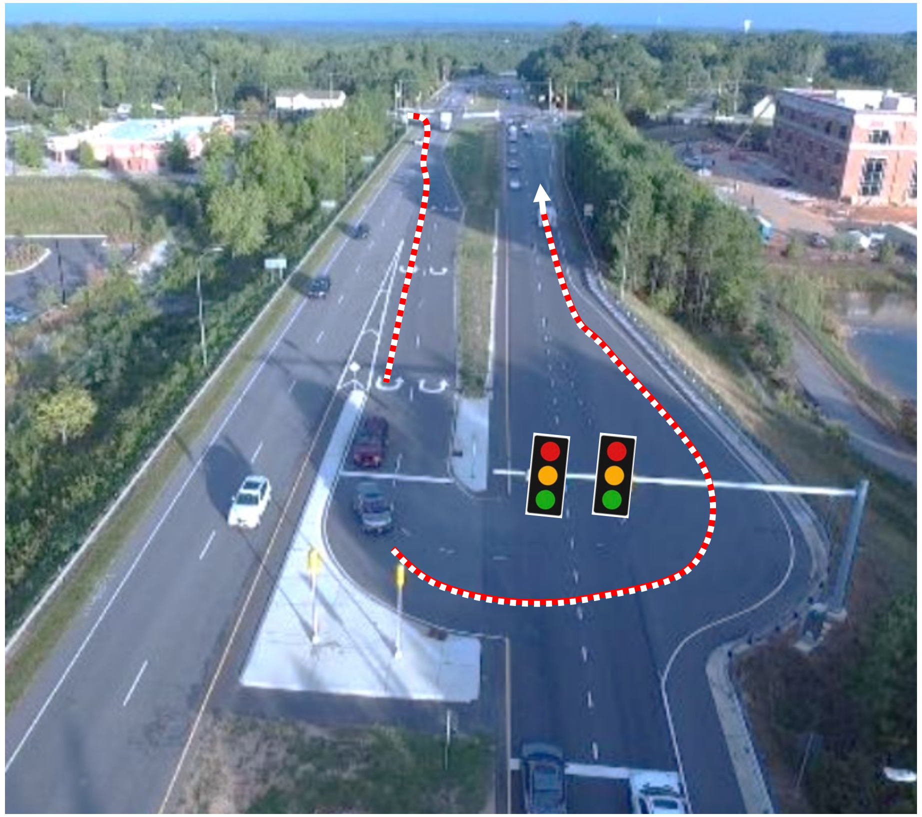
Right-turn only from minor street

U-Turn to complete the desired thru or left-turn movement

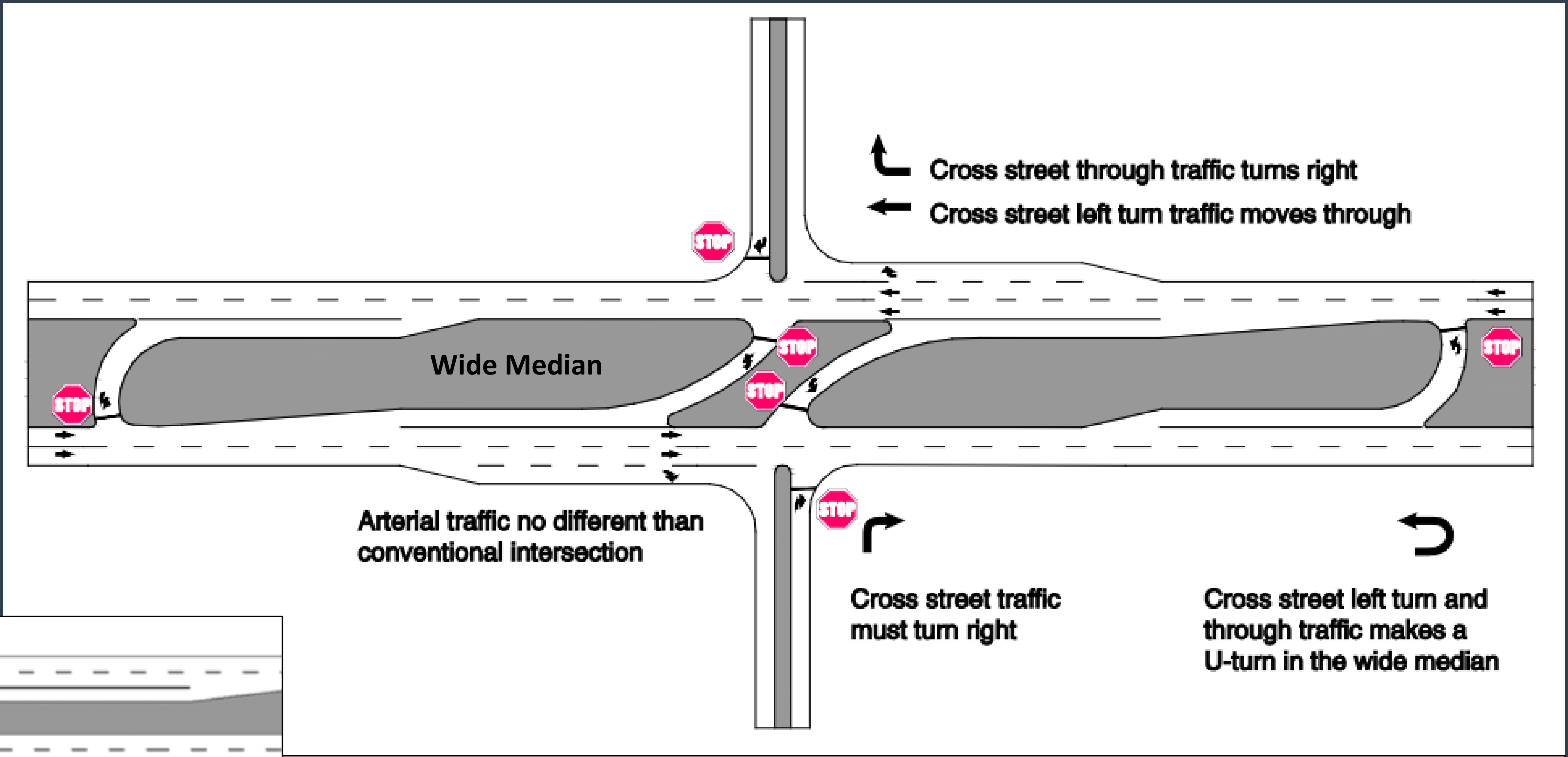
STOP or Signal Control

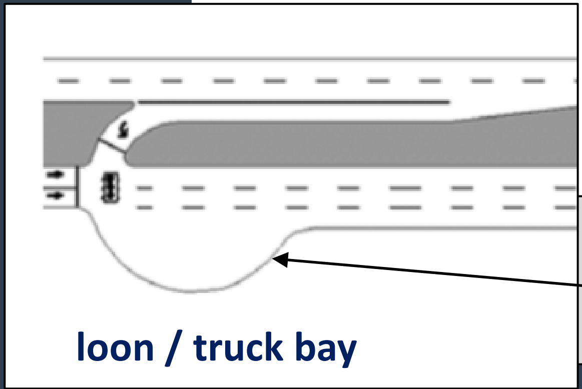
Restricted Crossing U-Turn (RCUT) Intersections





Restricted Crossing U-turn (RCUT)





Wide Median

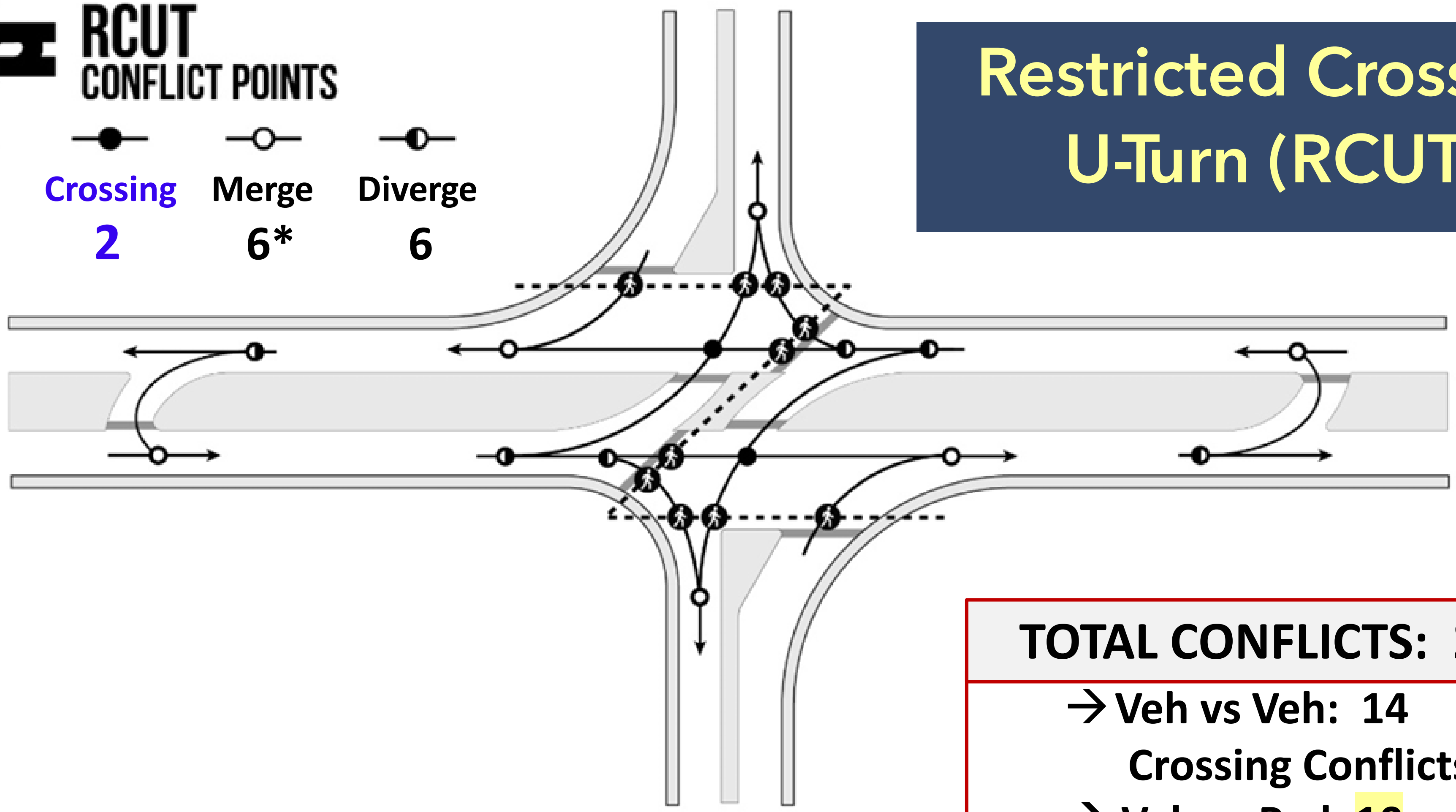
(loon or truck bay not required)

Signalized

RCUT CONFLICT POINTS

Ped	Crossing	Merge	Diverge
10	2	6*	6

Restricted Crossing U-Turn (RCUT)



TOTAL CONFLICTS: 24

→ Veh vs Veh: 14

Crossing Conflicts: 2

→ Veh vs Ped: 10

Source: FHWA

Figure 38. Graphic. Diagram of movement-based conflict points for Signalized RCUT intersections.

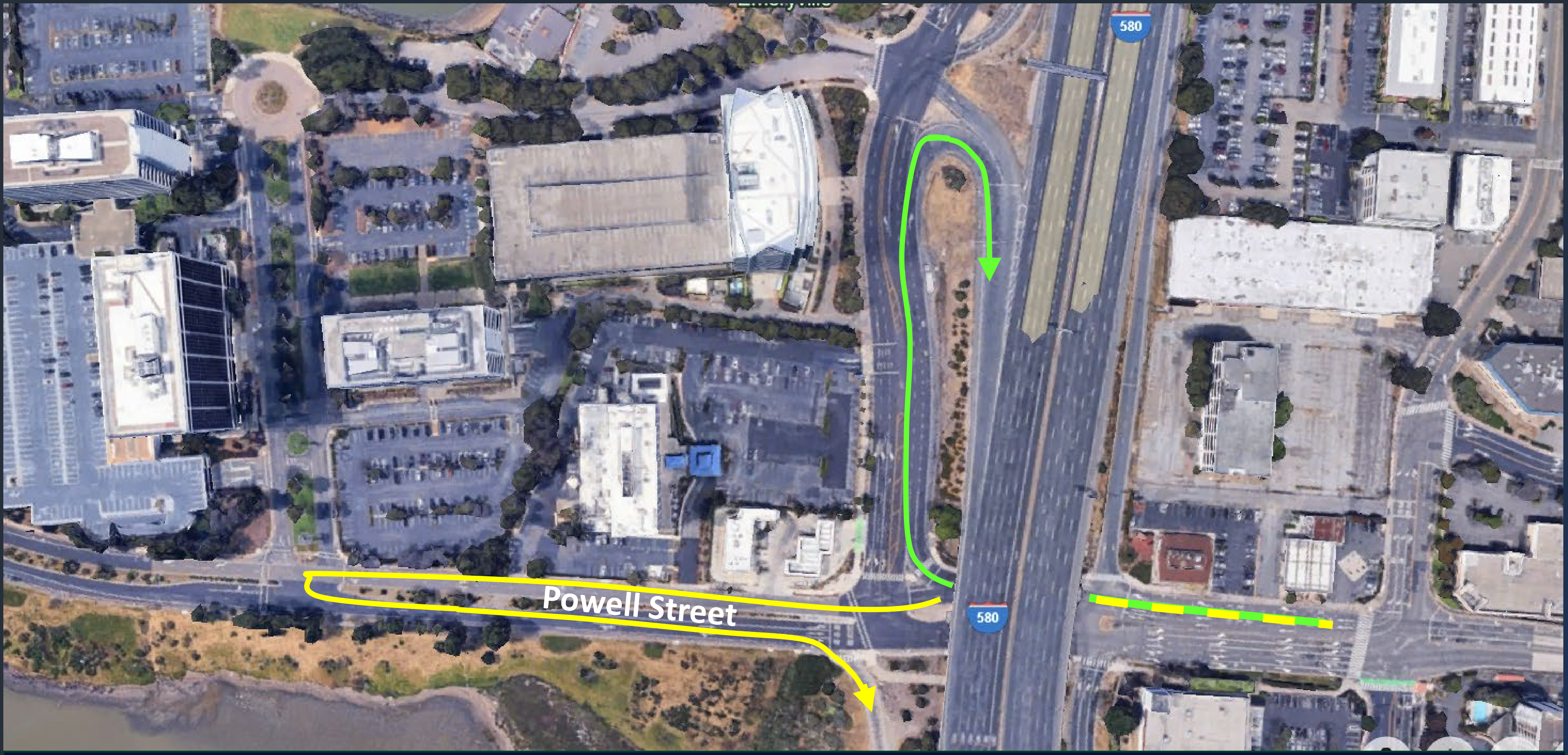
Restricted Crossing U-turn (RCUT)

OPERATIONAL BENEFITS

- Installing an RCUT can result in a:
  - 30% increase in throughput, and
  - 40% reduction in network intersection travel time

Source: FHWA < https://highways.dot.gov/safety/proven-safety-countermeasures/reduced-left-turn-conflict-intersections>

Example: RCUT at Interchange (cars only)
for WB to SB movement and bypass of "hook" on-ramp



Restricted Crossing U-turn (RCUT)

OPERATIONAL BENEFITS

- Installing an RCUT can result in a:
  - 30% increase in throughput, and
  - 40% reduction in network intersection travel time

SAFETY BENEFITS

Two-Way Stop-Controlled to RCUT:
54%
reduction in fatal and injury crashes.[2]

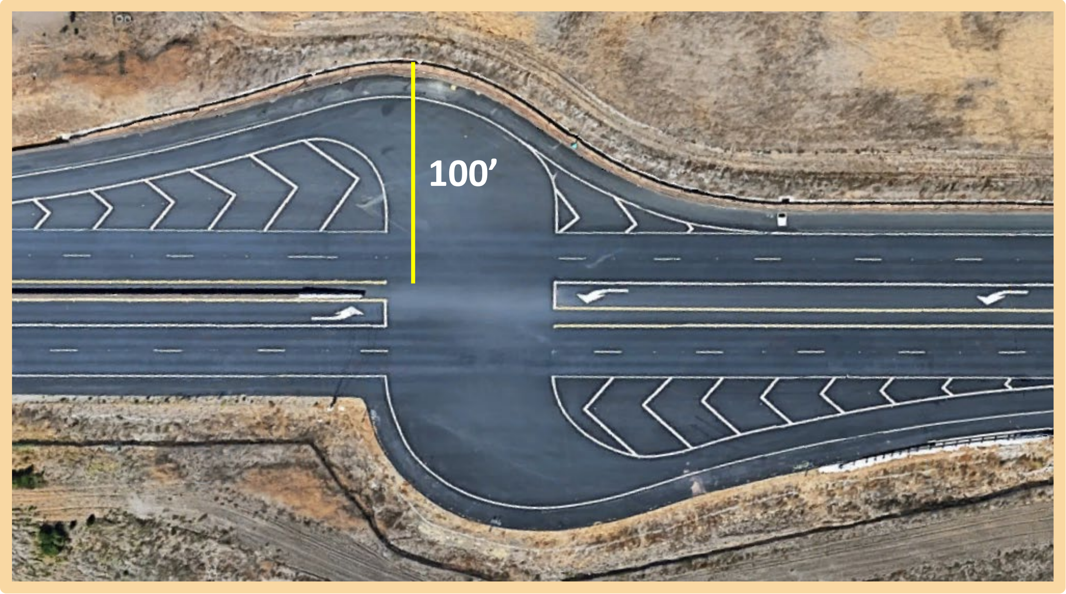
Signalized Intersection to Signalized RCUT:
22%
reduction in fatal and injury crashes.[3]

Unsignalized Intersection to Unsignalized RCUT:
63%
reduction in fatal and injury crashes.[4]

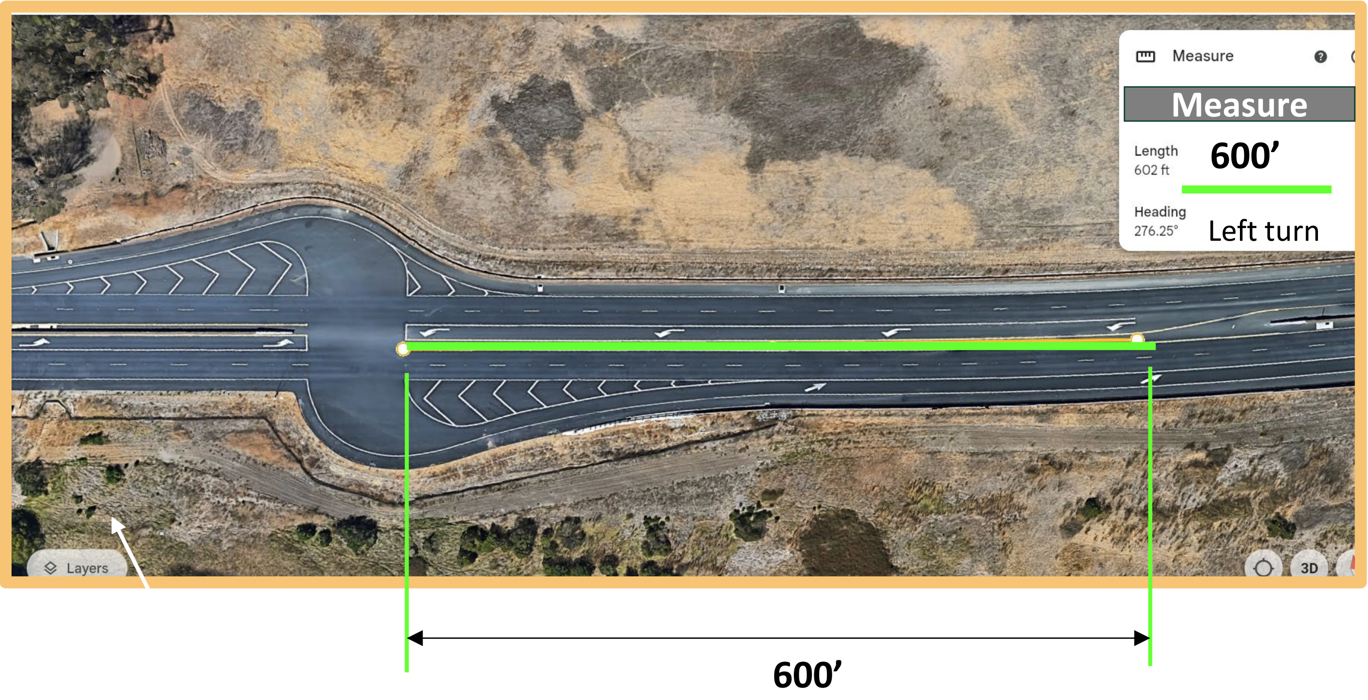
Source: FHWA < https://highways.dot.gov/safety/proven-safety-countermeasures/reduced-left-turn-conflict-intersections>

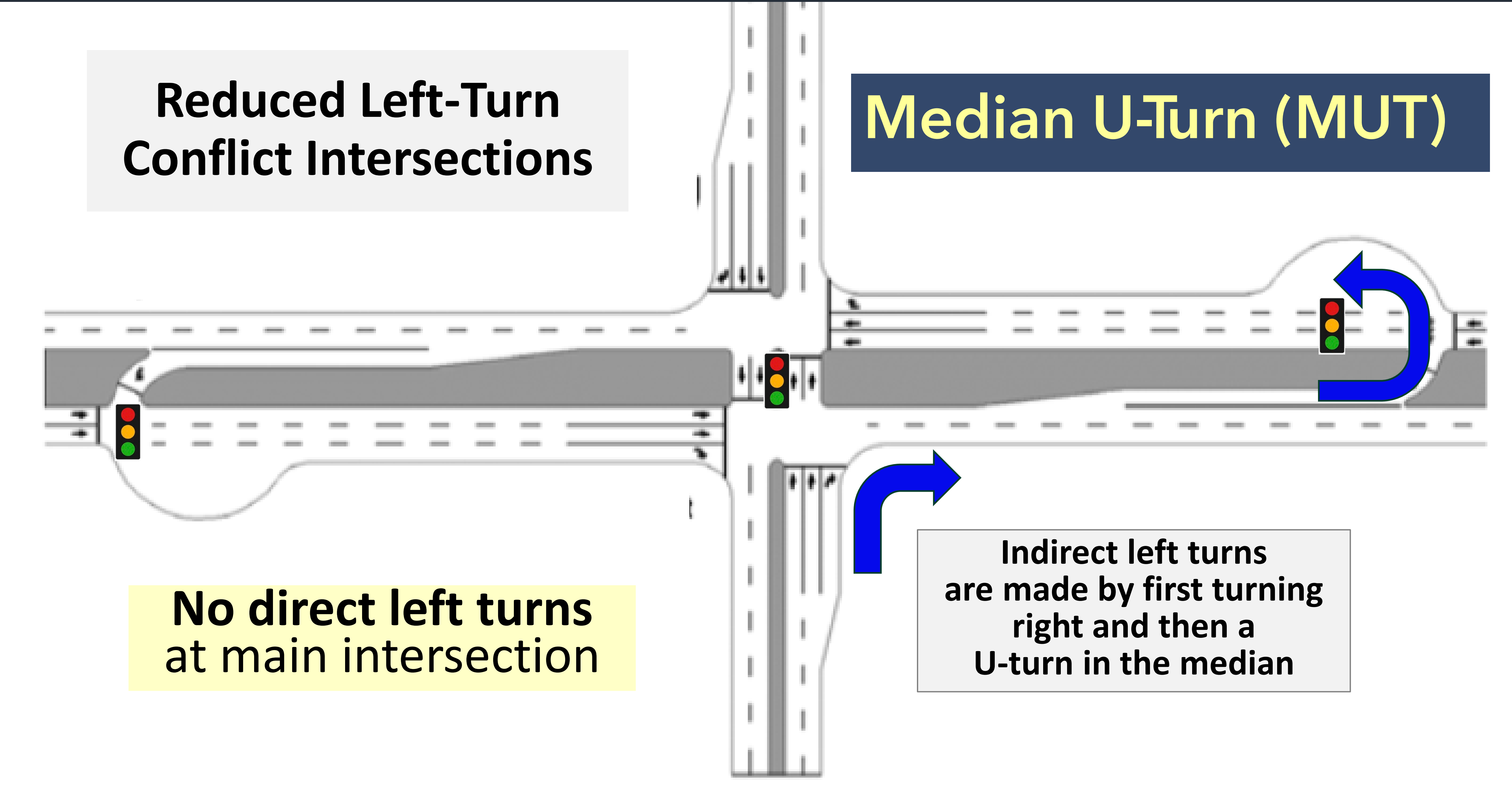
Restricted Crossing U-Turn (RCUT)

SR-12 (Jameson Canyon Rd)
2.2 miles west of I-80 near Fairfield



Back-to-back *loons* for U-turns by design vehicle

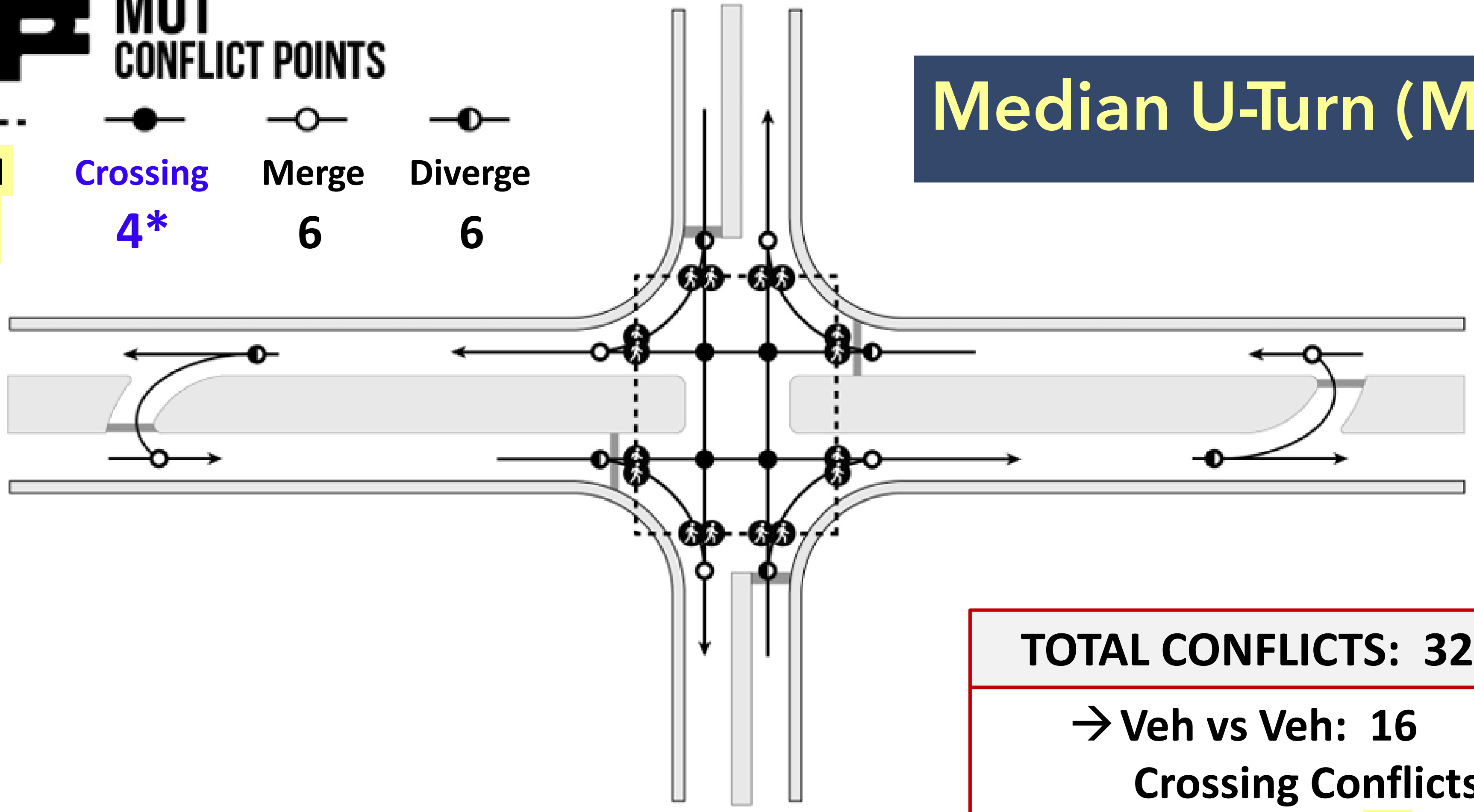



Reduced Left-Turn
Conflict Intersections
Median U-Turn (MUT)
No direct left turns
at main intersection
Indirect left turns
are made by first turning
right and then a
U-turn in the median

Median U-Turn (MUT)

MUT CONFLICT POINTS

Ped	Crossing	Merge	Diverge
16	4*	6	6



TOTAL CONFLICTS: 32

→ Veh vs Veh: 16

Crossing Conflicts: 4

→ Veh vs Ped: 16

Source: FHWA

Figure 40. Graphic. Diagram of movement-based conflict points for MUT intersections.

Median U-Turn

SAFETY BENEFITS

MUT

30%

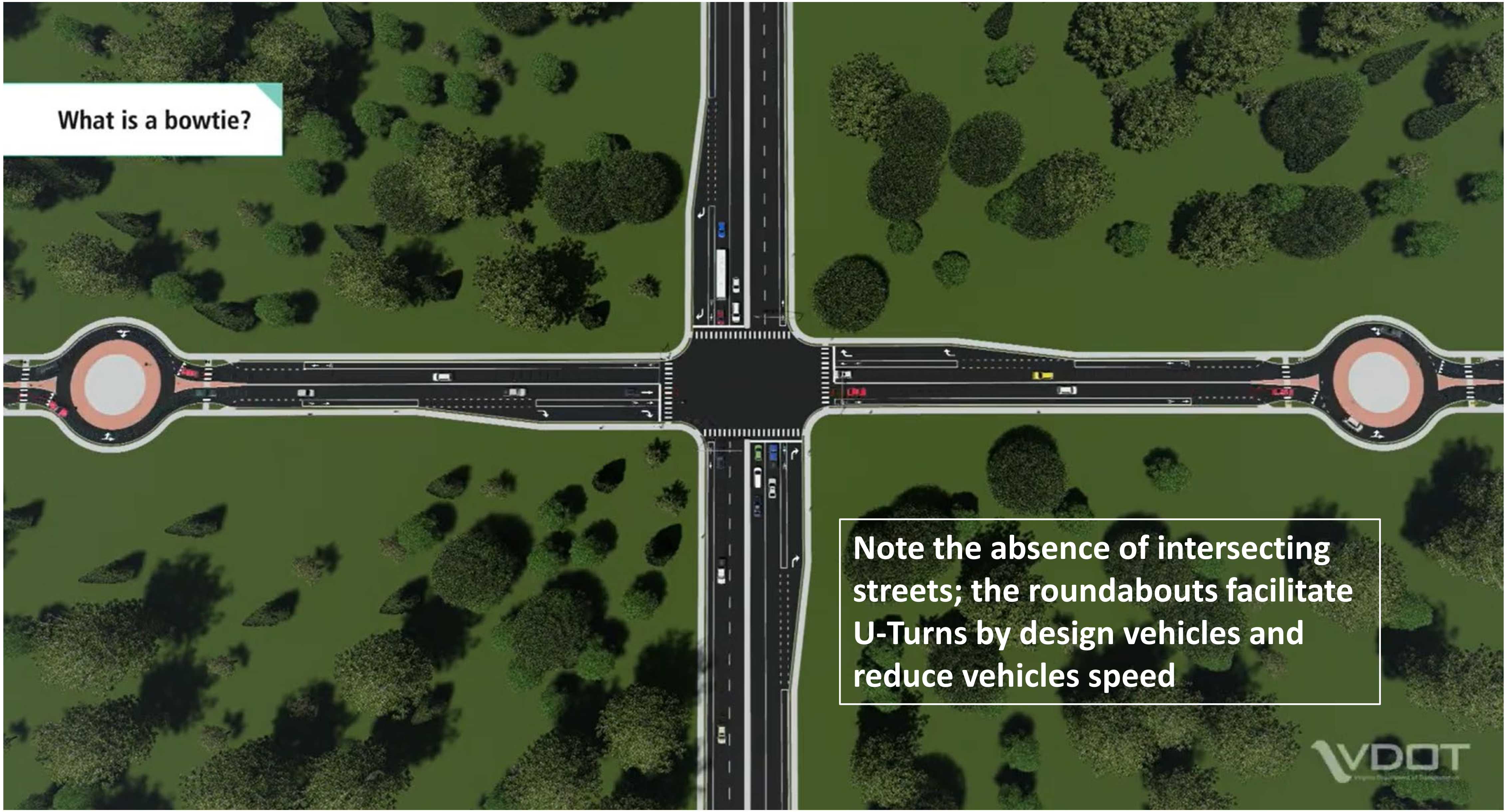
reduction in intersection-related injury crash rate.[5]

OPERATIONAL BENEFITS

- **Studies have shown a 20% – 50% improvement in Intersection throughout (for various lane configurations)**
- When implemented at multiple inter-sections along a corridor, the efficient two-phase signal operation can reduce delay, improve travel times, and create more crossing opportunities for peds and cyclists

No left turns permitted at intersection

What is a Bowtie Intersection?



Safe System Intersections & Control Strategies

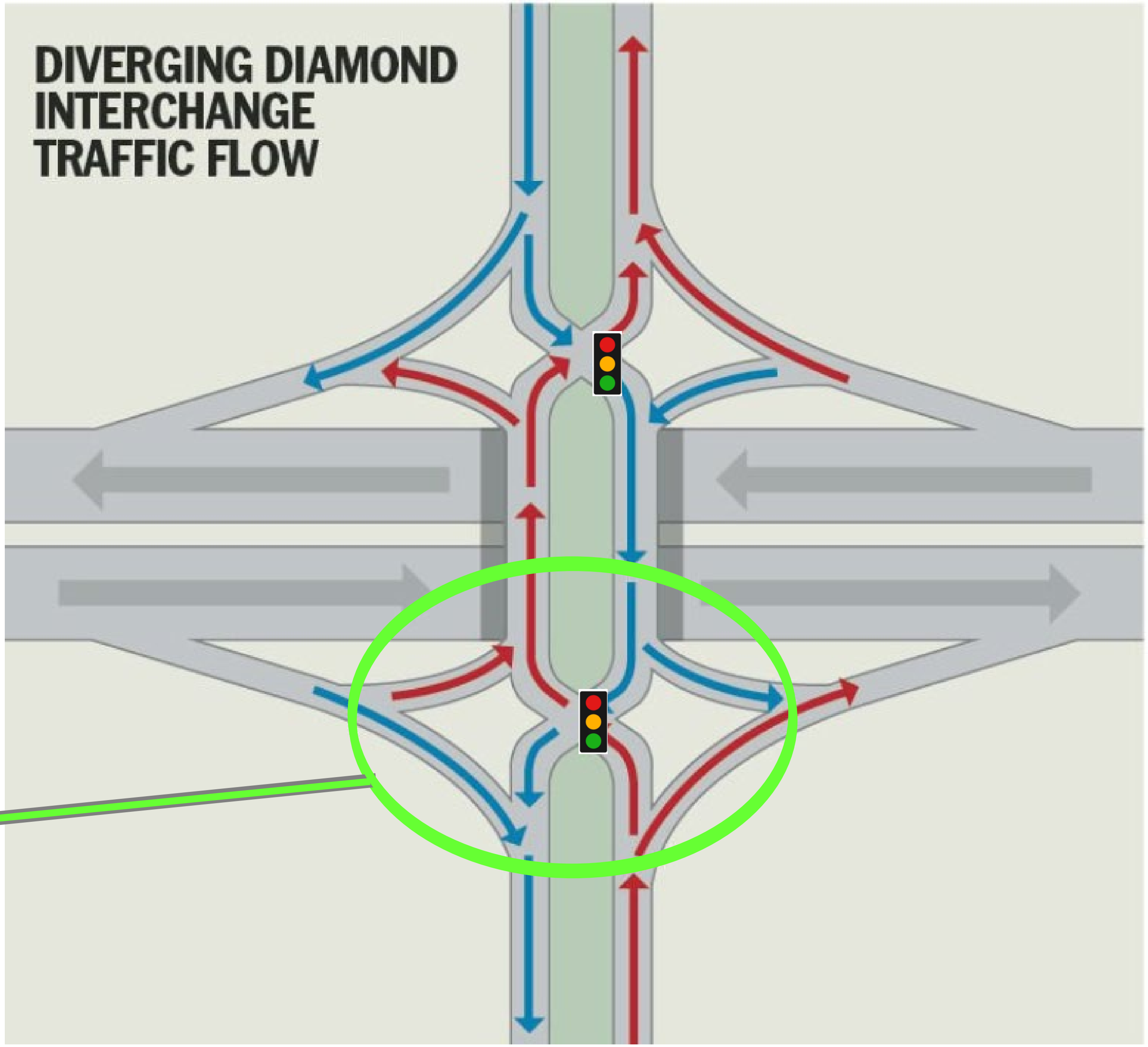
- ROUNDABOUTS
- PED HYBRID BEACONS
- REDUCED LEFT TURN CONFLICT INTERSECTIONS and INTERCHANGES (Diverging Diamond)

REDUCED LEFT TURN CONFLICT *INTERCHANGES*

- **Partial Cloverleaf**
- **Diverging Diamond (DDI)**

KEY FEATURES (of DDI)

- **Left Turns to/from ramps (across local arterial) are converted to merge / diverge conflicts**
- **2-Phase traffic signals**



https://www.youtube.com/watch?v=JnjqAwtkEkM

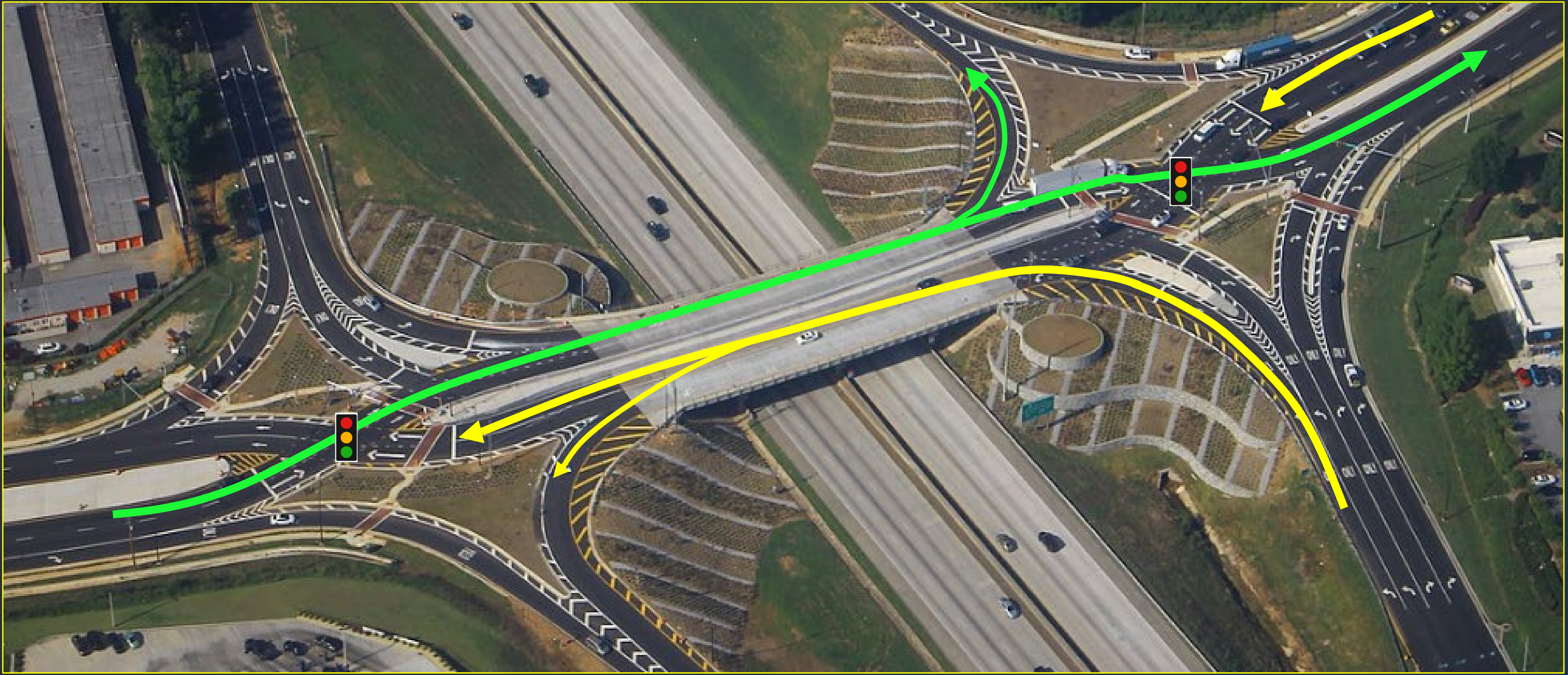
Reduced Left-Turn Conflict Intersections: **DDI**

Diverging Diamond Interchange (DDI)

Reduced Left-Turn Conflict Intersections: **DDI**

Diverging Diamond Interchange (DDI)

Reduced Left-Turn Conflict Intersections: **DDI**



Diverging Diamond Interchange (DDI)


ONLY

Diverging Diamond Interchange (DDI)

THIS COUNTERMEASURE IN PRACTICE

Minnesota DOT
Before-After Safety Evaluation

Total Crashes reduced from 304 to 37 after conversion to a DDI

Trucks Using a DDI in Salt Lake County, UT
Source: DDI Video FHWA-SA-14-019

The Minnesota Department of Transportation converted two signalized diamond interchanges, with a minimum of 28,000 AADT to a maximum of 40,000 AADT on major roads and minimum of 3,000 AADT to a maximum of 18,000 AADT on minor roads, to DDIs. According to a before and after safety evaluation conducted between 2006 to 2015, the signalized intersections resulted in an estimated 304 crashes, whereas 37 crashes were recorded after the DDI redesign.[11]

Diverging Diamond Interchange (DDI)

Safe System Alignment

- **50% reduction in conflict points** (veh-veh)
- **Eliminates most severe crash types**

WHAT ARE THE BENEFITS OF DIVERGING DIAMOND INTERCHANGES?

Compared to the conventional diamond interchange, which is the most common form in the United States, the DDI reduces vehicle-to-vehicle conflict points by nearly 50 percent and eliminates most severe crash types.[9] Converting traditional diamond interchanges to DDIs at 80 locations in 24 States resulted in a 44 percent reduction in fatal and serious injury crashes when applied in urban or suburban areas with a minimum of 1,295 AADT and maximum of 76,100 AADT on arterial roadways.[10]

SAFETY BENEFITS

Convert Traditional Diamond to DDI

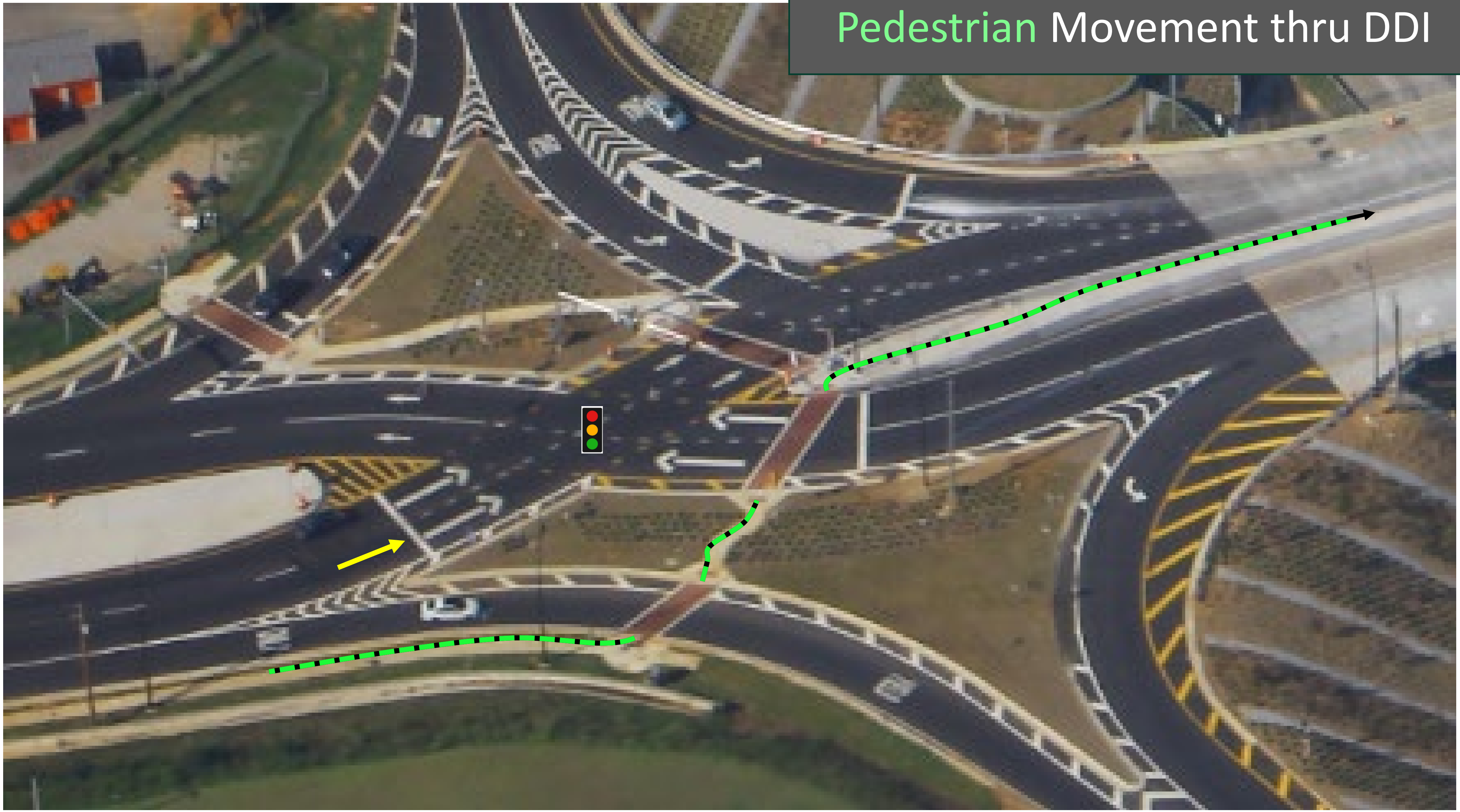
44% reduction

in fatal and severe injury crashes

Ped & Bike Movements thru the DDI

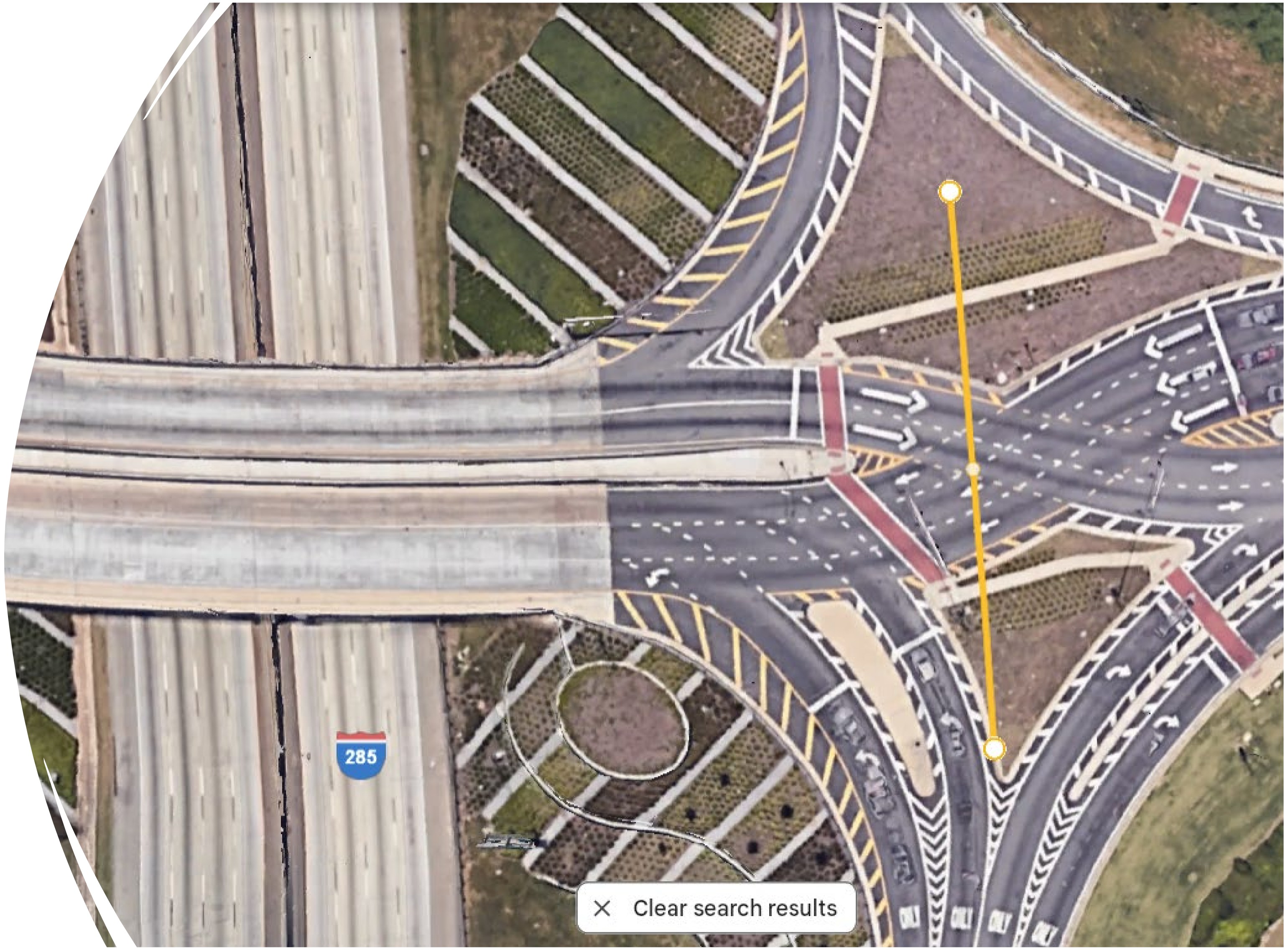

ONLY
ONLY
BRAUM'S
ALL KLEAR
417-890-6009
Cantina

Pedestrian Movement thru DDI



Diverging Diamond Interchange *Footprint:* 215' x 225'

I-285 at Camp Creek Parkway (Atlanta, GA)



Note pedestrian crossing "route" from structure median


Measure
Click points on the map to me
area
Length
175 ft
175’
Heading
268.19°
120
120
120
1276
Layers

14 traffic signal heads at one ramp terminal

Soscol Interchange Project: 4-NAP-29 / 221

4. PURPOSE AND NEED

The purpose of this project is to:

- Simplify and improve navigation, mobility, and traffic operations on Gilman Street between the West Frontage Road and 2nd Street through the I-80 interchange
- Reduce congestion, vehicle queues, and traffic, bicycle, and pedestrian conflicts
- Improve local and regional bicycle and pedestrian facilities through the I-80/Gilman Street interchange
- Improve safety at I-80/Gilman Street interchange

Summary / Comparison
Intersection Conflict Analysis Findings

	Intersection Conflicts					Speed	
	Ped	**Crossing**	**Merge**	**Diverge**	**Total**	**entering**	**CRF***
Traditional Crossing (2 & AWSC, Signal)	**24**	**16**	8	8	56	L-M-H	
Single-lane **Roundabout**	**8**	**0**	4	4	16	**< 20** (L)	**78-90%**
Two-lane **Roundabout**	**8**	**8**	8	8	32	**< 25** (L)	**67-90%**
RCUT (unsignalized)	**10**	**2**	6	6	24	L-M-H	**54-63%**
MUT (signalized)	**16**	**4**	6	6	32	L-M-H	**30%**
Displaced Left Turn (partial)	**22**	**14**	8	8	52	L-M-H	
Displaced Left Turn (full)	**20**	**12**	8	8	48	L-M-H	
Continuous Green T (only 3 legs)	**10**	**3**	3	3	19 (x2)	M-H	
Bowtie (major + 2 roundabout)	**16**	**4**	8	8	36	L-M-H	
Turbo **Roundabout**	**8**	**4**	6	4	22	**< 25** (L)	
T Intersection (ParClo ramp terminal)	**8**	**1**	3	2	14	L-M-H	

* % of Fatal and Injury Crashes Reduced

- 10 Minute Break

https://cwwp2.dot.ca.gov/vm/loc/d5/sr156sr25.htm

Advancing Turbo Roundabouts in the United States: Synthesis Report

FHWA Safety Program

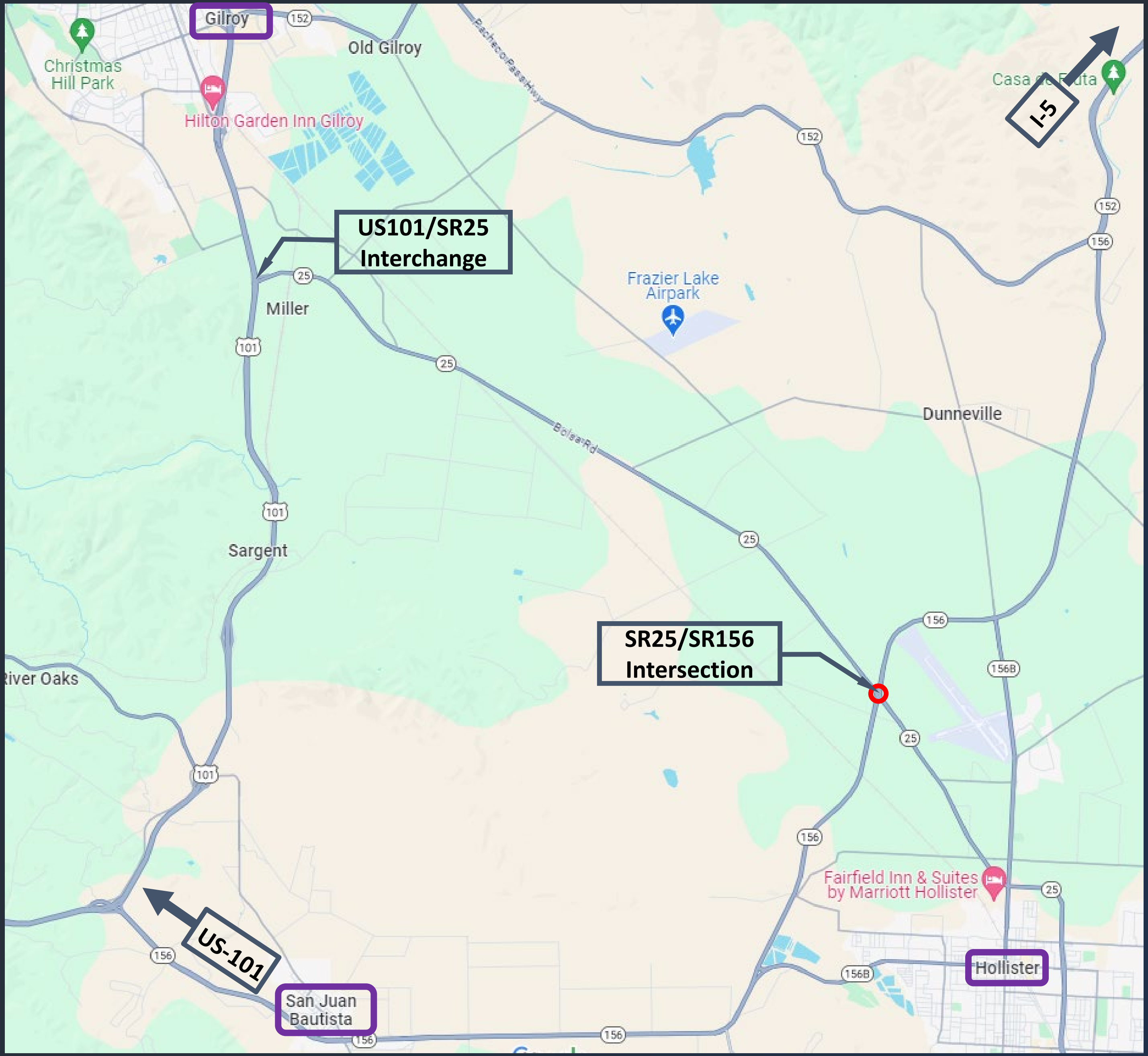
Cover images by Arcadis
Turbo Roundabouts, Netherlands

Potential Benefits of Turbo Roundabouts

An international crash-based safety evaluation suggests conversion of an intersection from yield-control, signalized, or old-style rotary to a turbo roundabout is associated with a **76% reduction in injury crash frequency**

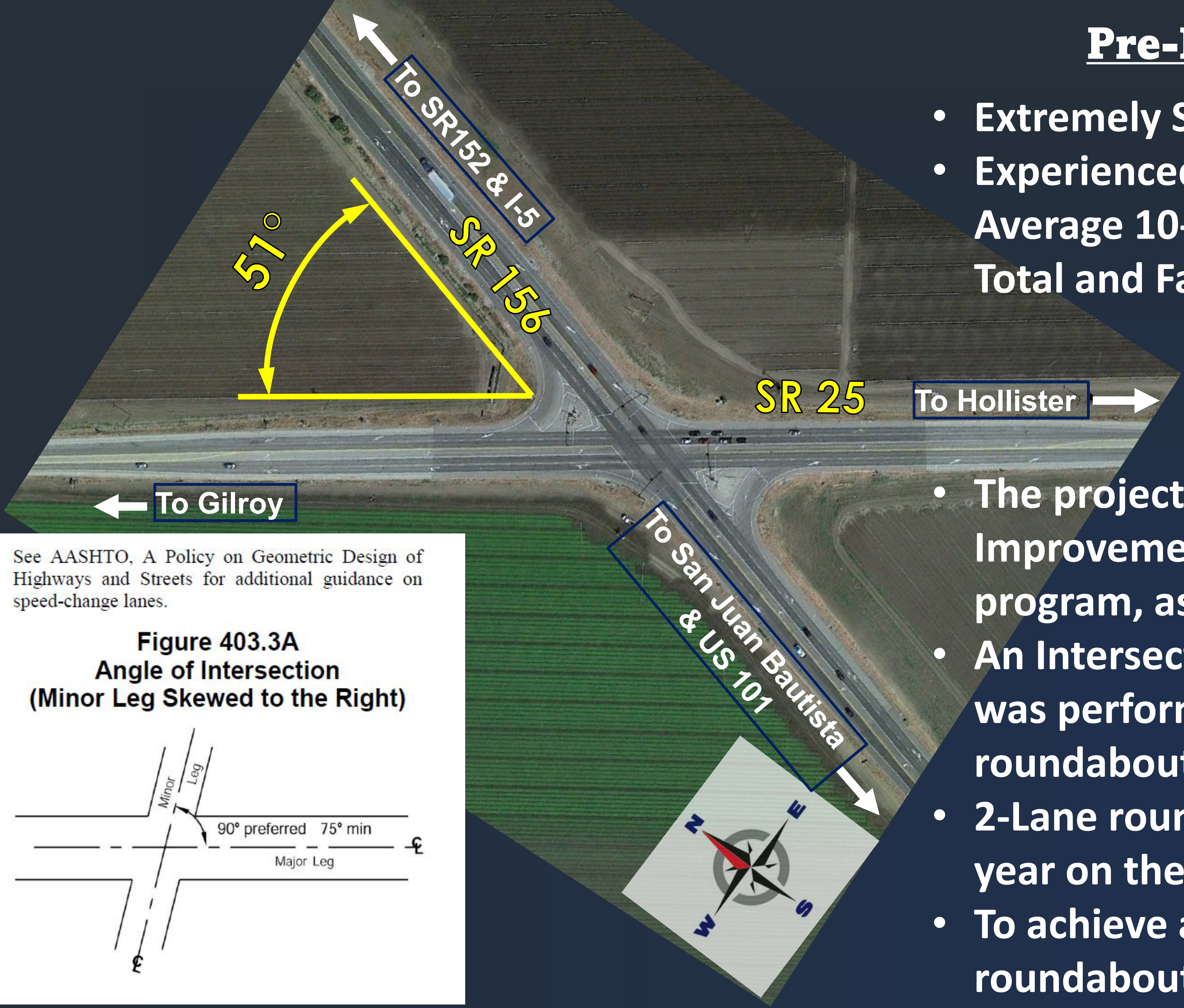
HOW ARE TURBO ROUNDABOUTS RELATED TO THE SAFE SYSTEM APPROACH?

A Case Study



Pre-Project Environment At the SR25/156

- Signalized Intersection Control
- SR156 was identified as a major trade corridor between I-5 and US101 and carries high HV traffic in the East-West direction with annual average of 12.7% [Highest = 17.7% May].
- City of Hollister has grown throughout the years and SR25 was seeing recurring AM and PM commuter traffic with annual average of 8.6% HV [Highest = 11.6% May].



See AASHTO, A Policy on Geometric Design of Highways and Streets for additional guidance on speed-change lanes.

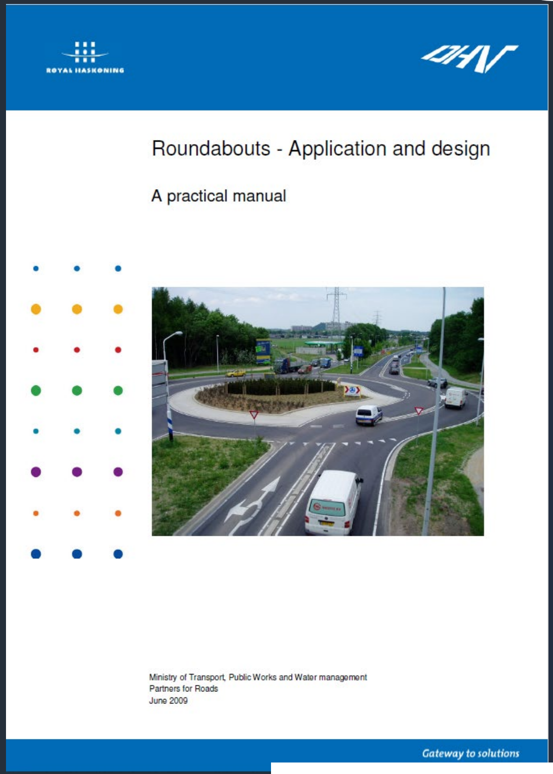
Figure 403.3A
Angle of Intersection
(Minor Leg Skewed to the Right)

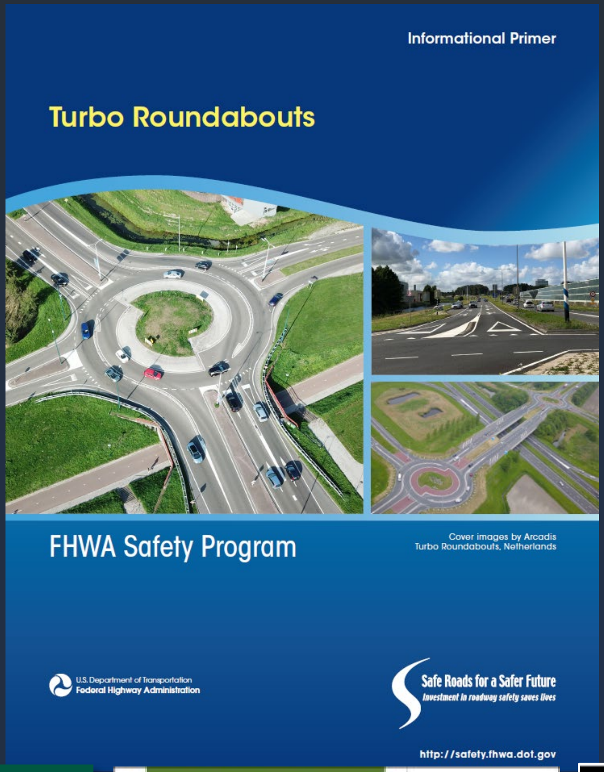
Pre-Project Intersection

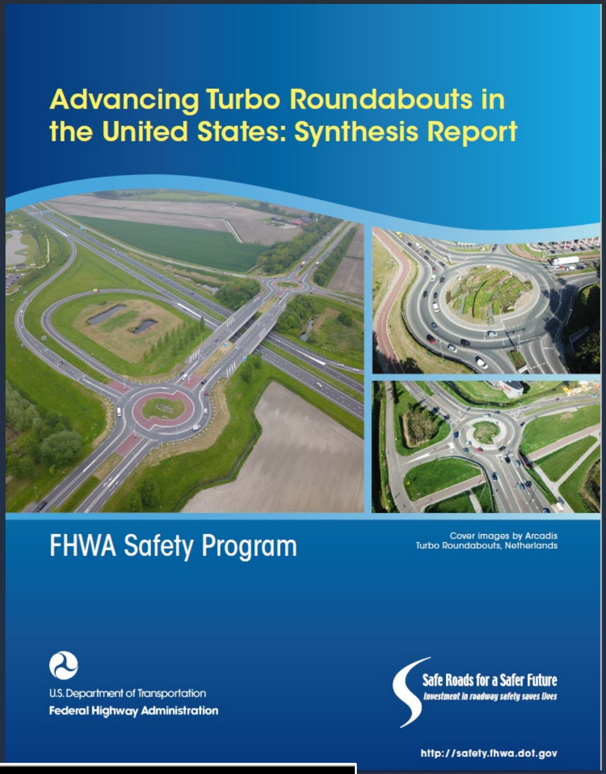
- Extremely Skewed Intersection.
- Experienced higher than Statewide Average 10-year collision rates both in Total and Fatal (2009-2018).

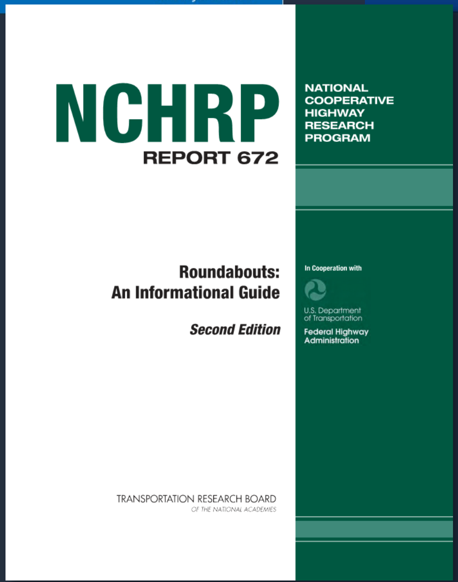
- The project was initiated as a Safety Improvement (010) through the SHOPP program, as an interim project.
- An Intersection Control Evaluation (ICE) was performed in 2017, Signal and roundabout were analyzed.
- 2-Lane roundabout will reach it's design year on the 12th year.
- To achieve a 20 years design life, a 3-lane roundabout was needed.

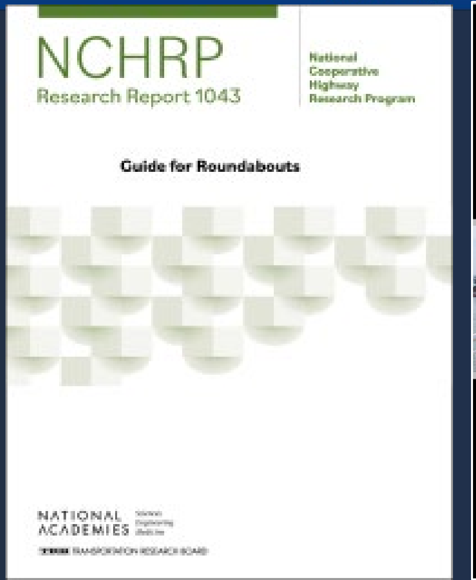
Design Manual & References

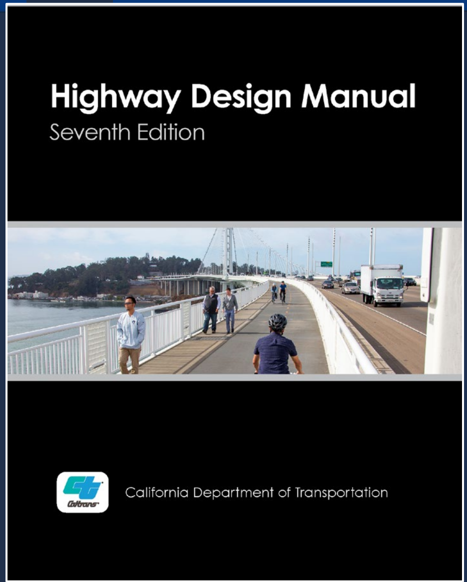






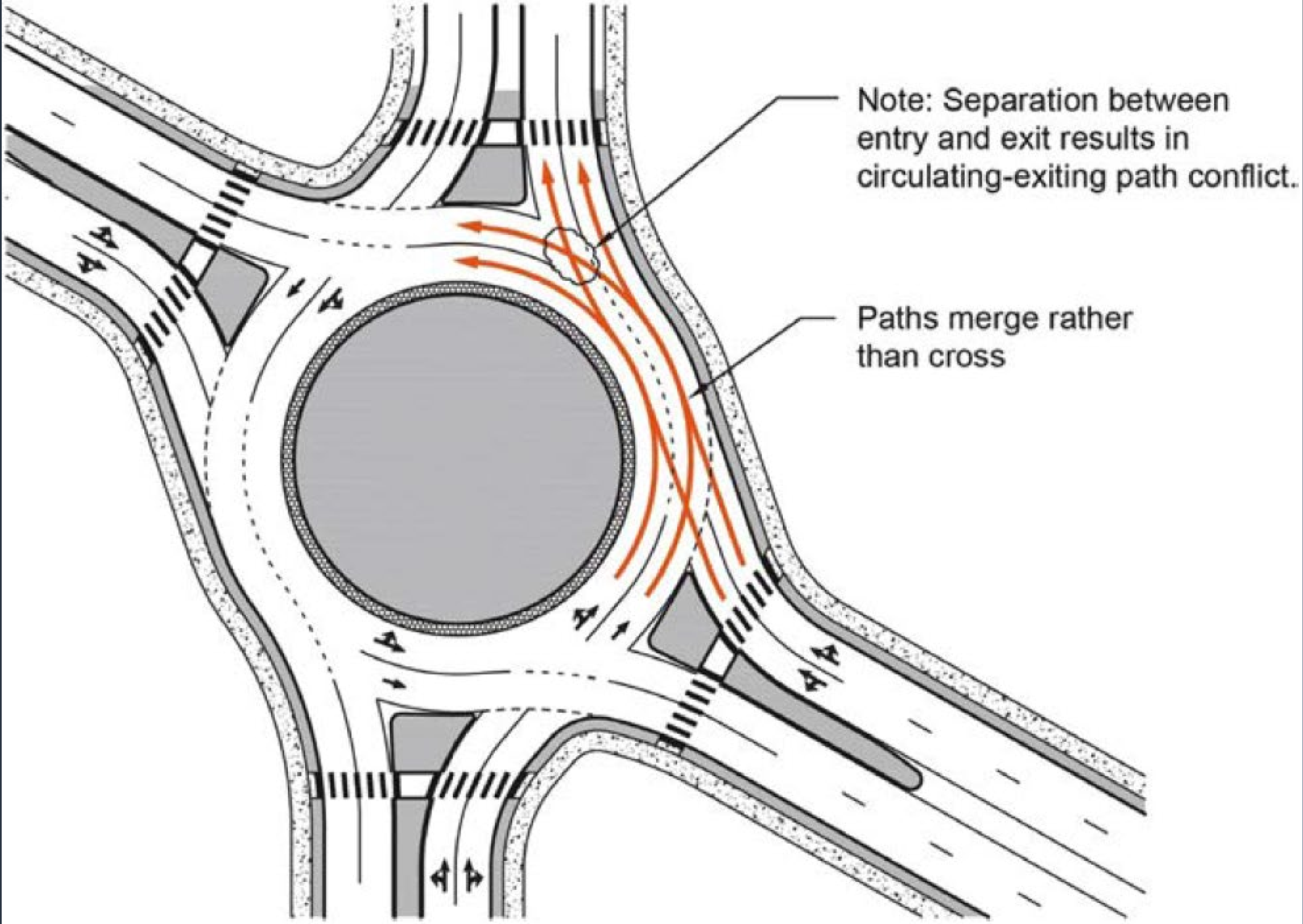






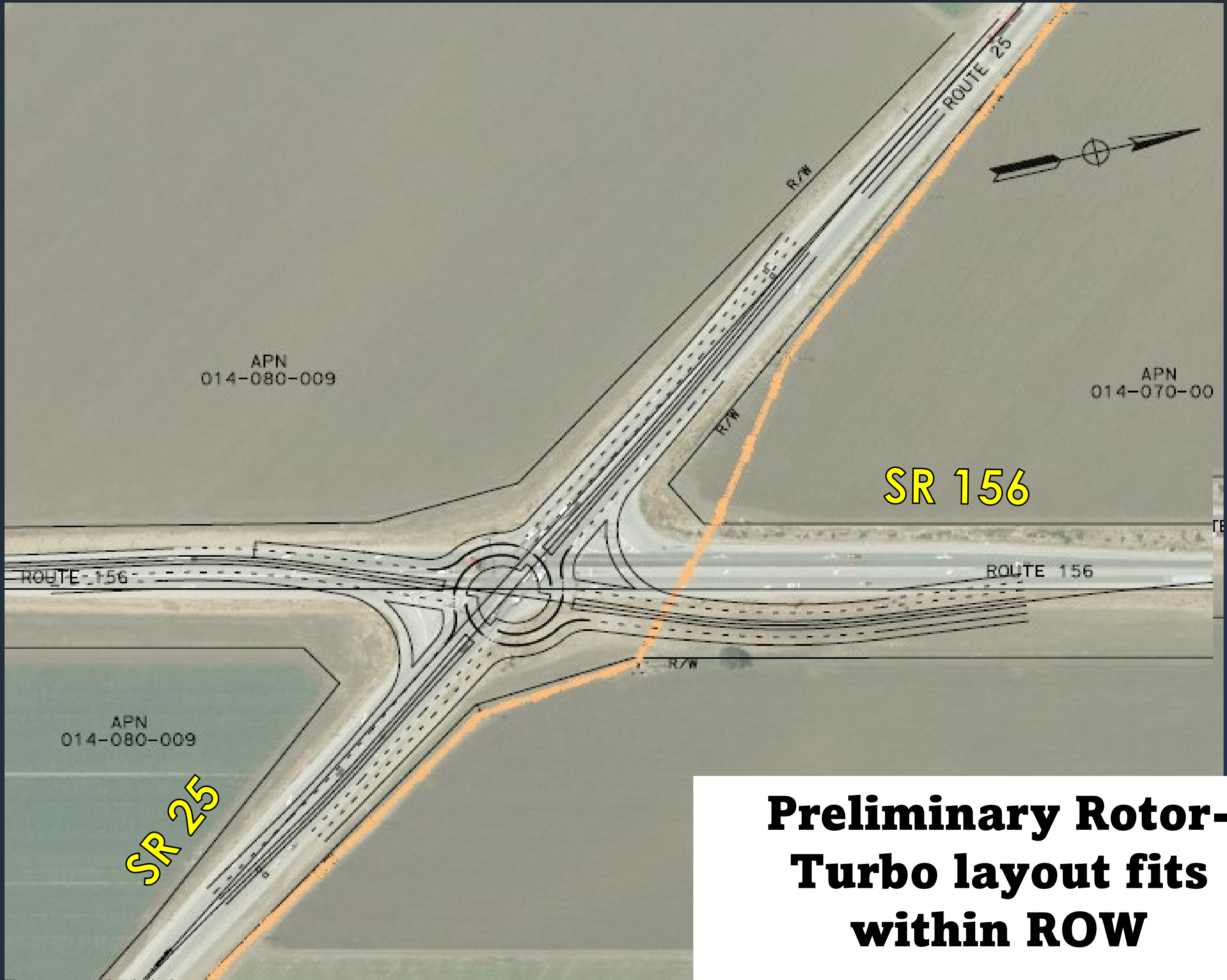
Multilane Roundabout Skew Conflict (2x2)

Exhibit 10.62. Exit-circulating conflict caused by large angle between legs.



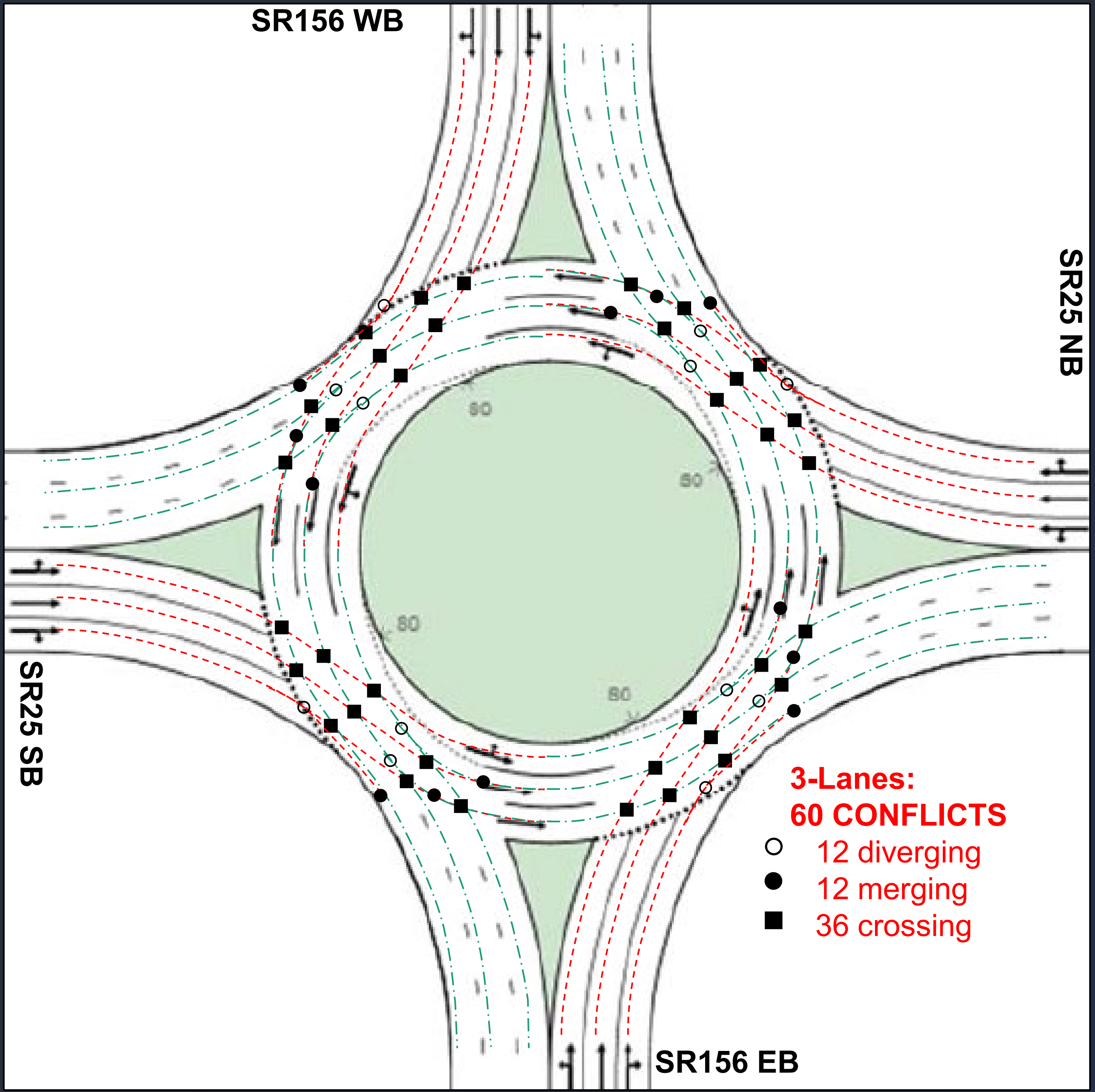
SOURCE: Adapted from Tian et al. and *NCHRP Report 672* (*27*, *2*).

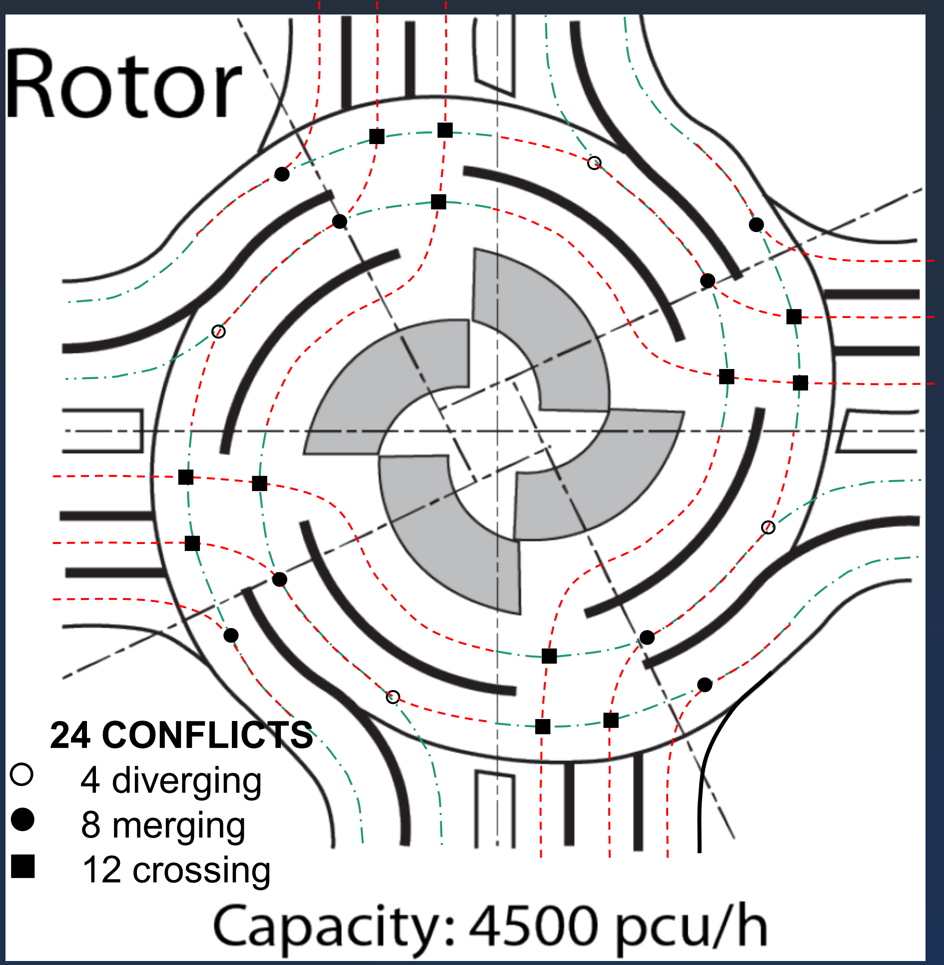
Resolving Traditional Multilane Skew Conflict



Preliminary Rotor-Turbo layout fits within ROW

Modern vs Rotor-Turbo Roundabout Conflicts

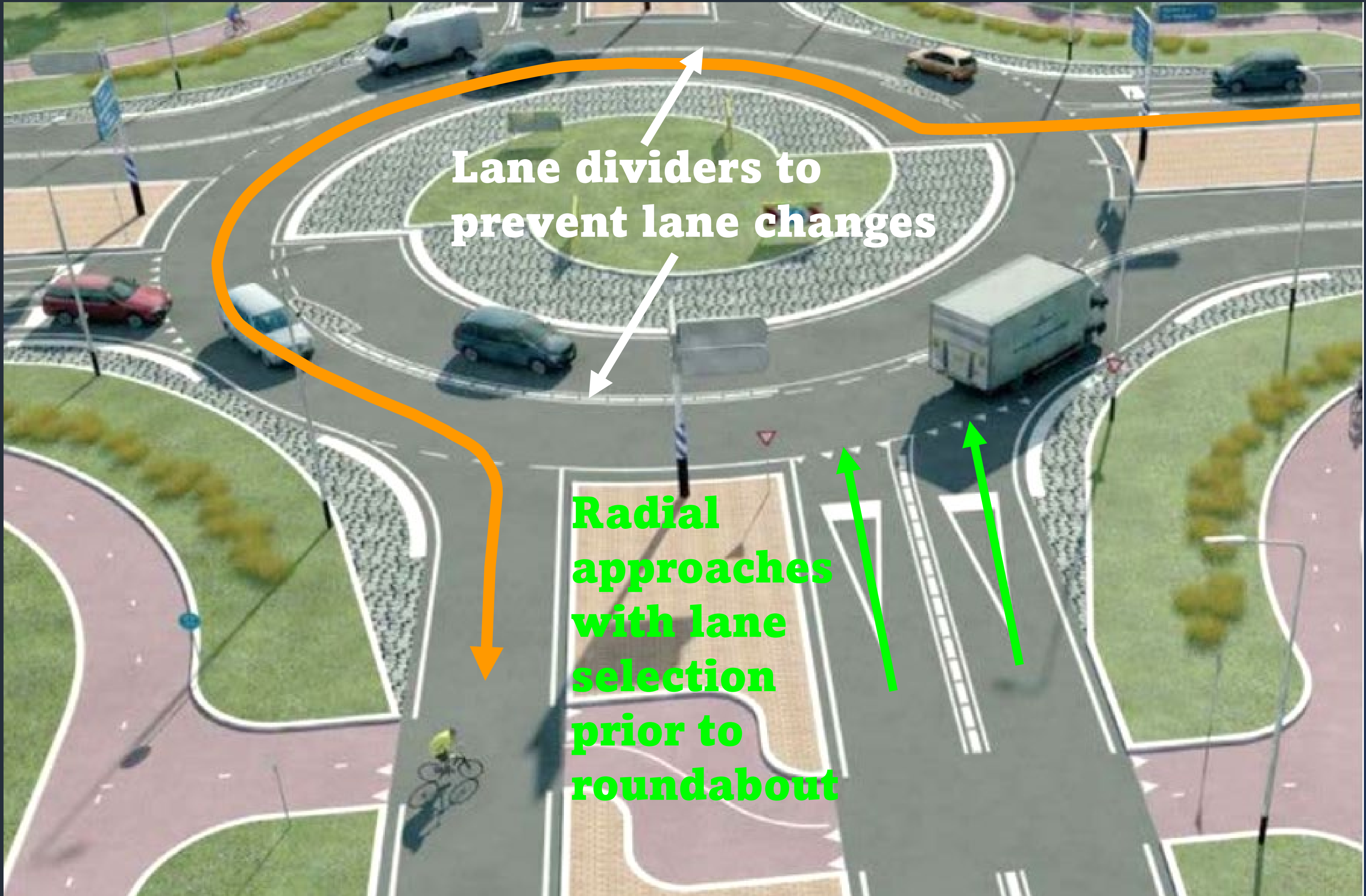




Source:

- Roundabouts – Application Design, A practical manual (Royal Haskoning, Netherlands)
- Advancing Turbo Roundabout in United States Synthesis Report (FHWA)

Turbo Roundabout Key Features



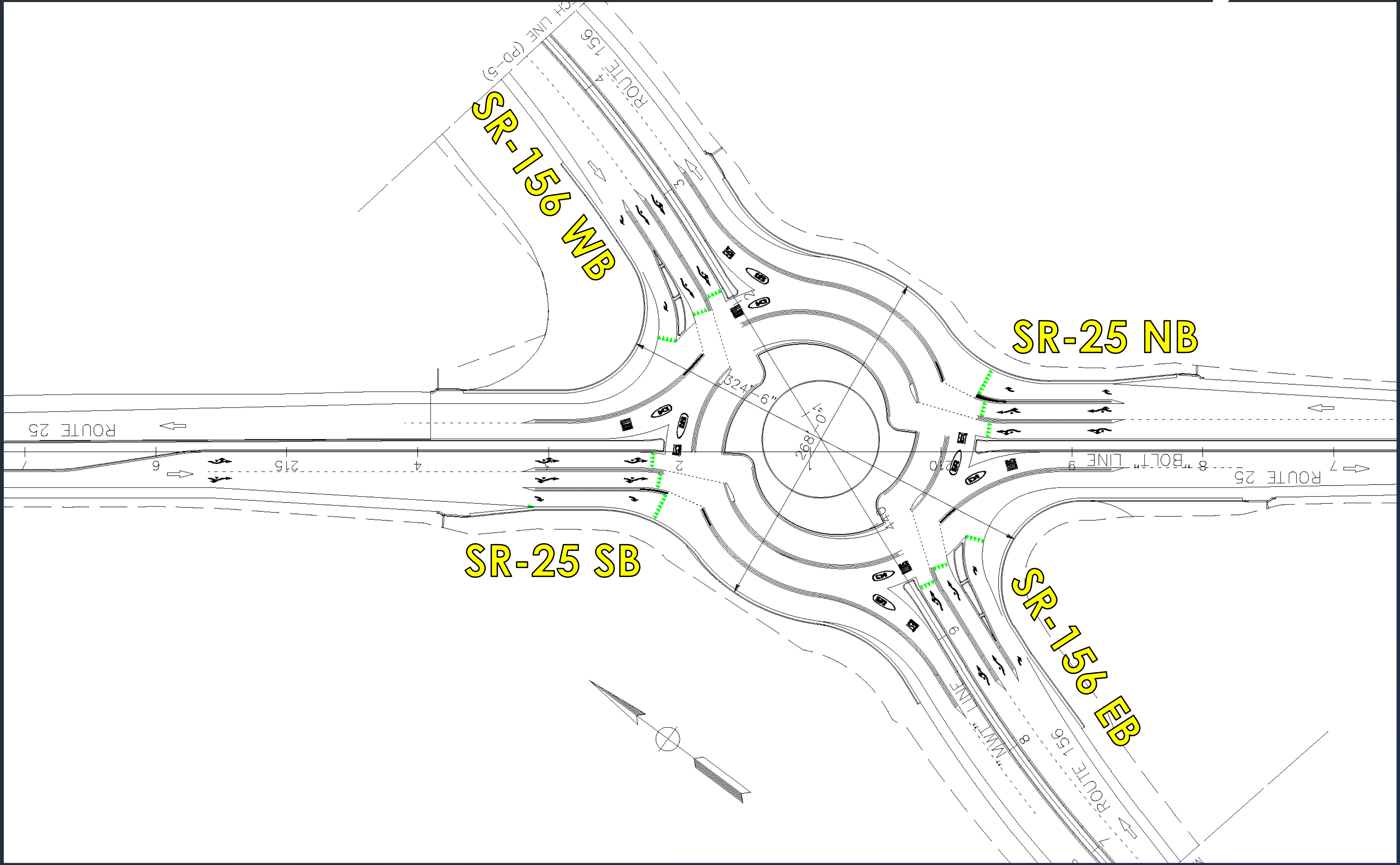
Continuous spiral paths to guide traffic from inside to outside

Traversable Lane Dividers is an essential element in the Turbo Design

Upstream Lane Selection Signing

- Advanced signage and pavement delineation is critical
- U-turns are not always feasible (but is possible)

SR25/156 Rotor-Turbo Roundabout Layout



ICDs = 324'-6" x 268'-0"

Dutch Rotor-Turbo Roundabout Capacity

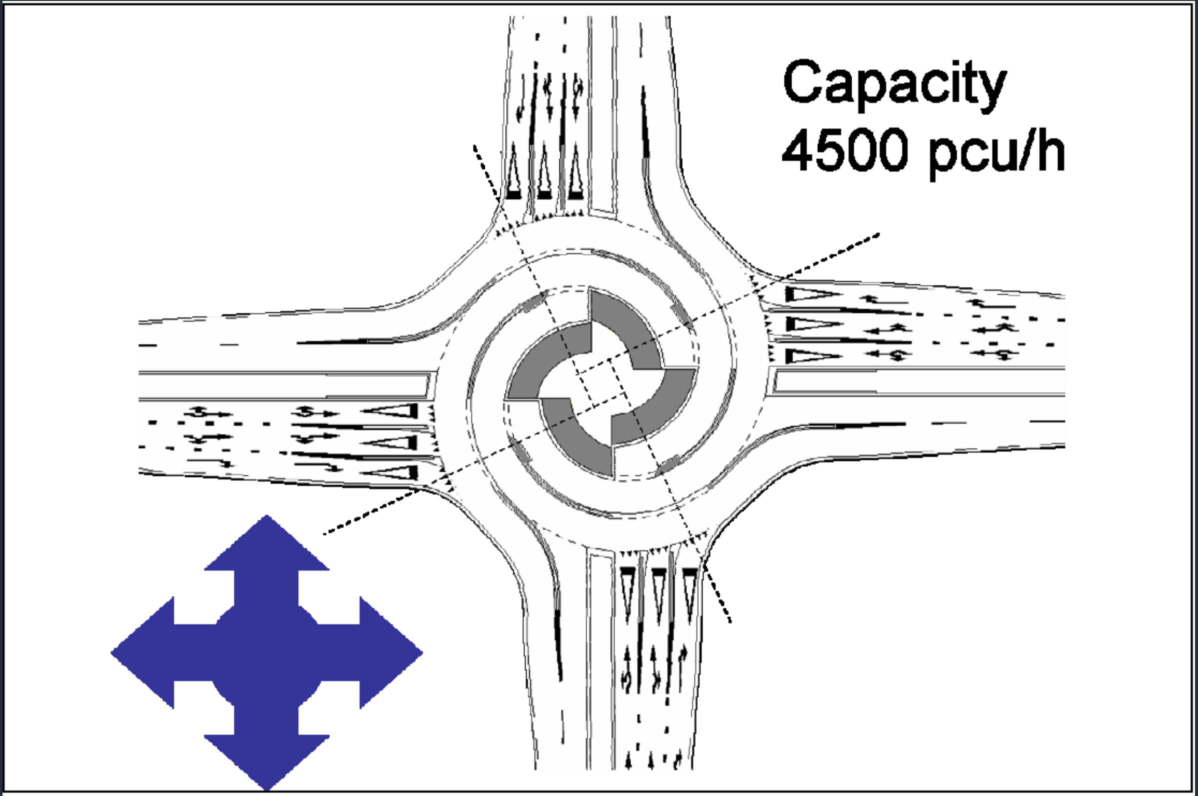


Figure 53: Rotor roundabout

Table 3. Approach capacity comparison table. Table based on Overkamp & van der Wijk, 2009.

Type of roundabout/intersection	Practice capacity[2] in peak hour (+/- 10% of AADT), all entries combined	Theoretical capacity[3] in peak hour (+/- 10% of AADT), all entries combined	Conflicting Traffic[4], $v_{predicted}$
Rotor roundabout (three entry lanes and two exit lanes)	4,500	5,000	2,500 to 2,800

AADT (2024 - 2025)

- Total = 51,793
- SR156 = 25,993, SR25 = 25,800
- Cars = 45,902 (88.6%)
- Trucks = 5,525 (10.7%)
- Buses = 235 (0.4%)
- Motorcycles = 130 (0.3%)
- Trucks, SR156 = 12.7%, SR25 = 8.6%

Typical Pk. Hr. Int. Flow

- AM Peak = 2,545 veh/h (3,103 pce/h)
- PM Peak = 3,105 veh/h (3,477 pce/h)

Vissim MicroSimulation,

AM LOS = C, Delay = 22.8 s/veh

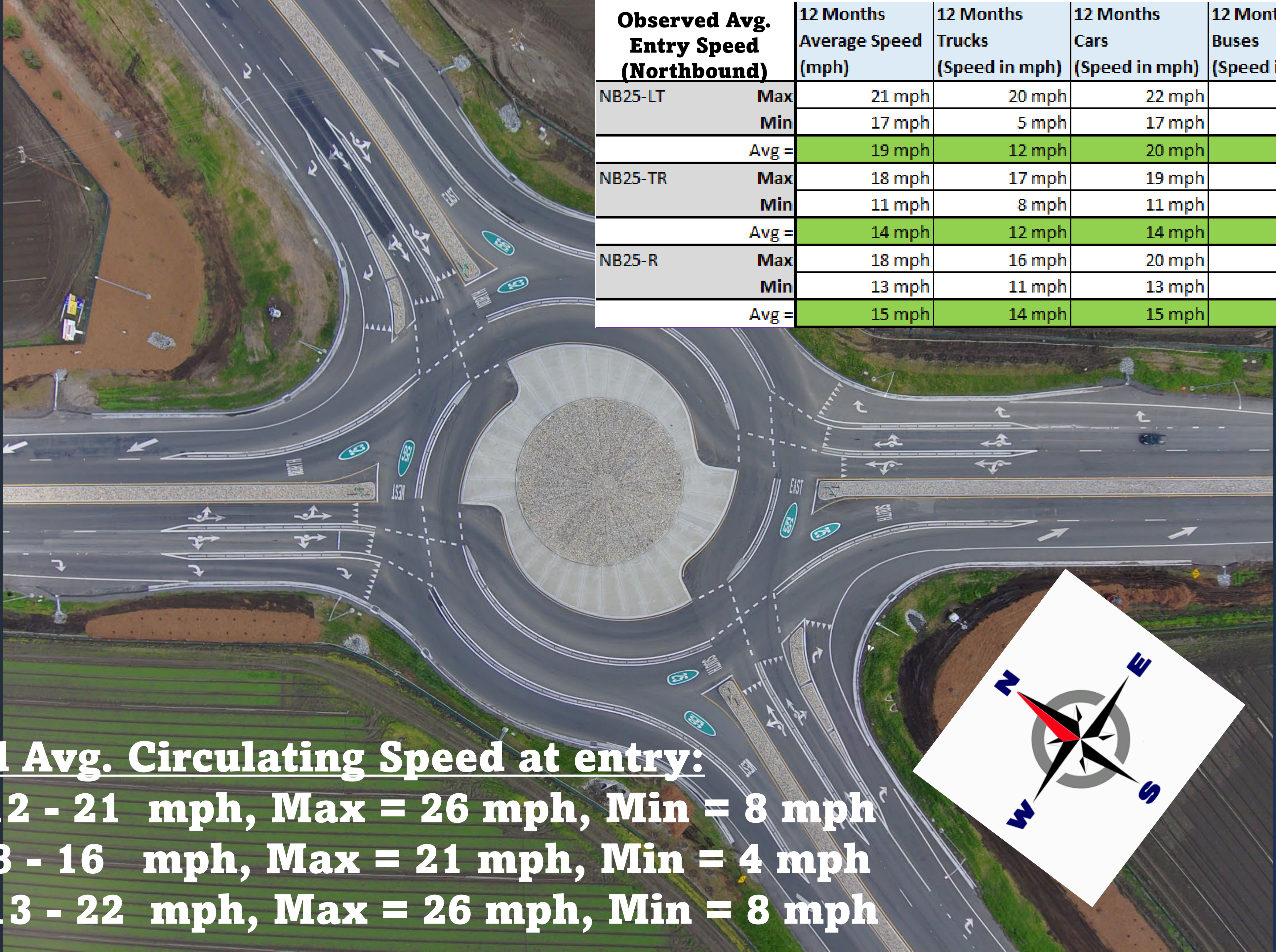
95^{th}Q = 587 ft.(WB)

PM LOS = C, Delay = 23.6s/veh

95^{th}Q = 612 ft.(EB)

We estimated Rotor-Turbo at SR25/156 has a capacity = 4,200 pce/h

Observed Avg. Entry Speed (Northbound)		12 Months Average Speed (mph)	12 Months Trucks (Speed in mph)	12 Months Cars (Speed in mph)	12 Months Buses (Speed in mph)	12 Month Motorcycles (Speed in mph)
NB25-LT	Max	21 mph	20 mph	22 mph	32 mph	26 mph
	Min	17 mph	5 mph	17 mph	5 mph	11 mph
	Avg =	19 mph	12 mph	20 mph	13 mph	20 mph
NB25-TR	Max	18 mph	17 mph	19 mph	25 mph	29 mph
	Min	11 mph	8 mph	11 mph	2 mph	6 mph
	Avg =	14 mph	12 mph	14 mph	13 mph	15 mph
NB25-R	Max	18 mph	16 mph	20 mph	21 mph	25 mph
	Min	13 mph	11 mph	13 mph	9 mph	7 mph
	Avg =	15 mph	14 mph	15 mph	15 mph	16 mph



Observed Avg. Circulating Speed at entry:

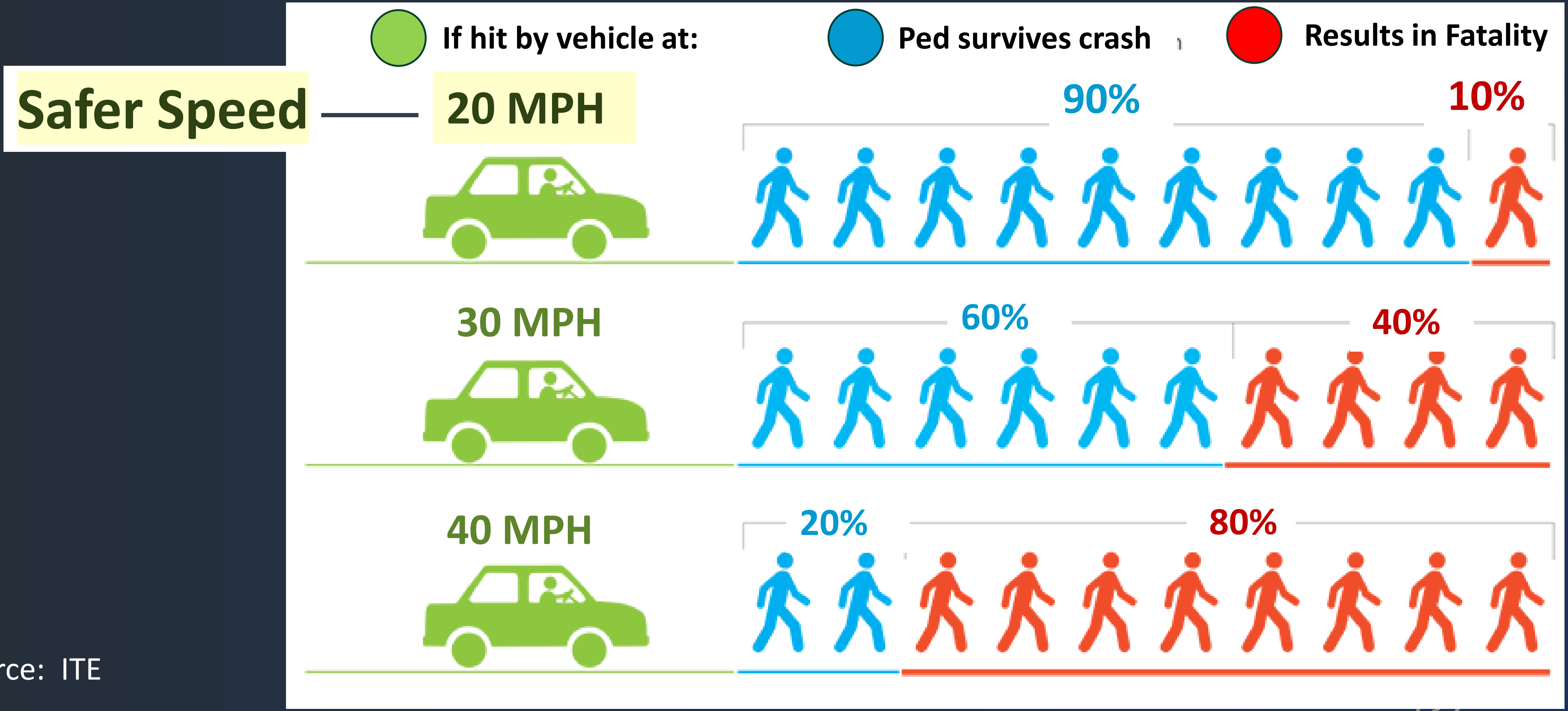
All = 12 - 21 mph, Max = 26 mph, Min = 8 mph

Truck = 8 - 16 mph, Max = 21 mph, Min = 4 mph

Car = 13 - 22 mph, Max = 26 mph, Min = 8 mph

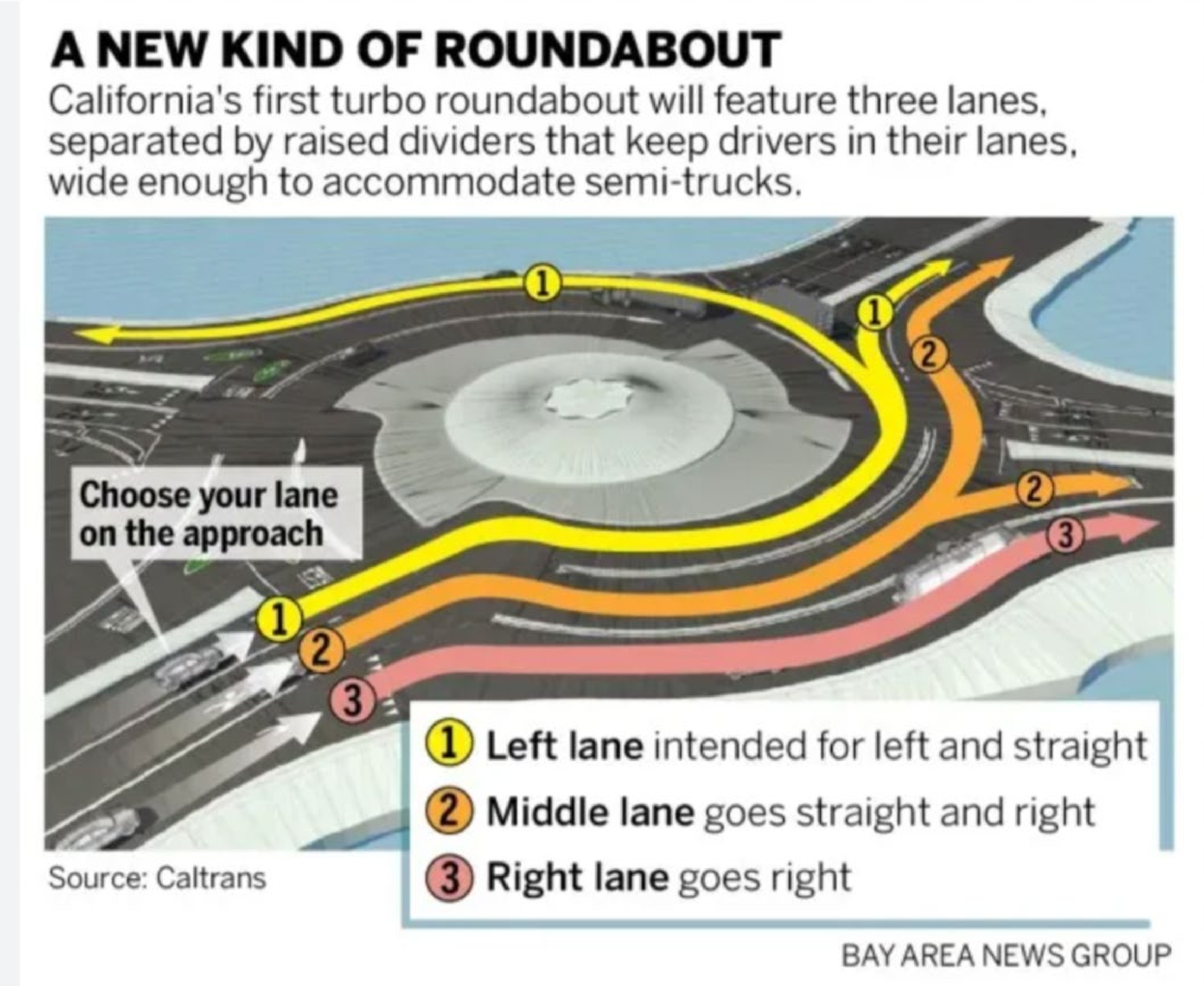
Safe System Hierarchy (Intersections)

Tier 2: Reduce Vehicle SPEED



Source: ITE

[Caltrans released PSA(Oct 2023): https://youtu.be/KHYo7Bl_zWg?si=XDgZ6zQhjc0zjMKy](https://youtu.be/KHYo7Bl_zWg?si=XDgZ6zQhjc0zjMKy)



Turbo Roundabouts:
A Review of Practices in the Czech Republic, the Netherlands, and Poland

May 2024
FHWA Global Benchmarking Program Report
RPT NO FHWA-HPL-24-015

Image Source: Google Earth

U.S. Department of Transportation
Federal Highway Administration

Key Findings and Observations

The study findings are organized into the following categories:

- **Safety Performance**
  - Deployment of turbo roundabouts shows a similar **reduction in fatal and injury crashes** to the deployment of conventional roundabouts.
  - Newly constructed turbo roundabouts or roundabouts retrofitted with turbo roundabout features have the potential to **reduce PDO crashes.**
  - The right-angle or rounded inner lane design in the center island results in **slower speeds** at the entry to the turbo roundabout.
  - Raised channelization results in **fewer conflict points.**
- **Operational Performance**
  - Turbo roundabouts facilitate **efficient movement of all users and vehicle types** including pedestrians, bicyclists, freight, transit, and motor vehicles.
- **Methods and Effectiveness of Lane Separation**
  - **Robust channelization** is essential. Raised channelization is generally more effective in keeping vehicles in their lanes than the use of flush markings. However there are certain trade-offs for such use.
  - Routine (daily and seasonal) and long-term **maintenance practices** for turbo roundabouts are widely accepted throughout the Czech Republic, Poland, and the Netherlands. Specification and design of the channelization materials and layout is done with maintenance consultation.
- **Signing and Pavement Marking Practices**
  - **Proper lane selection** on the approaches is more critical for turbo roundabouts due to the channelization (raised or flush) that discourages lane changing. This is facilitated by a series of **reinforcing signing and markings** in advance of the entry.
- **User Considerations and Experiences**
  - **Pedestrian and bicyclist** movements are not markedly different at the observed turbo roundabouts when compared to conventional roundabouts. Additionally, there are no special or different treatments present at turbo roundabouts than at other intersections.
  - **Large vehicles** such as buses and tractor-trailer trucks consistently clear turbo roundabouts with little difficulty in the countries studied. However, these vehicles are typically smaller and potentially more maneuverable than the U.S. equivalents, which may influence the transferability of this finding. Mountable truck aprons are provided within the circulatory roadway and between adjacent legs.
- **Design Guidance**
  - **A radial entry alignment** is more typical for turbo roundabouts than a tangential alignment, with no observed or reported issues with speed transition and control.
  - The **inner lane in the circulatory roadway** has two typical design options: right-angled and rounded. These designs result in differences in observed lane discipline due to their impact on sight lanes and lane selection.
- **Retrofitting Modern Conventional Roundabouts to Turbo Roundabouts**
  - **Reducing lanes and conflict points** improves safety and operations.
  - **Low-cost modifications** can be made using marking, signing, and curbing.

AFFORDABLE ROUNDABOUTS

Smaller, slower & *SAFER* for *ALL* Road Users

Overview presented by:

- Jerry Champa, Caltrans HQ
  Division of Safety Programs
  Office of Safe System Approach Integration

- Phil Rust, City of San Diego
  Engineering & Asset Management

- John Liu, Caltrans District 6
  Deputy Director for Traffic Operations & Maintenance

AFFORDABLE comes in many shapes, sizes & materials

Roundabouts can now be installed for a fraction of the funding & time required for traditional construction materials and methods

Quick Build Roundabout
Temporary or Interim Installation
(various sizes)

Mini-roundabout
48’ to 90’
(fully traversable)

Modular roundabout
pre-fabricated components
curbs and islands
(various sizes)

But can these *designs* accommodate large trucks, busses and traffic approaching at moderate to high-speeds, and yield the same results?

Why does Cost (Affordability) Matter?

Location: State Route 184 and Sunset Blvd near Arvin

Until recently, the total cost for a new single-lane roundabout was typically $6-10 Million:

- **Construction: $3 Million**
- **Project Support: $4 Million**
- **R/W: $1 Million**
- **TOTAL: $8 Million**

Cost estimates now range between $8 and $18 Million

Why does Cost (Affordability) Matter?

Cost estimates now range between $8 and $18 Million

What if $18 Million could pay for 6, 7 or even 10 Mini, Modular or Compact Roundabouts?

We could get more of the performance results we are seeking

COMPACT ROUNDABOUT along SR-25 Road Diet Corridor thru Kings Beach

All the features & benefits of a larger roundabout for all road users?

Example: Permanent High-Speed Compact Roundabout
Intersection of U.S. 395 and State Route 292 | Loon Lake, Washington

- WSDOT has made compact roundabouts part of their safety plan which has allowed them to be installed systemically because they are cheap and quick because the fit into the exiting RW.
- **This example: 12,000 ADT with high truck percentage with 65mph posted speed limit.**
- Pedestrian crossings to/from ice cream shop (located in upper left corner)
- **Constructed in 8 days; Cost = $900,000**

Highway 395 Compact roundabout

Source: WSDOT from California LTAP: Affordable Roundabouts: Smaller, Slower, Safer for All Travelers
https://youtu.be/QQmoaEQc1Ts?si=ShAW27Oxr29gYF2U

Compact Roundabout (ICD = 105’)
State Route 395 / 292 Junction
Loon Lake, WA

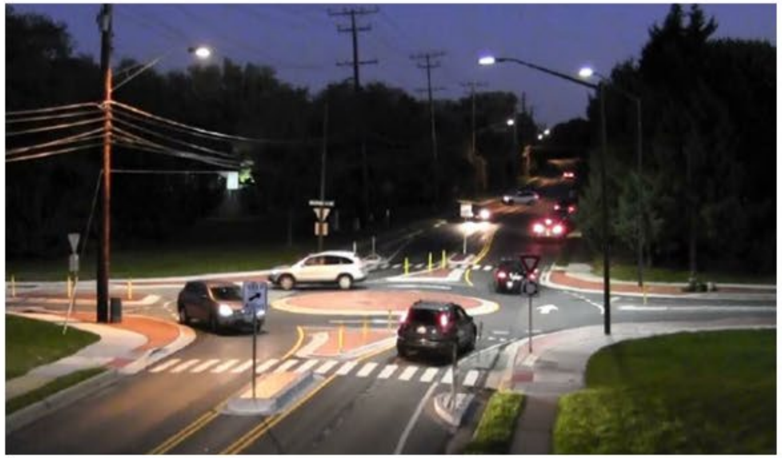
Affordable Roundabouts

Mini-roundabout

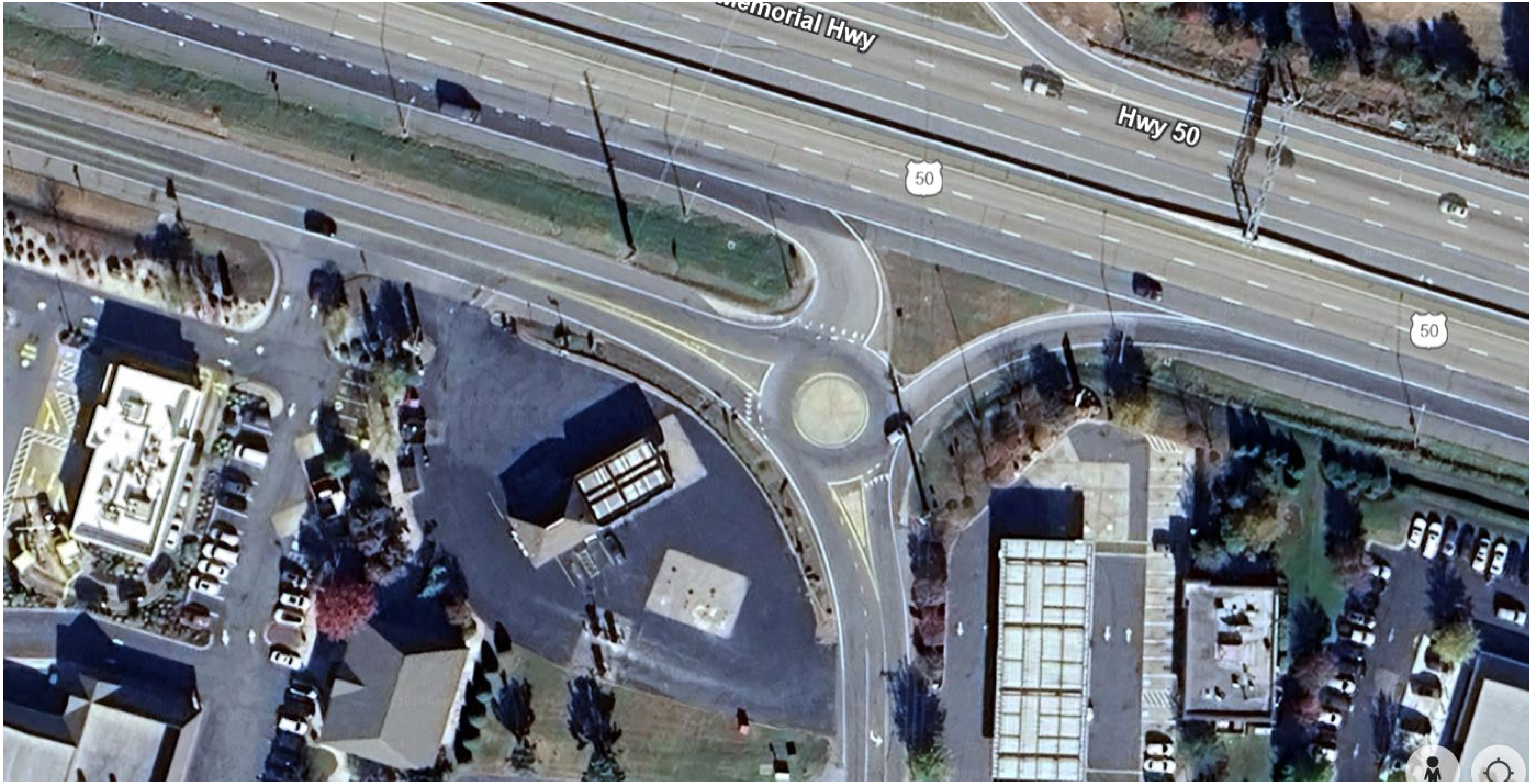
Tollgate & MacPhail
Bel Air, Maryland
Diameter: **60 feet**

Constructed in 2013 for $138,000

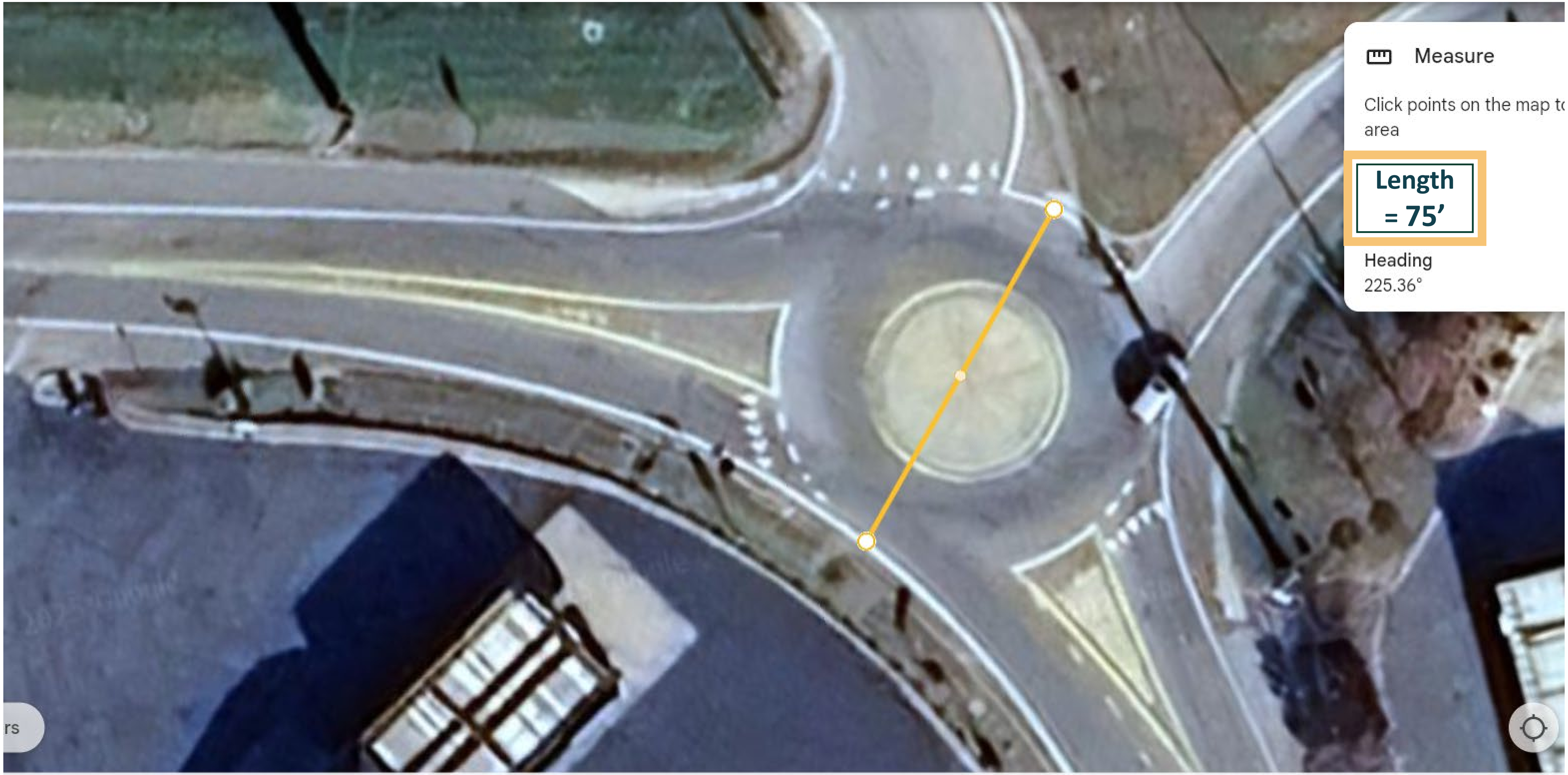
The *mini* was retrofitted within the footprint of the previous intersection configuration (with two-way minor stop control)



Mini-roundabout Case Study
< https://www.youtube.com/watch?v=3KLbr1awEbk >



Mini-roundabout at EB U.S. 50 ramp terminal for Thompson Creek Rd.
Stevensville, Maryland



Mini-roundabout at EB U.S. 50 ramp terminal for Thompson Creek Rd.
Stevensville, Maryland

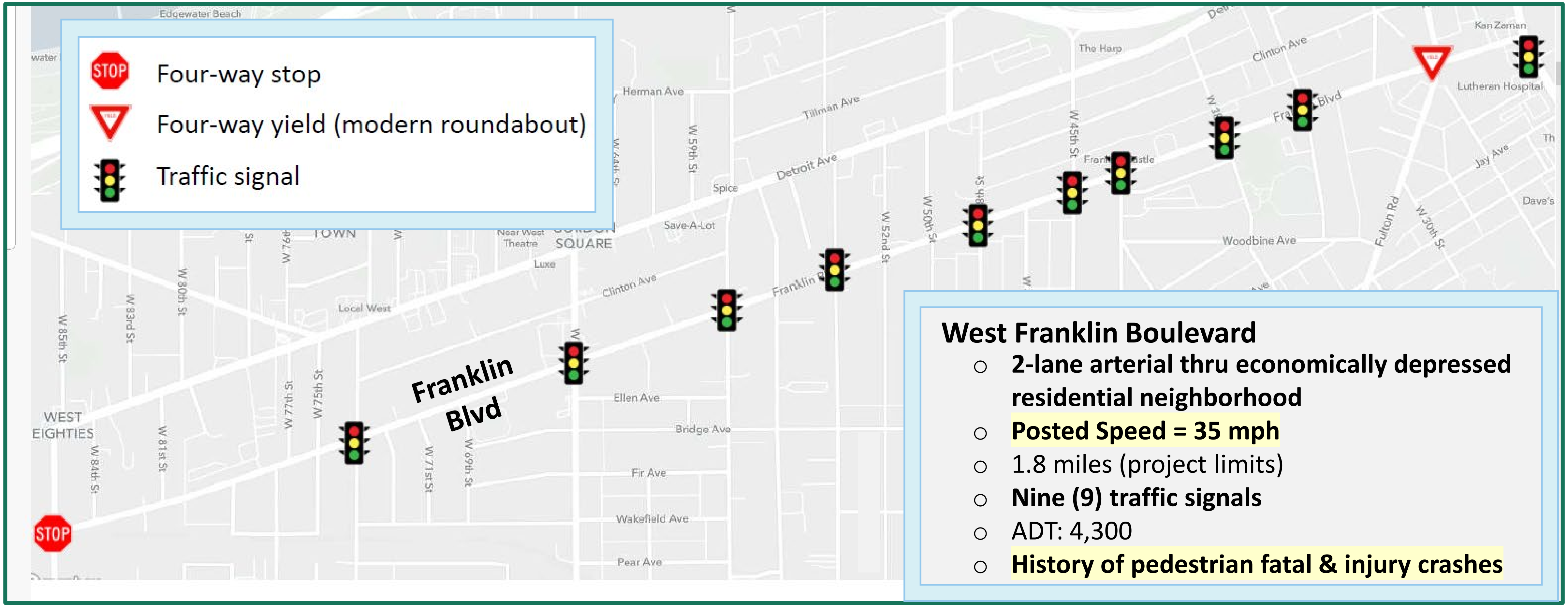
Northbound I-5 Ramp Terminal at La Novia Avenue | San Juan Capistrano, CA

West Franklin Blvd MINI-ROUNDABOUT CORRIDOR Project

City of Cleveland, Ohio

PRE-Project Conditions

Purpose & Need → Traffic Calming / Safety



West Franklin Boulevard

- **2-lane arterial thru economically depressed residential neighborhood**
- **Posted Speed = 35 mph**
- 1.8 miles (project limits)
- **Nine (9) traffic signals**
- ADT: 4,300
- **History of pedestrian fatal & injury crashes**

West Franklin Blvd MINI-ROUNDABOUT CORRIDOR Project

City of Cleveland, Ohio

POST-Project Intersection Control

West Franklin Blvd MINI-ROUNDABOUT CORRIDOR Project

Observations and Evaluation: Traffic Calming and Safety Findings

Pre-Project

Location	Direction	85th Percentile Speed (mph)
8205 Franklin Blvd.	Eastbound	32
	Westbound	36
6016 Franklin Blvd.	Eastbound	34
	Westbound	34
4610 Franklin Blvd.	Eastbound	34
	Westbound	32
3600 Franklin Blvd.	Eastbound	34
	Westbound	34
Corridor Average		**34**

Table 4: Measured Speeds, 2016 Speed Study

Post-Project

- Speeds slowed: 50th percentile ~22.5 mph; 85th percentile ~27
- Speed limit signage changed to 25 mph
- Crash records: too soon to say, but only 1 recorded roundabout-involved crash (PDO)

CITY OF CLEVELAND
Mayor Justin M. Bibb

West Franklin Blvd Mini-Roundabout Project

November 21, 2024

Construction Cost: $3,435,000

VA DOT's National Safety Award Winning *Instant* Roundabout *(2017)*

Location: Edgewater & Poland Road in South Riding, VA

- **Broadside crash pattern: 89% of Injury Crashes Reduced**
- **Recurrent peak hour congestion eliminated immediately**

Interim **Roundabout installed in 6 days**

Permanent **Roundabout constructed in 2019**

Source: FHWA INNOVATOR, Issue 66, 2018 – "Getting a Jump Start on Safer Intersections

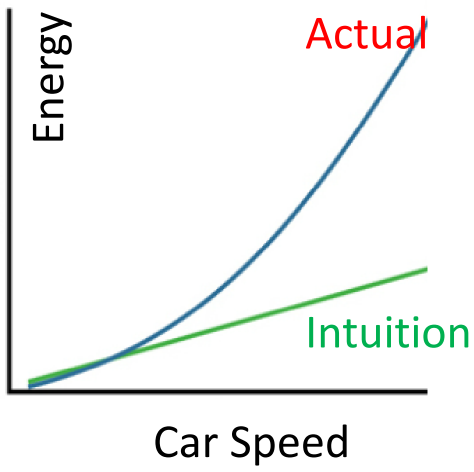
https://www.fhwa.dot.gov/innovation/innovator/issue66/issue66.cfm

MODULAR: Recycled plastic components for *curbed islands*

Components shipped to, and assembled at the project site

Safe Systems

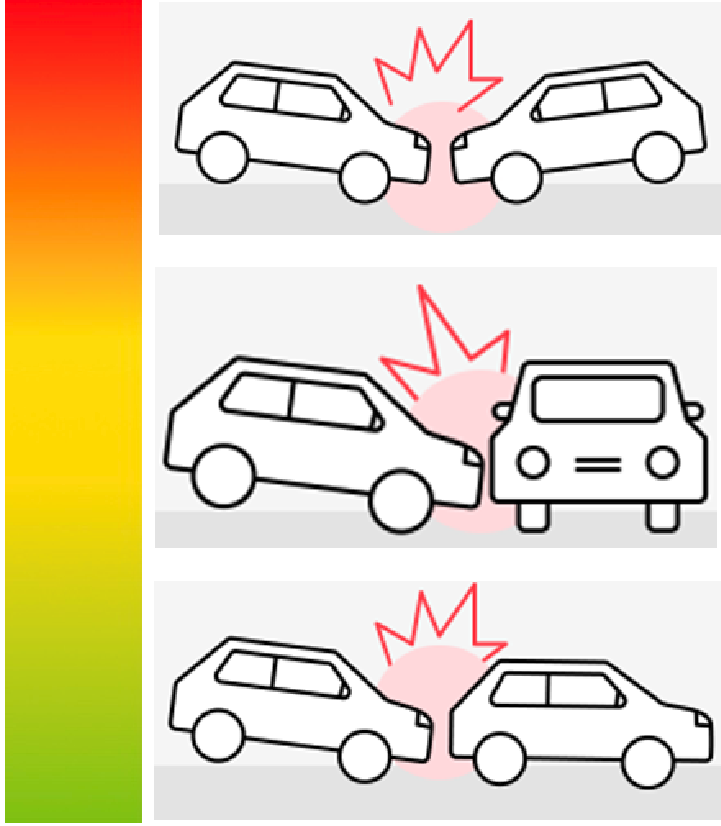
A) People Are Vulnerable
Reduce Crash Energy



1) Remove severe conflicts:
no head on, no broadside

2) Survivable speed using physics


Photo credit Patrick McGrady

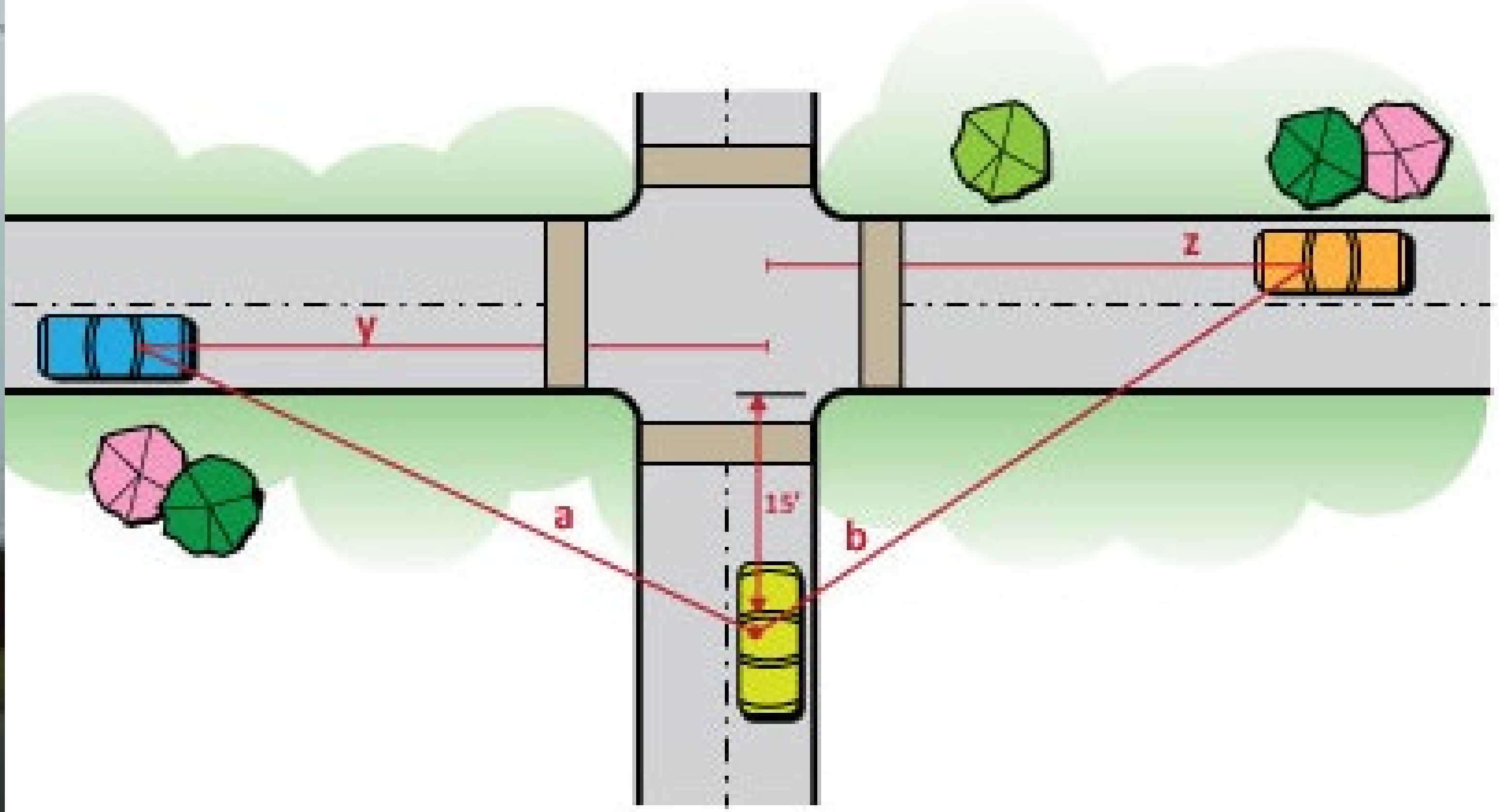


B) People Make Mistakes
Add Redundancy

3) Direct interaction, other person is the backup

4) Simplify conflicts: one direction at a time, spaced out, none from behind

Can a Traffic Signal qualify?



80ft Inscribed Diameter
AWSC w/2 bypass lanes
No pedestrian ramps to rebuild
In-street vertical signs
Right-only bike lanes/feedback

50mph approach
Jigsaw puzzle
Fresh pavement
11-12 nights
Variety of anchors

80ft Inscribed Diameter
AWSC w/4 through lanes
Islands are painted
4 short days
Side street refuges
Fence setback/vertical

Interchangeable curbs
Sheet flow drainage
Design year capacity
Bus moved their stop
Elderly pedestrians

Modular Curb

L = 4 ft

City of San Diego Modular Roundabout (Quick Build) Installation

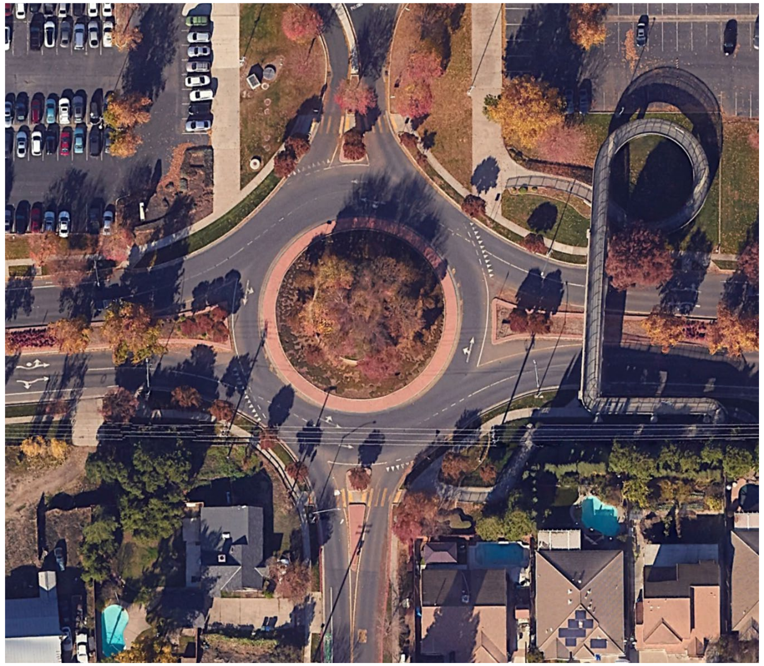
CITY OF MODESTO CALIFORNIA

QUICK BUILD ROUNDABOUTS

MICHAEL SACUSKIE, ASSISTANT CITY ENGINEER

CITY OF MODESTO CALIFORNIA

"Roundabout"



Sylvan and Millbrook

City Of Modesto Roundabout Inventory

Number	Roundabout Location	Inscribed Circle Diameter	Central Island Diameter	Raised Central Island	Truck Apron Width	# Of Circulating Lanes	Bypass Lanes (Y/N)	Circulating Road Width	Circulating Road Width Max	Entry Width Min.	Entry Width Max	Date Built
1	Vintage/Bluebird	74.5/ 80	37	10.5	13.25	1	N	16.25	18	12	13.7	2019
2	Vintage/Landmark	71	40	24	8	1	N	13.35	13.8	10	11.3	2018
3	Founders/Limelight	116	81	61	10	1	N	17.4	18.2	15.75	19.7	2021
4	Grecian/Lifescapes	90.5	61.5	47	7.25	1	N	13.65	15.25	13.1	14	2000
5	Claratina/Coffee	114	81	65	8	1	Y	16.25	16.5	14	14.8	2020
6	Bowen/Phelps	89	56	41.5	7.25	1	N	15	16.6	12	13.5	2003
7	Bowen/Fremont	72	35	14	10.5	1	N	14.75	15.5	10.5	13.6	2003
8	F/4th (MJC West Campus)	104	71	54	8.5	1	N	16	16.4	12	17	2016
9	student center/6th	133.5	100.5	80	10.25	1	N	16.5	16.75	16.5	16.75	2017
10	B/6th	113	81	64.5	8.25	1	N	15.75	16.5	15.75	16.75	2016
11	La Loma/G	120	96/80	75/60.5	10.5/9.75	1	N	16.75	18.85	13.3	14.25	<1998
12	La Loma/Buena Vista	87	51	36	7.5	1	N	18	18.25	12.35	15.35	2021
13	La Loma/Santa Ana	89	52	36.5	7.75	1	N	17.2	19.3	11.6	15.4	2021
14	Litt Road/Soccer Complex	144/128	94	70	12	1	N	16.4	16.6	16.5	20	2013
15	Sylvan/Roselle	187	129	106	11.5	2	N	31	31.6	24.9	26	2008
16	Sylvan/Millbrook	182	120	106	7	2/1	N	17.5	31.7	14.3	24.3	2008
17	Sylvan/Litt	191	118.5	98	10.25	2/1	N	15.6	33	16.4	33.2	2013
18	Hillgen/Wood Sorrel	91/88	52.5	33.5	9.5	1	N	15.5	16	12.5	18.3	2010
19	La Force/Hillglen	98/90	53	36.5	8.25	1	N	17.4	18	13	14.6	2010
20	Kodiak/Lincoln oak	90	50	36	7	1	N	18.9	19.7	12.7	14.3	2015
21	Kodiak/Roselle	173	106.5	90	8.25	2/1	N	23	31.5	16	26.2	2017
22	Floyd/Roselle	173	110.5	92.5	9	2	N	31.5	31.8	23.2	23.9	2008
23	Encina/Conejo	89	51	35.5	7.75	1	N	16.8	17	15.2	16.2	2004
24	Chandon/Calero	92/96.5	61	47.5	6.75	1	N	13.3	14.25	12.5	13.5	2001
25	Merle/Maid Mariane	92.5	54.5	38	8.25	1	N	17	17.5	14.8	15.2	2008
26	Sharon/Maid Mariane	87	52	35	8.5	1	N	15.3	15.6	13.7	15.5	2008
27	Paradise/Chicago	112' to 120'				1	N					2024
28	Washington/Vine	102'				1	N					2024
29	Paradise/Tuolumne					1	Y					2026
30	Tuolumne/Roselawn					1	N					2026
31	9th/Carver					1	N					2026
32	9th/Tully					1	N					2026
33	9th/Needham					1	N					2026
34	College/Bowen					1	N					2027
35	Kodiak/Orchard	90	55	41	7	1	N	17.3	17.45	11.9	15	2020
36	Kodiak/Temescal	84	53	39	7	1	N	15	15.3	11.4	13	2019

LEGEND

- (red) modern roundabout
- (yellow) Iterim painted, modern roundabout
- (green) Currently in the design or construction phase

CITY OF MODESTO CALIFORNIA

City Of Modesto Traffic Circle Inventory

Number	Roundabout Location	Inscribed Circle Diameter	Central Island Diameter	Raised Central Island	Truck Apron Width	# Of Circulating Lanes	Bypass Lanes (Y/N)	Circulating Road Width	Circulating Road Width Max	Entry Width Min.	Entry Width Max	Date Built
37	Tradition/Princeville	67	16	N/A	N/A	1	N	25.5	25.5	13.4	14	1998
38	Flushing Meadows/Paramount	67.5/71	15	N/A	N/A	1	N	26.25	28	13.6	14	2001
39	Fallen Oak/Fetereia	68/72.5	15	N/A	N/A	1	N	26.5	28.75	13.3	13.75	2001
40	Fallen Oak/Southgrove	65/68	15	N/A	N/A	1	N	25	26.5	13.5	15	1998
41	Fallen Oak/Bear River	67	15	N/A	N/A	1	N	26	26	13.5	14	1998
42	Lauding/Breezeway	51/88	16	N/A	N/A	1	N	17.5	36	12	15.9	2001
43	Ridgemont/Ashbrook	65.5	16	N/A	N/A	1	N	24.75	24.75	13.4	13.7	2001
44	Will Scarlet/Maid Mariane	65.5/73.5	16	N/A	N/A	1	N	24.75	28.75	15	18	2001
45	Cummins	98	50.5	N/A	N/A	1	N	23.5	24	N/A	N/A	<1998
46	Harvard/Myrtle	102	42.5 avg.	N/A	N/A	1	N	35.3	35.8	N/A	N/A	<1985
47	Scenic Oaks	106	60.5	47	6.75	1	N	22.75	22.75	N/A	N/A	2009

LEGEND

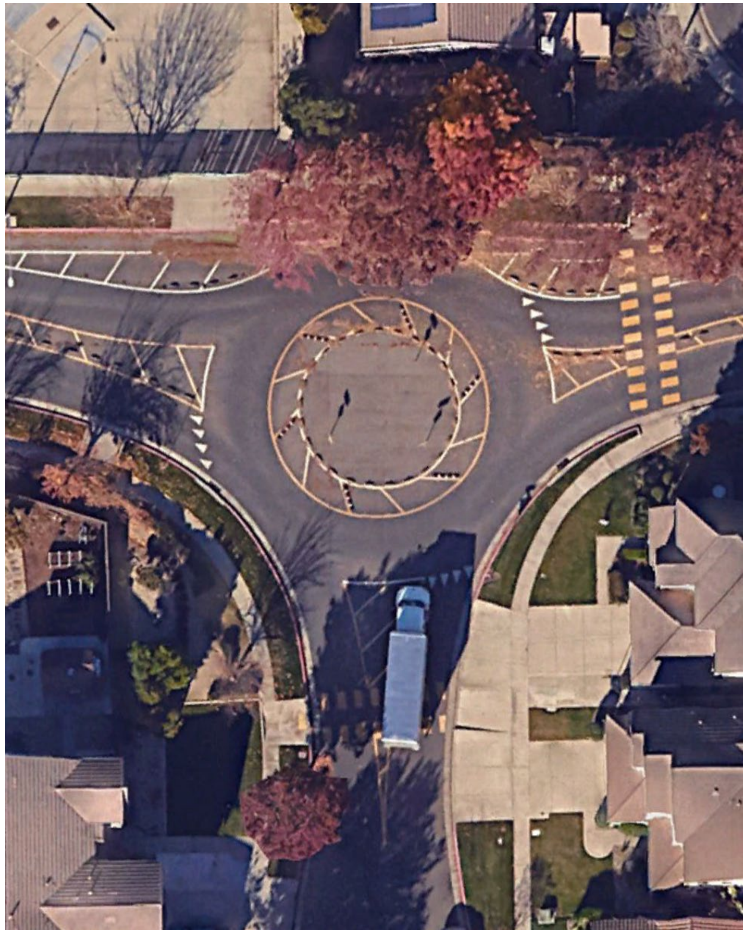
- unique traffic circles (blue)
- Traditional traffic circle, minimum striping (grey)

"Traffic Circle"

- Low cost
- Compact Size
- Traffic calming
- Improve traffic safety
- Fits within right of way
- Gateway Opportunities

Maid Mariane and Will Scarlet

Kodiak Drive and Temescal Drive
(Quick Build Roundabout)



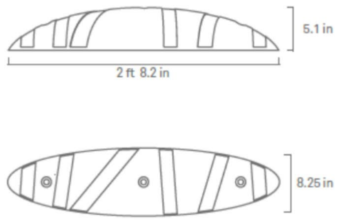
Zebra and Rubber Speed Bump Locations

Kodiak Drive and Temescal Drive, Modesto CA

Kodiak Drive and Temescal Drive
(Quick Build Roundabout)

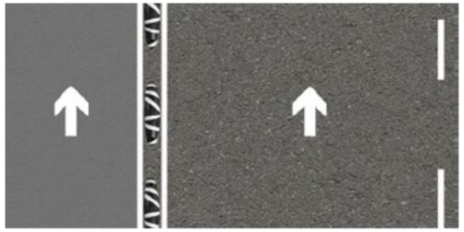
https://www.zicla.com/en/zebra-cycle-lane-separator/

Zebra 13



Weight	19 lb
Length	2 ft 8.2 in
Height	5.1 in
Width	8.25 in
Color	Black

ZICLA®



Parallel

(20) White Zebra's

(88) Yellow Zebra's

Traffic Safety Store

https://www.trafficsafetystore.com/

6' Heavy-Duty Rubber Speed Bump

12" wide and 2.25" tall
Approx. 55 lbs
no channels

$128.50 ~~$149.95~~ each	$128.50 ~~$138.25~~ each	$128.50 each
Quantity 1-14	Quantity 15-49	Quantity 50+

Mounting Hardware Choices:

Quantity: (14) 6' Long Heavy-Duty Rubber Speed Bump

Kodiak Drive and Temescal Drive
(Maintenance Considerations)

Kodiak Drive and Orchard Park Way

(Quick Build Roundabouts)

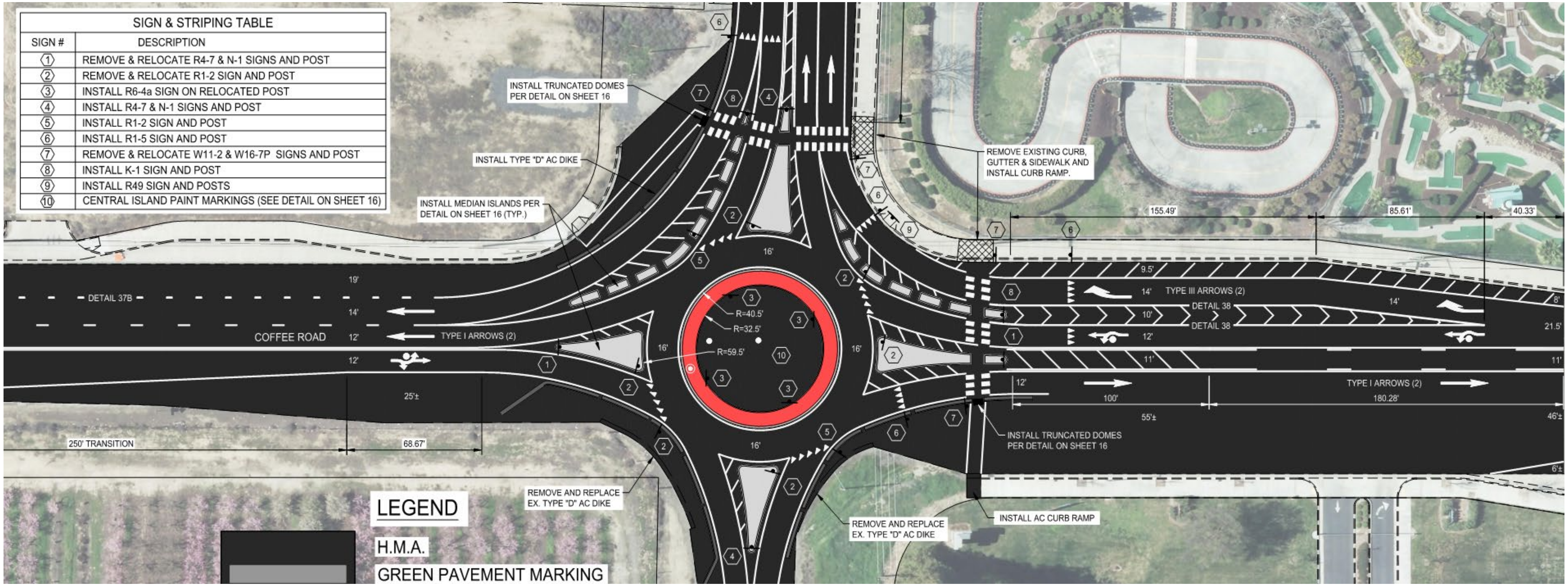
Kodiak Drive and Orchard Park Way
(Quick Build Roundabouts)

Coffee Road and Claratina Avenue

(Quicker Build Roundabouts)

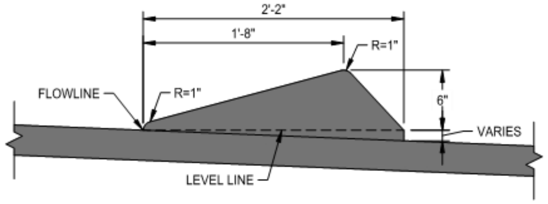
Coffee Road and Claratina Avenue

(Quicker Build Roundabouts)

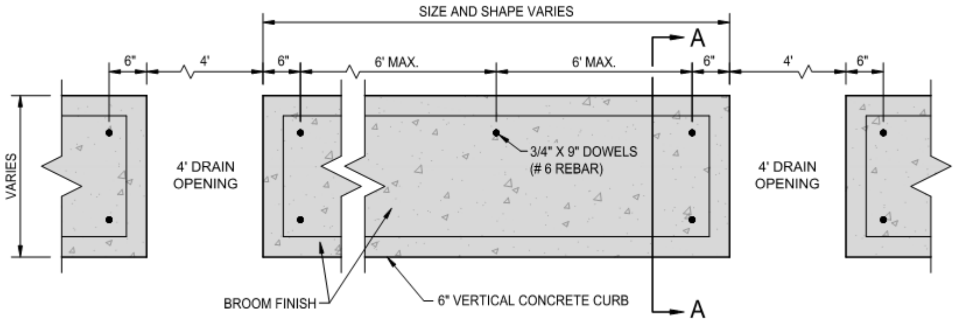


Coffee Road and Claratina Avenue

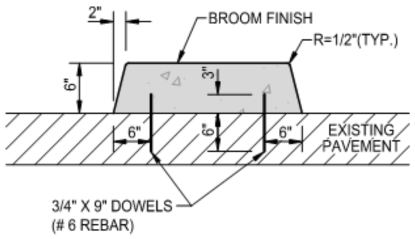
(Quicker Build Roundabout Details)



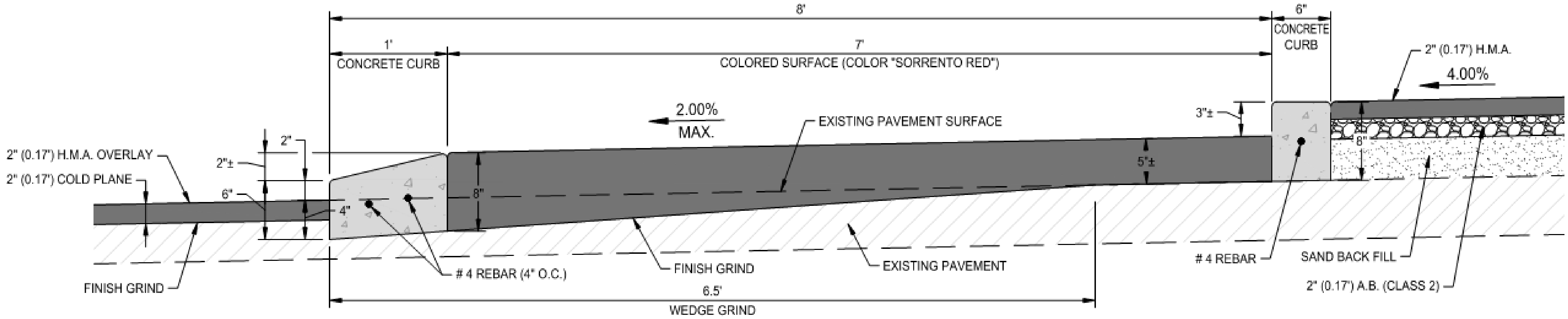
TYPE "D" AC DIKE



PLAN

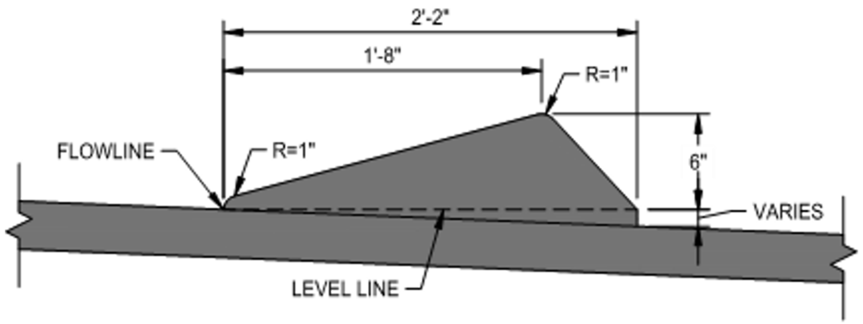


SECTION A-A



TRUCK APRON DETAIL

Coffee Road and Claratina Avenue
(Outside Roundabout Curb)



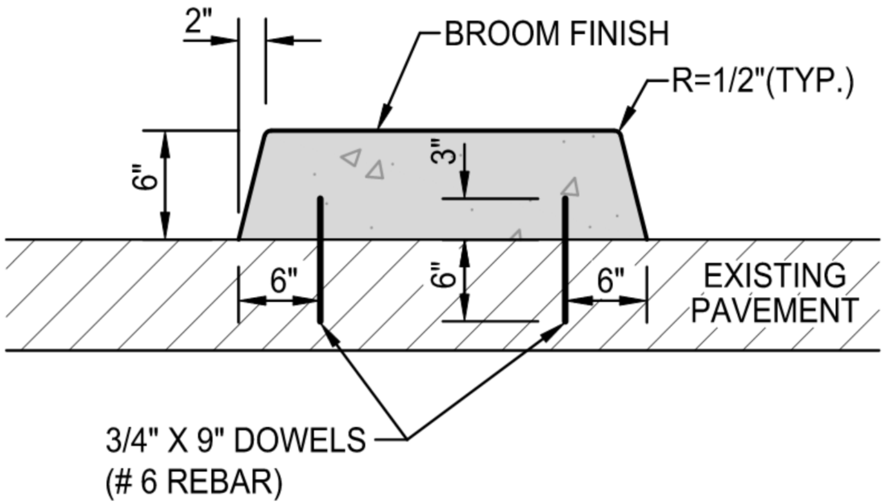
TYPE "D" AC DIKE

Coffee Road and Claratina Avenue

(Splitter Island and Median Curb)

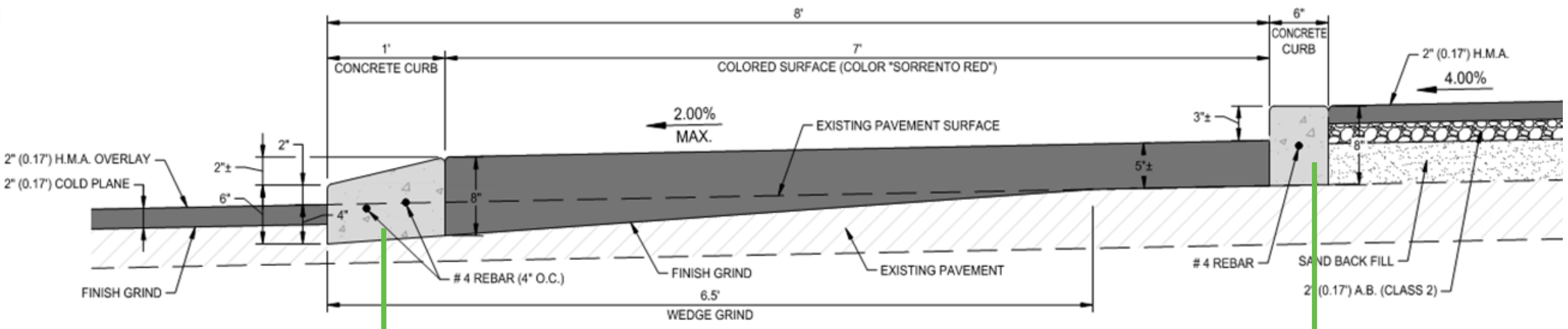
NOTES:

1. DOWELS SHALL BE 3/4" DIA. WITH LENGTH AS SHOWN. IN EXISTING CONCRETE PAVEMENT DRILL HOLES 1-1/2" DIA. AND GROUT DOWELS. IN A.C. PAVEMENT DRIVE DOWELS.
2. CONCRETE FOR THE SEPARATOR SHALL BE MINIMUM 3000 PSI PORTLAND CEMENT CONCRETE (TYPE II), 1" MAX. AGGREGATE WITH 4" MAX. SLUMP.
3. CONTRACTOR SHALL USE POLYPROPYLENE FIBER (FIBERMESH 650) WITH A CONTENT 3LBS PER CUBIC YARD.



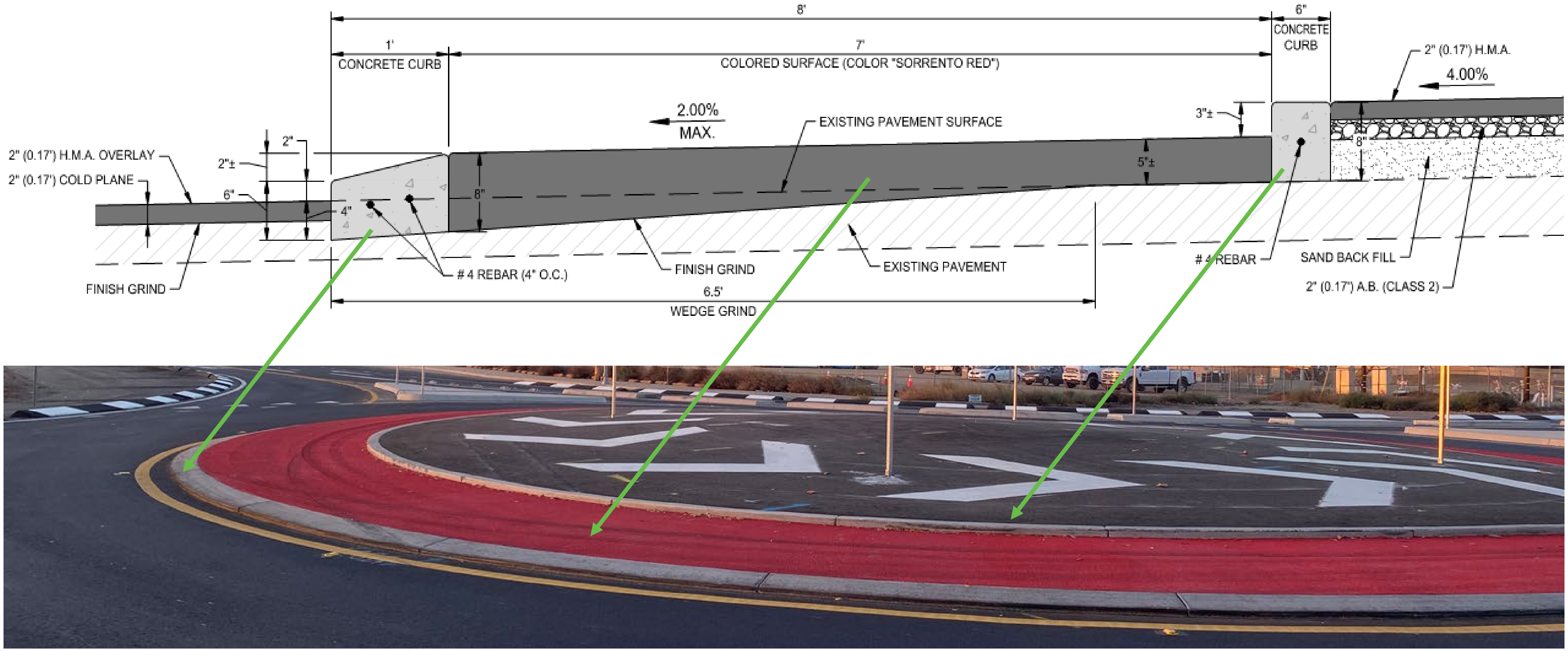
Coffee Road and Claratina Avenue

(Central Island and Truck Apron)



Coffee Road and Claratina Avenue

(Central Island and Truck Apron)



Coffee and Claratina Roundabout
(Quicker Build)

Item #	Item Description	Units	Quantity	Unit Price	Extension
Bid Alternate 2					
201	Water Pollution Control Plan (WPCP)	LS	1	$4,500.00	$4,500.00
202	Traffic Control	LS	1	$40,000.00	$40,000.00
203	Monument Preservation	LS	1	$4,000.00	$4,000.00
204	ADA Ramp Field Design, Layout and Staking	LS	1	$3,500.00	$3,500.00
205	Sawcut PCC and AC	LF	300	$3.00	$900.00
206	Remove and Replace Concrete Flatwork (Sidewalk and Curb Ramp)	SF	1100	$30.00	$33,000.00
207	Remove and Replace Concrete Curb and Gutter	LF	120	$45.00	$5,400.00
208	Cast Iron Detectable Warning Plate	SF	120	$30.00	$3,600.00
209	Place Hot Mix Asphalt at Curb Ramps	TON	10	$250.00	$2,500.00
210	Remove and Replace Catch Basin with Type 1	EA	1	$5,000.00	$5,000.00
211	Remove and Replace Pull Box	EA	2	$1,200.00	$2,400.00
212	Cold Plane Asphalt Concrete	SF	202590	$0.20	$40,518.00
213	Type A Hot Mix Asphalt 0.17' Thick	TON	2583	$90.00	$232,470.00
214	Hot Mix Asphalt Dike (Type D)	LF	500	$11.00	$5,500.00
215	Trunk Apron and Roundabout Island Paving	TON	110	$250.00	$27,500.00
216	Trunk Apron Curb	LF	460	$80.00	$36,800.00
217	Concrete Median Islands	SF	5585	$18.00	$100,530.00
218	Adjust Water Valve Box to Finished Grade	EA	41	$500.00	$20,500.00
219	Adjust Detector Handhole Box to Finished Grade	EA	4	$600.00	$2,400.00
220	Adjust Sewer Manhole to Finished Grade	EA	5	$800.00	$4,000.00
221	Adjust Storm Manhole to Finished Grade	EA	1	$800.00	$800.00
222	Removal and Installation of Striping, Markings and Signage	LS	1	$95,000.00	$95,000.00
				Subtotal	$670,818.00

Benefits
- Lower cost
- Traffic calming
- Adjustable design
- Quicker construction
- Improve traffic safety
- Get community buy in!

Chicago and Paradise Roundabout
(Landscaped Central Island)

Washington and Vine Roundabout
(Brick Paver Central Island)

Sylvan and Millbrook Roundabout
(Pedestrian Overcrossing)

CITY OF
MODESTO
CALIFORNIA

Performance-Based Practical Design

ISOAP Virtual Workshop

California LTAP Center

June 16, 2025

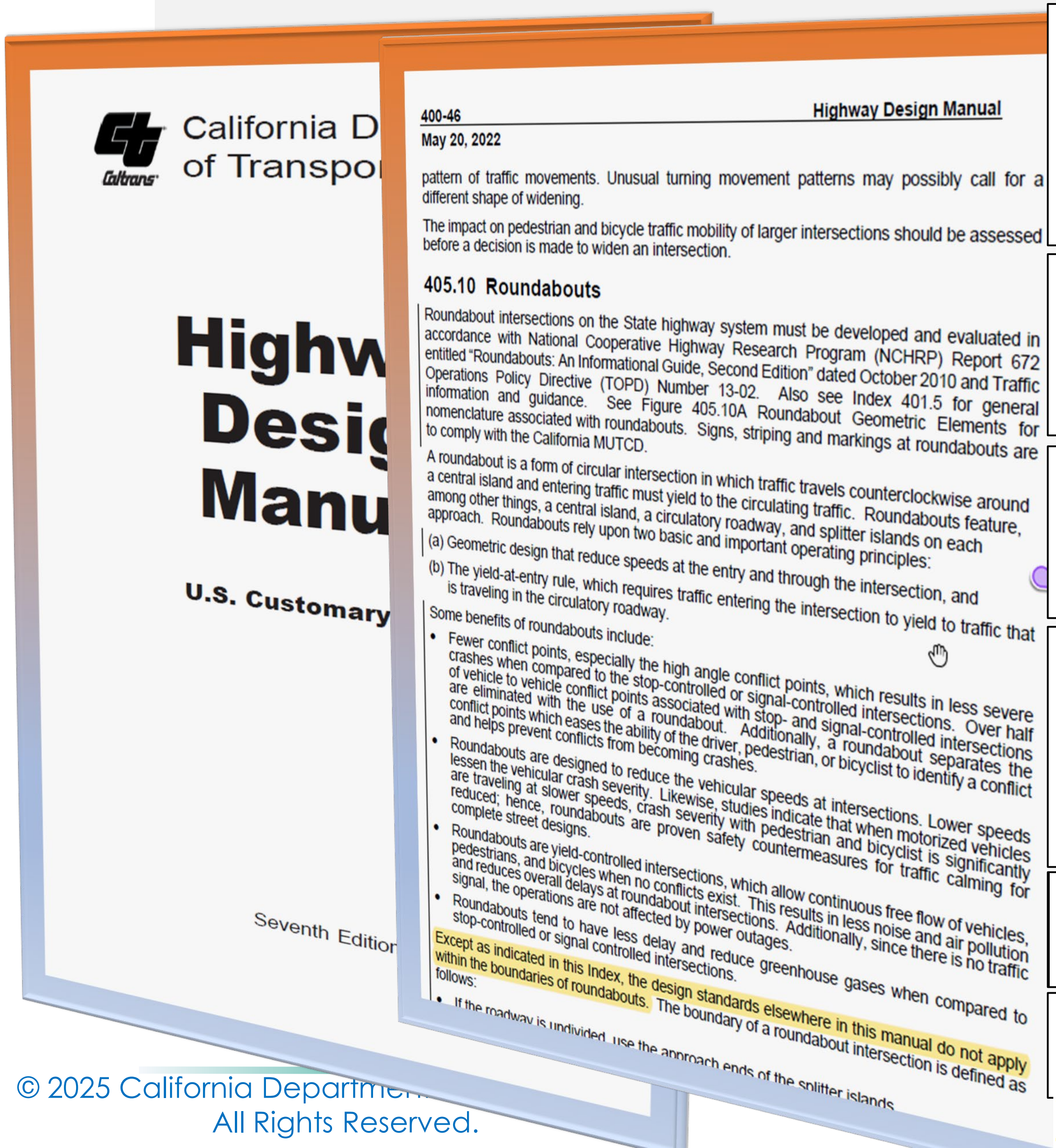
PROJECT DELIVERY
DOC | DOD | DES | DEA | DPM | DRWLS

Division of Design
Office of Project Support

Overview

- ❑ Roundabouts
  - ❖ Highway Design Manual (HDM) Standards
  - ❖ Guidance
- ❑ Performance-based Decision Making
  - ❖ Basic Principles: Nominal vs Substantive example
  - ❖ Roundabout Designs Principles: Performance Measures, Design Influences, and Performance Checks
- ❑ Affordable Roundabouts
  - ❖ Design Principles/Practical Design

HDM Roundabout Standards


California D
of Transpo

Highw
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Manu

U.S. Customary

Seventh Edition

400-46 Highway Design Manual
May 20, 2022

pattern of traffic movements. Unusual turning movement patterns may possibly call for a different shape of widening.

The impact on pedestrian and bicycle traffic mobility of larger intersections should be assessed before a decision is made to widen an intersection.

405.10 Roundabouts

Roundabout intersections on the State highway system must be developed and evaluated in accordance with National Cooperative Highway Research Program (NCHRP) Report 672 entitled "Roundabouts: An Informational Guide, Second Edition" dated October 2010 and Traffic Operations Policy Directive (TOPD) Number 13-02. Also see Index 401.5 for general information and guidance. See Figure 405.10A Roundabout Geometric Elements for nomenclature associated with roundabouts. Signs, striping and markings at roundabouts are to comply with the California MUTCD.

A roundabout is a form of circular intersection in which traffic travels counterclockwise around a central island and entering traffic must yield to the circulating traffic. Roundabouts feature, among other things, a central island, a circulatory roadway, and splitter islands on each approach. Roundabouts rely upon two basic and important operating principles:

(a) Geometric design that reduce speeds at the entry and through the intersection, and

(b) The yield-at-entry rule, which requires traffic entering the intersection to yield to traffic that is traveling in the circulatory roadway.

Some benefits of roundabouts include:

- Fewer conflict points, especially the high angle conflict points, which results in less severe crashes when compared to the stop-controlled or signal-controlled intersections. Over half of vehicle to vehicle conflict points associated with stop- and signal-controlled intersections are eliminated with the use of a roundabout. Additionally, a roundabout separates the conflict points which eases the ability of the driver, pedestrian, or bicyclist to identify a conflict and helps prevent conflicts from becoming crashes.
- Roundabouts are designed to reduce the vehicular speeds at intersections. Lower speeds lessen the vehicular crash severity. Likewise, studies indicate that when motorized vehicles are traveling at slower speeds, crash severity with pedestrian and bicyclist is significantly reduced; hence, roundabouts are proven safety countermeasures for traffic calming for complete street designs.
- Roundabouts are yield-controlled intersections, which allow continuous free flow of vehicles, pedestrians, and bicycles when no conflicts exist. This results in less noise and air pollution and reduces overall delays at roundabout intersections. Additionally, since there is no traffic signal, the operations are not affected by power outages.
- Roundabouts tend to have less delay and reduce greenhouse gases when compared to stop-controlled or signal controlled intersections.

Except as indicated in this Index, the design standards elsewhere in this manual do not apply within the boundaries of roundabouts. The boundary of a roundabout intersection is defined as follows:

- If the roadway is undivided, use the approach ends of the splitter islands

(4) *Entry Speeds.* Lowering the speed of vehicles entering and traveling through the roundabout is a primary design objective that is achieved by approach alignment and entry geometry.

The following entry speeds should not be exceeded:

- Single lane entry, 25 miles per hour.
- Multilane entry, 30 miles per hour.

iv. At pedestrian crossing locations the accessibility design will be treated as a midblock pedestrian street crossing. See DIB 82 for more information. Pedestrian crossings may also be used by bicyclists; thus, these crossings need to be designed for both bicyclist and pedestrian needs and should be a minimum of 8 feet wide, 10 feet is preferred.

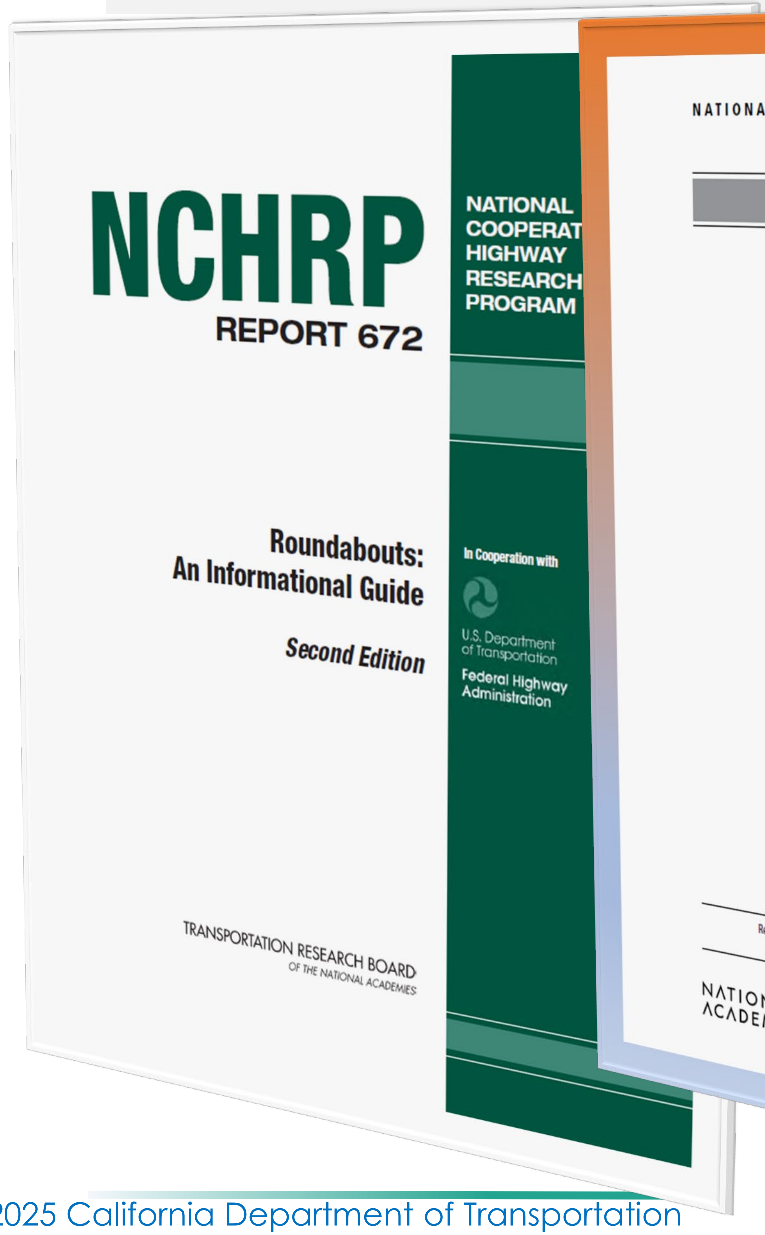
v. A landscape buffer/strip, detectable by cane and under foot, between the sidewalk and the back of curb for the circular roadway of the roundabout should be a minimum of 2 feet wide, 3 feet is preferred. For more information see NCHRP Report 834, entitled "Crossing Solutions at Roundabout and Channelized Turn Lanes for Pedestrians with Vision Disabilities." See Figure 405.10C.

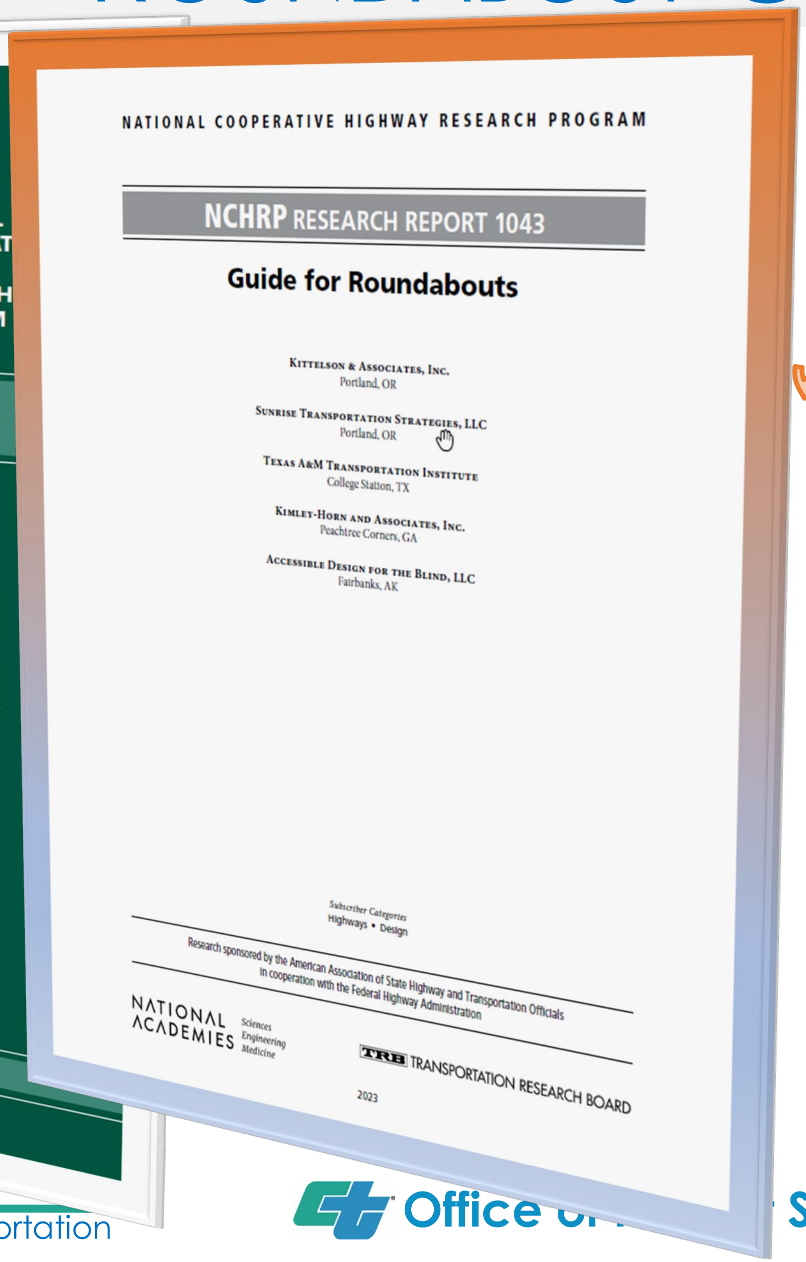
- To accommodate mounted cyclists and pedestrians, a sidewalk should be included and have a minimum paved width of 8 feet, 10 feet is preferred.
- A minimum 2-foot horizontal clearance from the outside paved edge of the sidewalk to obstructions should be provided, 3 feet is preferred. Although not considered a shoulder, the surface should be flush with the edge of the sidewalk to allow bicyclists to recover. The surface material only needs to support the sidewalk pavement and minimize edge drop-off.

(13) *Access Control.* The access control standards in Index 504.3(3) and 504.8 apply to roundabouts at interchange ramp intersections. The dimensions shown in Index 504.8 are to be measured from the ICD.

A bypass lane is not included in the number of entry lanes. Although, a bypass lane prohibits entry into the circulatory roadway, the bypass lane should also meet the speed requirements to ensure that diverge and merge speeds are within 10 mile per hour of each other and vehicle speeds are not more than 20 mile per hours at pedestrian crossings. See Index 405.3(2)(b).

ROUNDABOUT GUIDANCE


NCHRP
REPORT 672
NATIONAL
COOPERAT
HIGHWAY
RESEARCH
PROGRAM
Roundabouts:
An Informational Guide
Second Edition
In Cooperation with
U.S. Department of Transportation
Federal Highway Administration
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES


NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM
NCHRP RESEARCH REPORT 1043
Guide for Roundabouts
Kittelson & Associates, Inc.
Portland, OR
Sunrise Transportation Strategies, LLC
Portland, OR
Texas A&M Transportation Institute
College Station, TX
Kimley-Horn and Associates, Inc.
Peachtree Corners, GA
Accessible Design for the Blind, LLC
Fairbanks, AK
Subscriber Categories
Highways • Design
Research sponsored by the American Association of State Highway and Transportation Officials
in cooperation with the Federal Highway Administration
NATIONAL ACADEMIES Sciences Engineering Medicine
TRB TRANSPORTATION RESEARCH BOARD
2023

"RANGES"

"TYPICALLY"

"STARTING VALUE"

"GENERALLY"

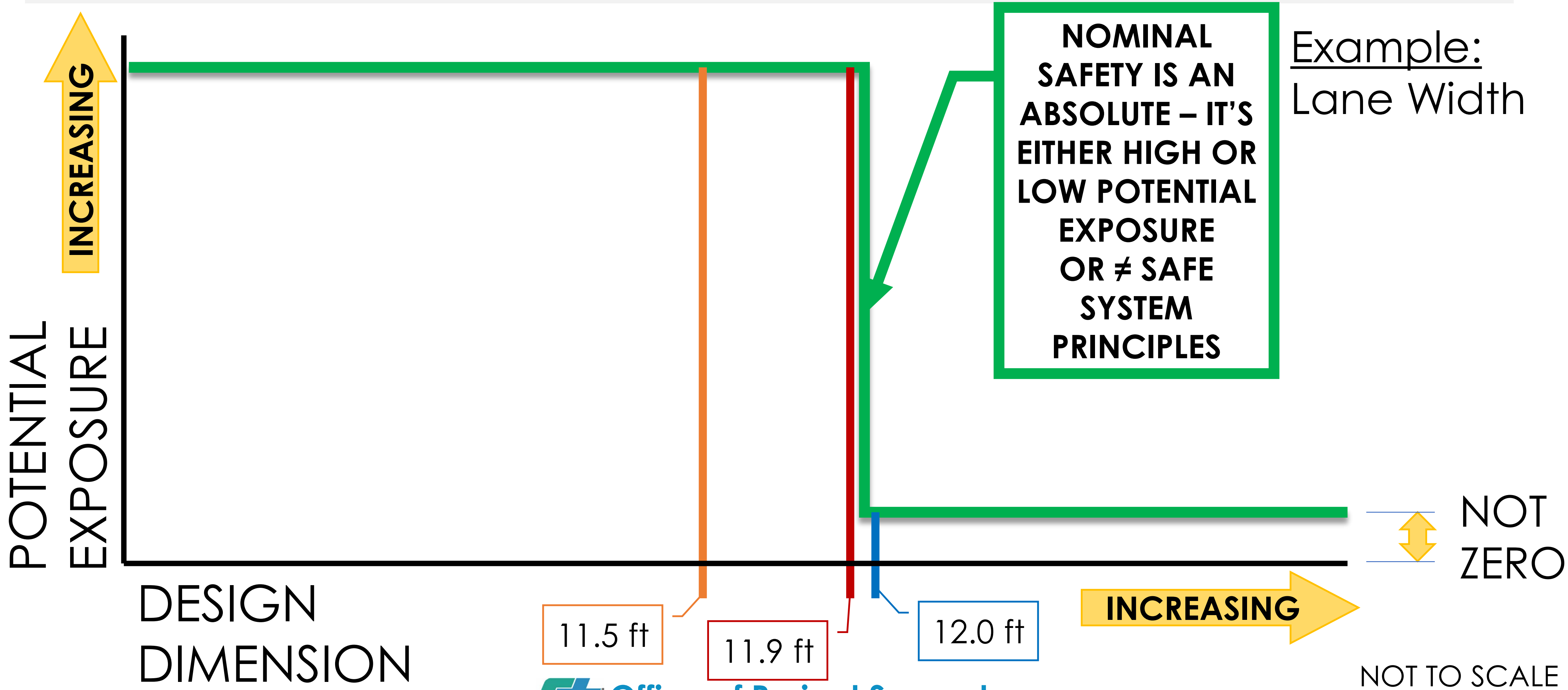
Flexibility

Performance-Based Decision Making

Performance-Based Tools and Designs

- Highway Capacity Manual
- Highway Safety Manual
- Diverging Diamond Interchanges
- Roundabouts

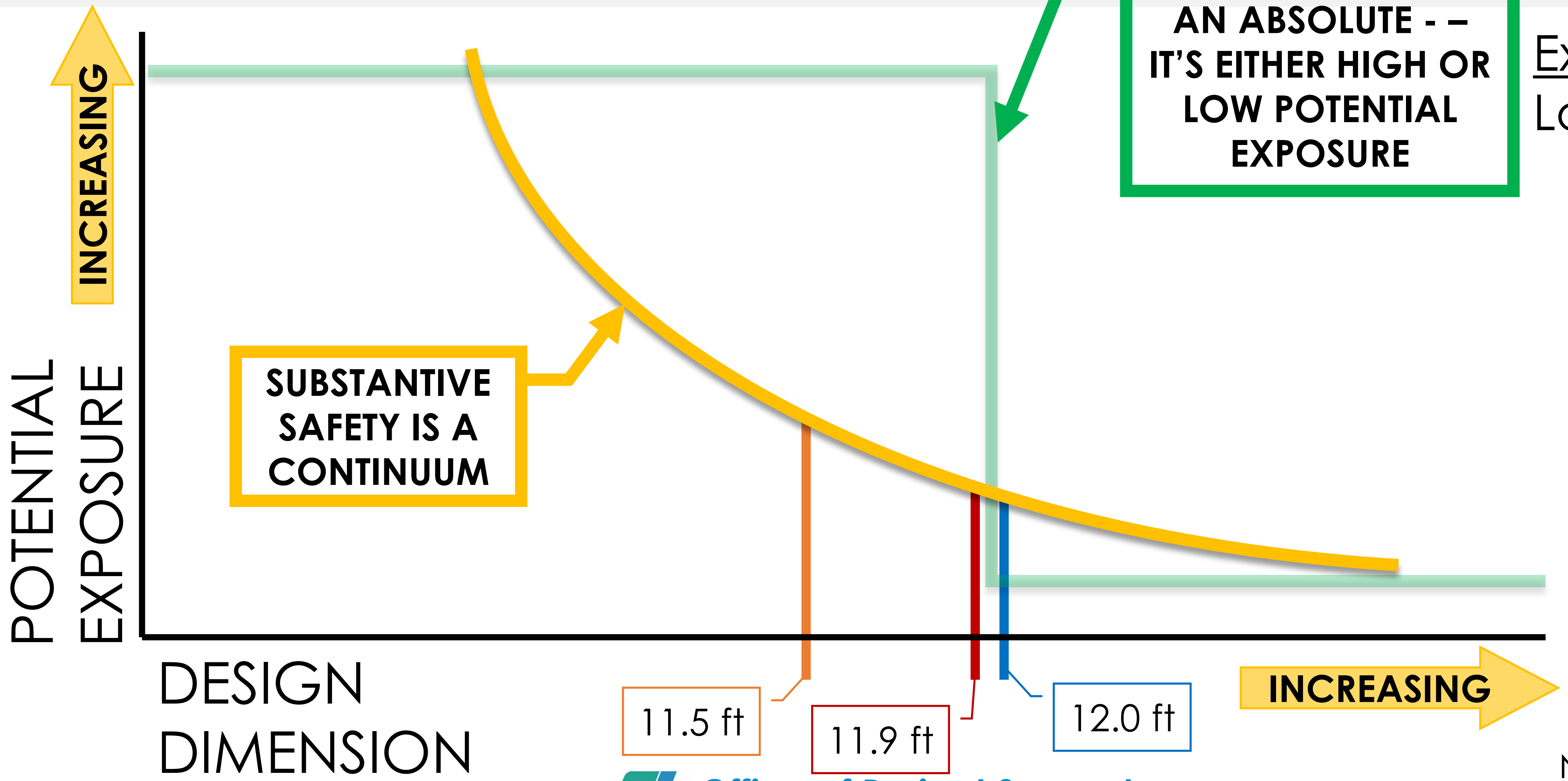
Performance-Based Decision-Making Principles Nominal Example



Example:
Lane Width

Office of Project Support

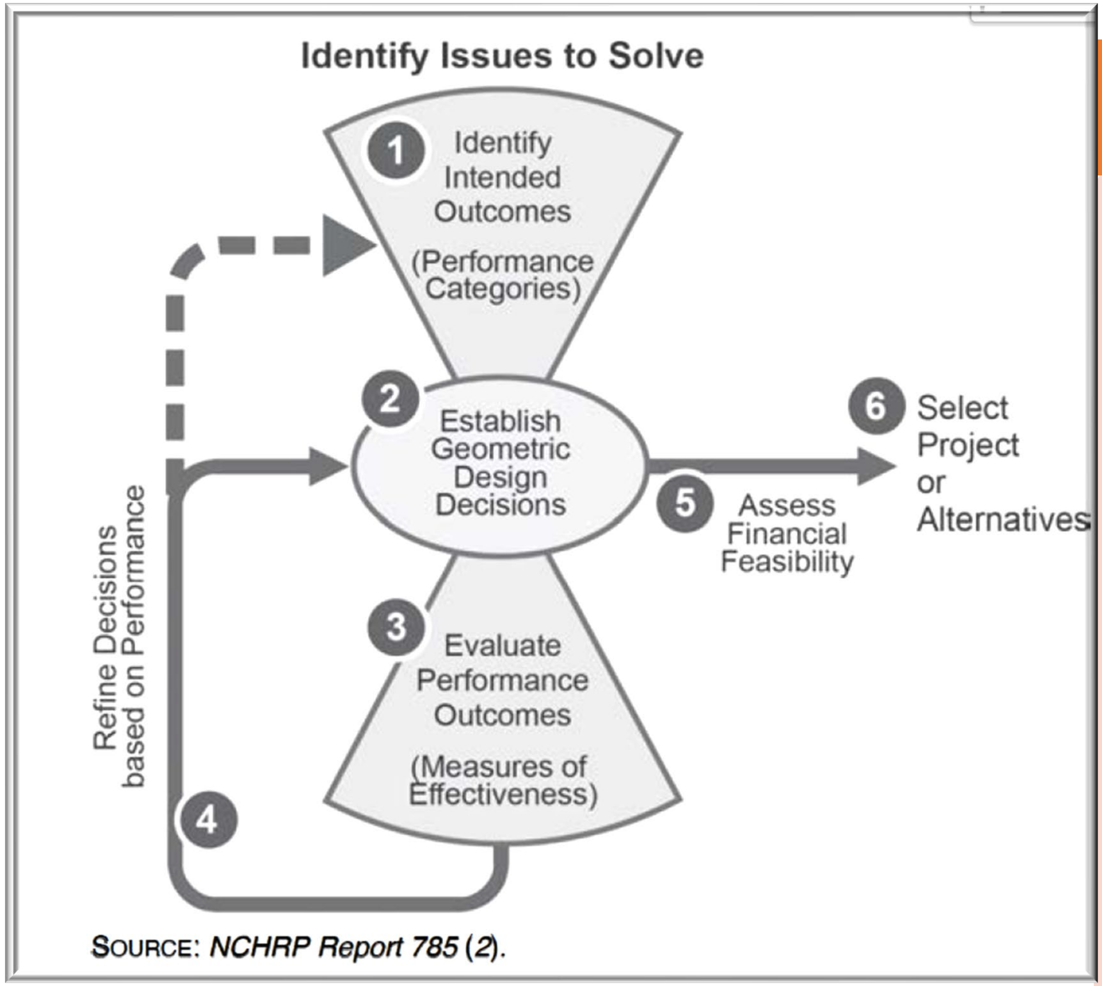
Performance-Based Decision-Making Principles
Substantive Example (HSM)



Example:
Lane Width

NOT TO SCALE

Performance-Based Decision Making
Roundabout Design Principles & Performance measures



NCHRP Report 1043 - Exhibit 3.5

1 Performance Measures

Safety	Ops	Bike/Ped	Enviro/ROW
Conflicts	DPHD	Conflicts	Footprint Constraints
Speeds	Queue Length	Accessibility	
Crash Severity	Degree of Saturation, V/C	Speed	

Office of Project Support

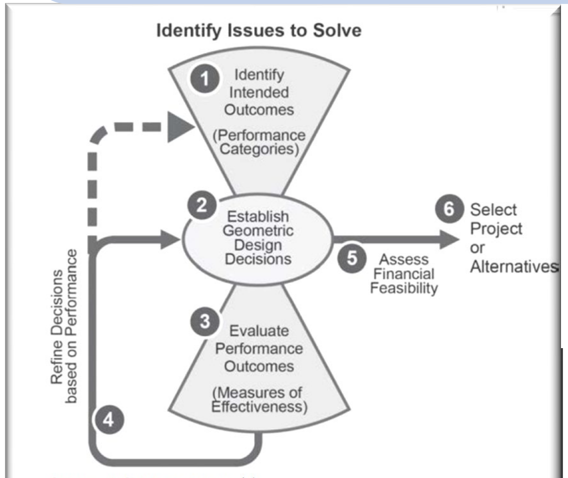
Performance-Based Decision Making
Roundabout Design Principles & Main Influences

2

NCHRP Report 1043 - Exhibit 10.2

Horizontal Design Performance Influences

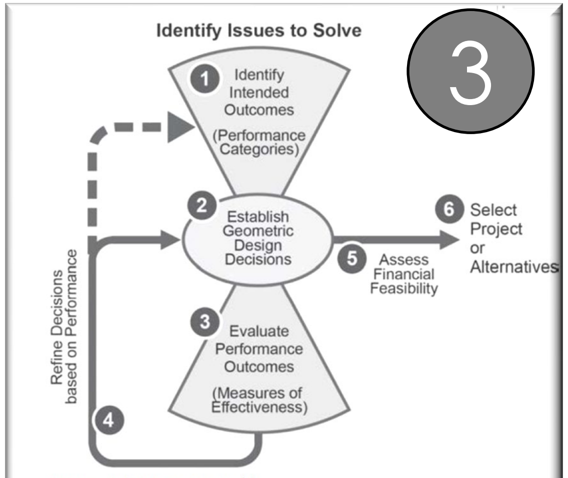
- Roundabout size and shape → ICD……circular, oval peanut?
  - Lane configuration → Single, Multilane, Hybrid….Mini?
  - Design vehicle → CA Legal, STAA. What are the req. turning movements?
  - Approach alignment
- Roundabout location → Doesn't need to be centered at exist. intersection
- Roundabout approach and entry → Radial, Offset Left, Offset Right…..
- Facilities for pedestrians and bicyclists



Source: *NCHRP Report 785* (2).

Office of Project Support

Performance-Based Decision Making
Roundabout Design Principles & Performance Checks



SOURCE: *NCHRP Report 785* (2).

Performance Checks	
• Geometric speeds	→ Fastest path
• Sight distance and visibility	→ Site Triangles, ISDs, & View Angle
• Vehicle path alignment	→ Natural path
• Design vehicles	→ Truck Turn Templates
• Bicyclist and pedestrian design flags	
• Pedestrian crossing assessment	
• Pedestrian wayfinding assessment	

NCHRP Report 1043 - *Exhibit 9.3*

AFFORDABLE ROUNDABOUTS

Quick Build
temp or interim installations

Mini
ICD: 48 – 90 ft

Modular
Pre-fabricated

HDM INDEX 405.10(3)

A mini-roundabout may be an acceptable roundabout design on low volume routes or ramp terminals. With an inscribed circle diameter of less than 90 feet, the central island will need to be fully traversable to accommodate the design vehicles movements.

Office of Project Support

Affordable Roundabouts – Minis & Compacts

Similarities to SLRs

- ❖ Design Principles/Outcomes: speed and severe conflict point reduction
- ❖ Performance Measures, Influences and Checks

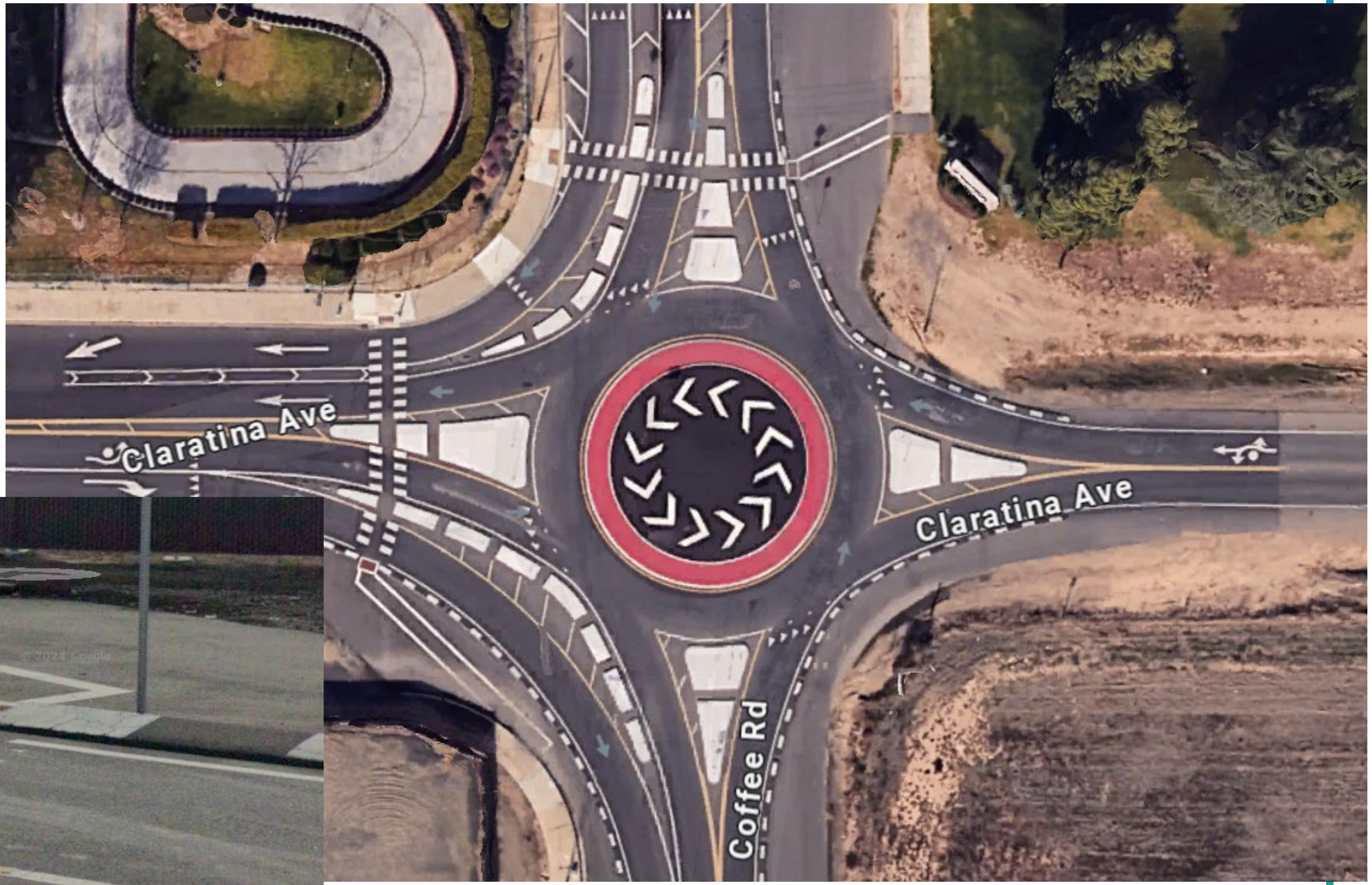
Differences between SLRs

- ❖ Trucks/Buses:
  - Central Islands: fully traversable for Minis and possibly traversable for Compacts
  - Splitter islands: may be traversable resulting in one stage xing for peds.
  - Low Truck & Bus volumes: BUT turning movements critical operationally
- ❖ Approach speeds: ~ 30 to 35 mph BUT can still be used on higher speeds w/ approach treatments
- ❖ ~15,000 ADT or less (Rule of Thumb)

Affordable Roundabouts – Quick Build & Interim Designs (Coffee Rd. & Claratina Ave.)

2008/2009 – 2021

2021– Present



Engineering Judgement

NOTHING replaces Engineering Judgement.

Thank you!

Trucks and OSOW Vehicles

Key considerations

1. Select appropriate design vehicle
2. Needs for oversize/overweight vehicles
3. Determine necessary intersection turning movements

Consult with the District Truck Access Manager

Design Vehicles

Highway Design Manual (HDM) Topic 404.4 provides a list of design vehicles and the vehicle templates.

1. **Surface Transportation Assistance Act of 1982 (STAA) truck 56′ and 67′ turning radius**
2. **CA legal truck 50′ and 60′ turning radius (CA legal route)**

   HDM specifies to use STAA vehicle on CA legal route; it is an advisory design standard
3. **40′ bus, 45′ bus/motorhome**
4. **60′ articulated bus**

Permitted Vehicle – OSOW

- Width > 8.5 feet (there are general exceptions such as bike rack on bus)
- Length > non-permitted vehicle
- Height of vehicle and load combination >14 feet (CVC 35250) with exception (double-deck bus 14 feet 3 inches)
- Weight limit – gross weight and axle weight (depend on the axle groups). Not going into detail discussion. Related to pavement design and the bridge permit load rating.

Example of Transportation Permit

STATE OF CALIFORNIA • DEPARTMENT OF TRANSPORTATION
TRANSPORTATION PERMIT
TR-0772 (NEW 12/2013) APP ID: 810597

PERMIT VALID: FROM: **04/05/2021** TO: **04/11/2021**

PERMIT NUMBER: **e21-027872**

THIS PERMIT SHALL BE CARRIED IN THE VEHICLE AT ALL TIMES AND IS VALID ONLY WHEN IT INCLUDES ALL THE REQUIRED ACCOMPANIMENTS.

CONTACT: **MIKE MASHBURN**
NAME: **MASHBURN TRANSPORTATION**
ADDRESS: **22140 ROSEDALE HWY**
CITY / STATE / ZIP: **BAKERSFIELD, CA 93314**
PHONE NO.: **(661) 368-1133** FAX NO.: **(661) 588-5731**

load description

DESCRIPTION OF THE LOAD OR EQUIPMENT AND MODEL NUMBER:
1/ COOLING TUBE - UNIT RC3

load dimension

DIMENSIONS OF LOAD:
13'6"W X 47'L X 14'1"H

Transportater

DESCRIPTION OF HAULING EQUIPMENT:
3AX TRAC 2AX JP 2AX DOLLY

MOVEMENT AUTHORIZED:
PERMIT VALID FOR SEVEN CONSECUTIVE DAYS.
SEE 24/7 TRAVEL CONDITIONS FOR AUTHORIZED TIMES OF MOVEMENT.
☐ NO NIGHT TRAVEL
SINGLE TRIP
LOAD TYPE: **HAUL**

REQUIRED ACCOMPANIMENTS:
☒ PERMIT CONDITIONS 2007
☒ 24/7 SPECIAL CONDITIONS
☒ LOS ANGELES AREA CURFEW MAP
☒ PILOT CAR SPECIAL CONDITIONS
☐
☐
☐
☐
☐

VEHICLE WIDTH:	KINGPIN TO LAST AXLE:	SEMI-TRAILER LENGTH:	COMB. VEHICLE LENGTH:
10' 0"	46' 0" MAX	na	85' 0" MAX

Veh L

AXLE NUMBER:	1	2	3	4	5	6	7	8	9	10	11
NUMBER OF TIRES PER AXLE:	2	4	4	4	4	8	8				
DISTANCE BETWEEN AXLES:	16' 0" MIN	4' 4" MIN	22' 8" MIN	4' 6"	20' 5" MIN	6' 0"					
AXLE WIDTH AT TIRE SIDEWALL:	8' 0"	8' 0"	8' 0"	8' 0"	8' 0"	10' 0"	10' 0"				
MAXIMUM ALLOWABLE WEIGHT:	12,500	46,550		46,725		60,000					

NOT TO EXCEED THE LOADED DIMENSIONS SHOWN BELOW OR AXLE WEIGHTS SHOWN ABOVE WEIGHT CLASS: **B P 7**

MAXIMUM HEIGHT: **16' 0"** MAXIMUM WIDTH: **13' 6"** MAXIMUM OVERALL LENGTH: **85' 0"** MAXIMUM OVERHANG: **0' 0"**

ORIGIN: **AZ LINE 8** DESTINATION: **TRACY**

AUTHORIZED HIGHWAYS *(Other government agency permits may be required whenever the * is shown in the route.)*
* from AZ LINE 8 - 8W - 115N - 78W - 86N - 10W - to INDIAN CANYON DR / PALM SPRINGS EXIT (INDIAN CANYON DR N/B OFF RAMP EXIT 120) * from DILLON RD - 62W - 10W - to RTE 79 SOUTH/BEAUMONT AVE exit (BEAUMONT AVE N/B OFF RAMP exit 94) - from BEAUMONT AVE S/B ON RAMP - 10W - 215N - 210W - 15N - 395N - 58W - 223W - 5N - to RTE 46 LOST HILLS (PASO ROBLES E/B OFF RAMP exit 278 - DETOUR VIA RAMPS- from PASO ROBLES HWY W/B ON RAMP - 5N - 140E - 5N - to NEWMAN (STUHR RD E/B OFF RAMP exit 423) - DETOUR VIA RAMPS - from STUHR RD W/B ON RAMP - 5N - 580W - to CHRISMAN RD N/B OFF RAMP exit 76 *

route information

W/B 10 @ 10/111 CONN (PALM SPRINGS) TO 10/60 JCT RTE - RESTRICTION - MAX WIDTH 11-0 - THRU 12/30/2022, 11PM TO 7AM

Different Transportation Permit Types

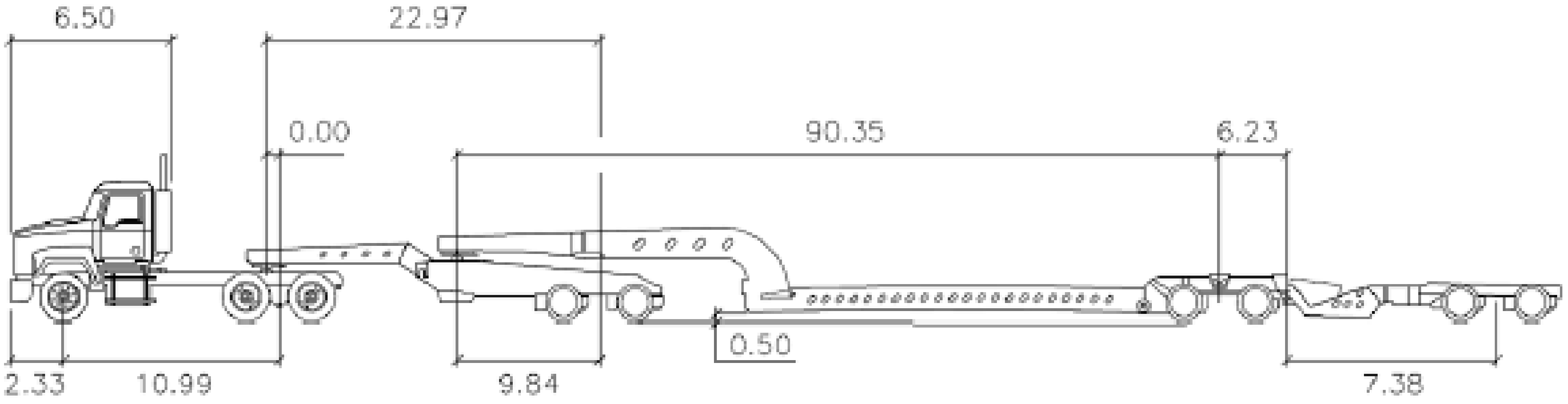
- Single Trip Permit
- Annual Permit
- Repetitive Permit
- Sea Container Permit
- Variance Permit
- Motorsport Permit

Designing Roundabouts for OSOW

- Minimum OSOW design vehicle

Figure 405.10B

Oversize/Overweight Design Vehicle-CALTRANS OS OW HEAVY HAUL



Designing Roundabouts for OSOW

Accommodate specific turning movement based on history

- Review authorized highway section of the Transportation Permit, can conduct site visit
- Consult with Office of Commercial Vehicle Operations for historical data
- Contact District Truck Access Manager

Superload

- Special OSOW vehicle/transporter – superload
- Categorized as variance permit (W>15′; L>135′; H>17′ and exceeds weight)
- Typically requires escort by CHP

Strategies to Accommodate OSOW

STAA/CA legal

- Use all lanes for multilane roundabout
- Utilize the truck apron
- Shape of the truck apron
- Shape of the roundabout
- Central island traversable
- Truck blister (outside truck apron)

Strategies to Accommodate OSOW

OSOW vehicle/superload

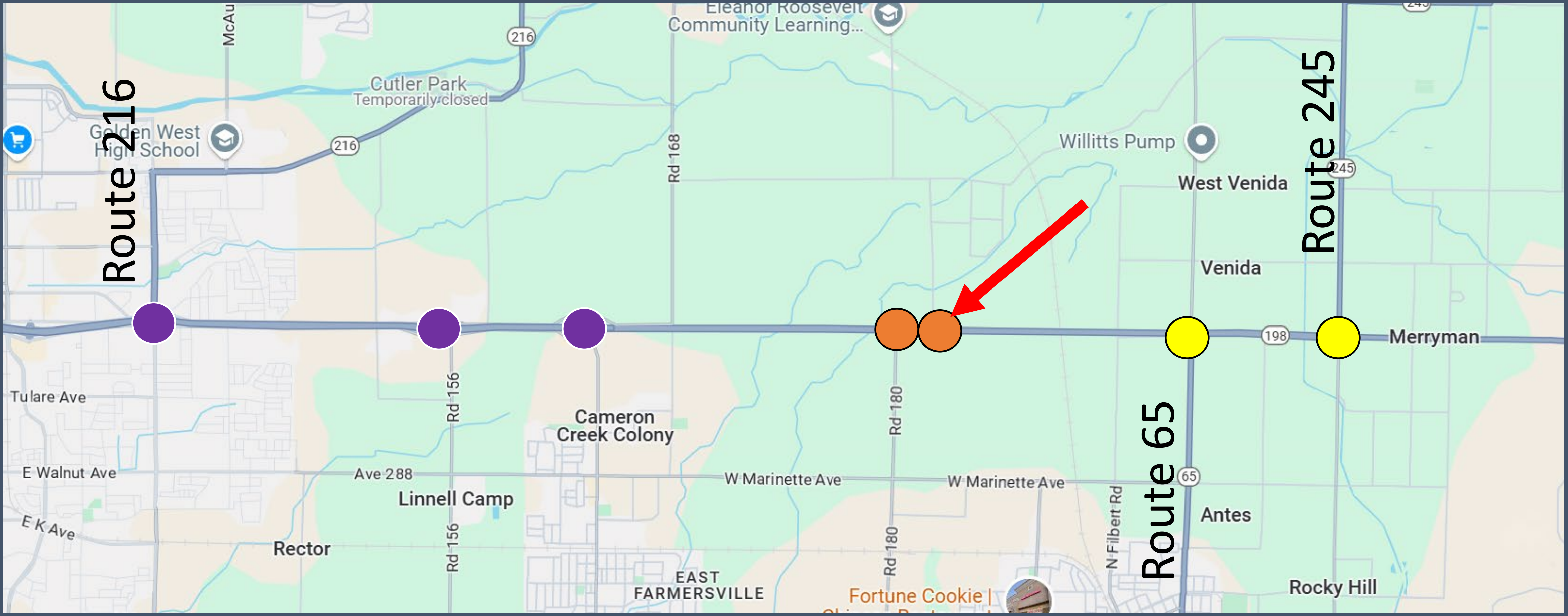
- Use wood/metal block as ramp
- Mountable curb at splitter islands
- Removable signpost – Standard Plan RS5
- Travel at opposite lane with CHP escort
- Alternate route option
- Adequate structural section
- Restrict certain OSOW vehicle

ISOAP Stage 1 Case Study – RCUT

- SR-198 at Road 182 in Tulare County
- Public request to prohibit eastbound U-turns

- ¼ mile intersection spacing
- Diverter previously placed at Road 180

Control along the Route 198 Corridor



Existing Interchange   Existing Minor Stop   Existing Traffic Signal

Stage 1 Screening and Initial Assessment

- **Step 1.1 – Is ISOAP required?**

  Yes, widening is proposed to add acceleration lanes with the RCUT.

- **Step 1.2 – Determine intended project outcome, place type, design vehicle, and gather data**

  There is a pattern of eastbound left-turn collisions with westbound through vehicles. The place type is undeveloped corridor, with scattered rural residential land use. The design vehicle is STAA truck as Route 198 is an STAA Terminal Access Route. The 2040 Concept and UTC are both 4-lane expressways. However, some right-of-way was previously acquired for a future interchange.

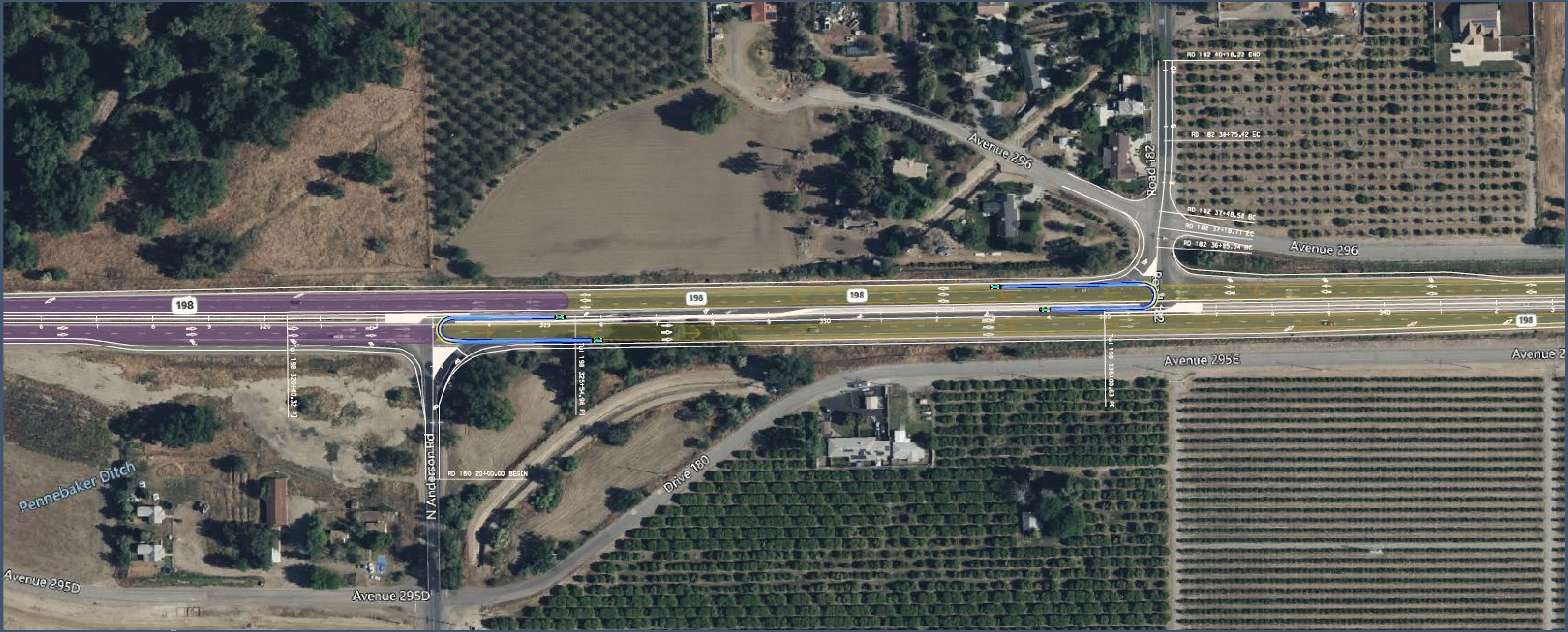
Stage 1 Screening and Initial Assessment

- **Step 1.3 – Ped and bike planning and feasibility assessment**
  There is no notable pedestrian or bicycle activity at the intersection. Immediate vicinity is expected to remain agricultural.

- **Step 1.4 - R/W and operational feasibility assessment**
  Existing expressway right-of-way is narrower than for typical expressways, with closely spaced frontage roads. Right-of-way is more expansive at Road 180 for the potential trumpet interchange. Route 198 AADT is 25,000. AM peak volumes of 98 EB U-turns and 54 left turns vs 1131 WB approaching vehicles.

Proposed RCUT with Acceleration Lanes and Extended LT Lanes

Proposed RCUT with Acceleration Lanes



Stage 1 Screening and Initial Assessment

- **Step 1.5 – Transit and freight assessment**

  Existing Tulare County Regional Transit Agency fixed-route buses run on Route 198 with approximate 30-minute headways.

  Route 198 is an STAA Terminal Access route. STAA trucks should be accommodated for all turning movements.

Stage 1 Screening and Initial Assessment

- **Step 1.6 – Initial safety assessment**

  There were 9 collisions in 3 years. The predominant collision pattern is eastbound left-turn vehicles colliding with westbound through vehicles. There is a secondary pattern of southbound left-turn vehicles colliding with eastbound or westbound through vehicles.

  Adding acceleration lanes for the U-turn movement would reduce the potential conflict with fast-moving vehicles.

Stage 1 Screening and Initial Assessment

- **Step 1.7 – Eliminate infeasible strategies**
  Cost of the roundabout is beyond available funding in the near or long-terms. An isolated high-speed rural traffic signal is not desirable. RCUT with extended left-turn lanes does not satisfy the Safety Index.

- **Step 1.8 – Findings and recommendations**
  The RCUT with added acceleration lanes addresses the safety concern and is recommended. Cost is $2.3 million, and Safety Index is satisfied for a safety project. Document findings and submit for approval. ISOAP concludes.

ISOAP Stage 1 (Screening and Initial Assessment) Long Form

Prepared by: John Liu

Checked by: Enter text

Cty-Rte-PM: Tul-198-R17.008

Major Street: Route 198

Minor Street: Road 182

Project EA: Enter text

Date: 2/18/2025

Step 1.1 Is ISOAP Required?

Applicability criteria

☐ New public road, private road, or high-volume (1,000 ADT) driveway

☐ New freeway interchange

☐ Change in type of traffic control (stop, yield, signal)

☐ Pedestrian hybrid beacon (PHB) at an intersection

☒ Major physical changes to intersection approaches (including ramp terminals), such as adding a leg to an intersection or widening to provide an additional through or turn lane

Step 1.2 Determine Intended Project Outcome, Place Type, Design Vehicle, and Gather Data

Determine desired result of project, collaborating with functional units and stakeholders as needed (for example, safety improvement, improve walkability, reduced queuing): Improve safety by addressing broadside crashes.

Gather available existing traffic data

Major street:

- Route classification: Expressway
- Lane configuration: Two lanes in each direction, EB left-turn channelization
- Existing ADT: 23,200
- Future ADT: Enter text
- Speed limit: 65

End of Day 1

ISOAP Workshop Day 2

Intersection Safety and Operational Assessment Process

LMS Course Code 102700 for Caltrans Employees

California LTAP

June 17, 2025

John Liu, Deputy District Director

Caltrans District 6 Division of Maintenance and Operations

Jerry Champa

Caltrans HQ Division of Safety Programs

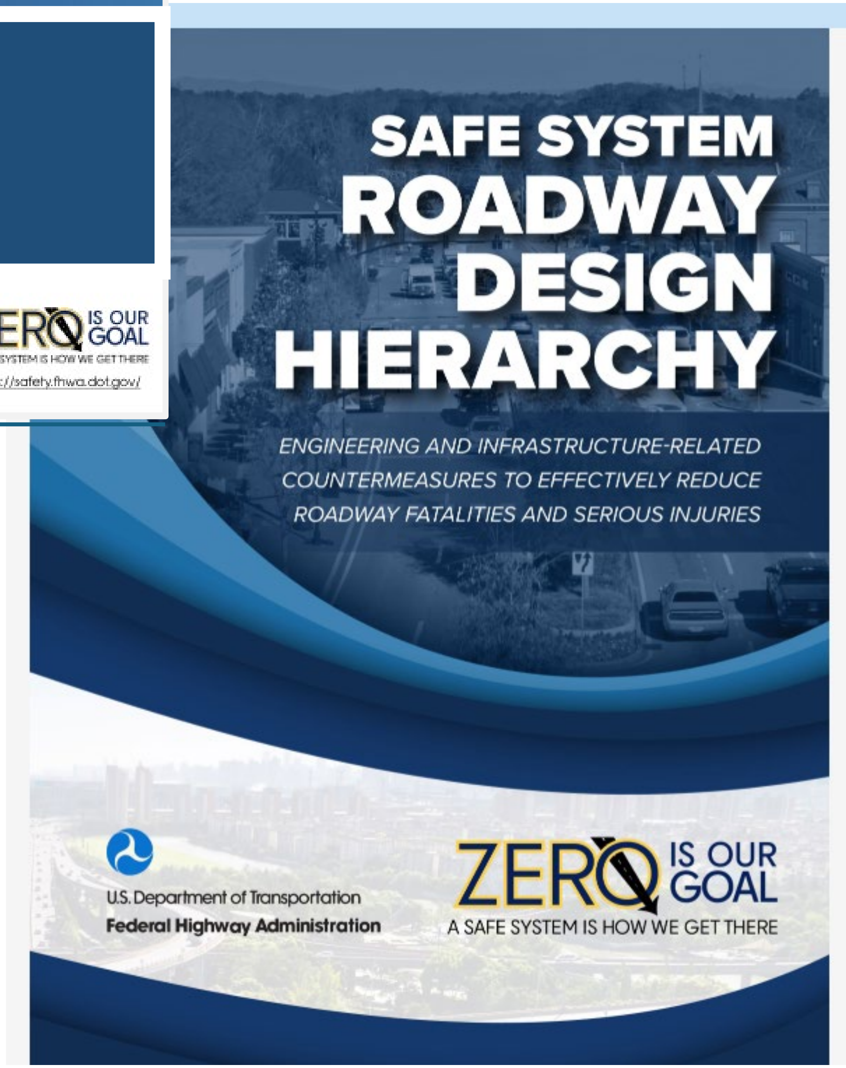
Schedule – June 17

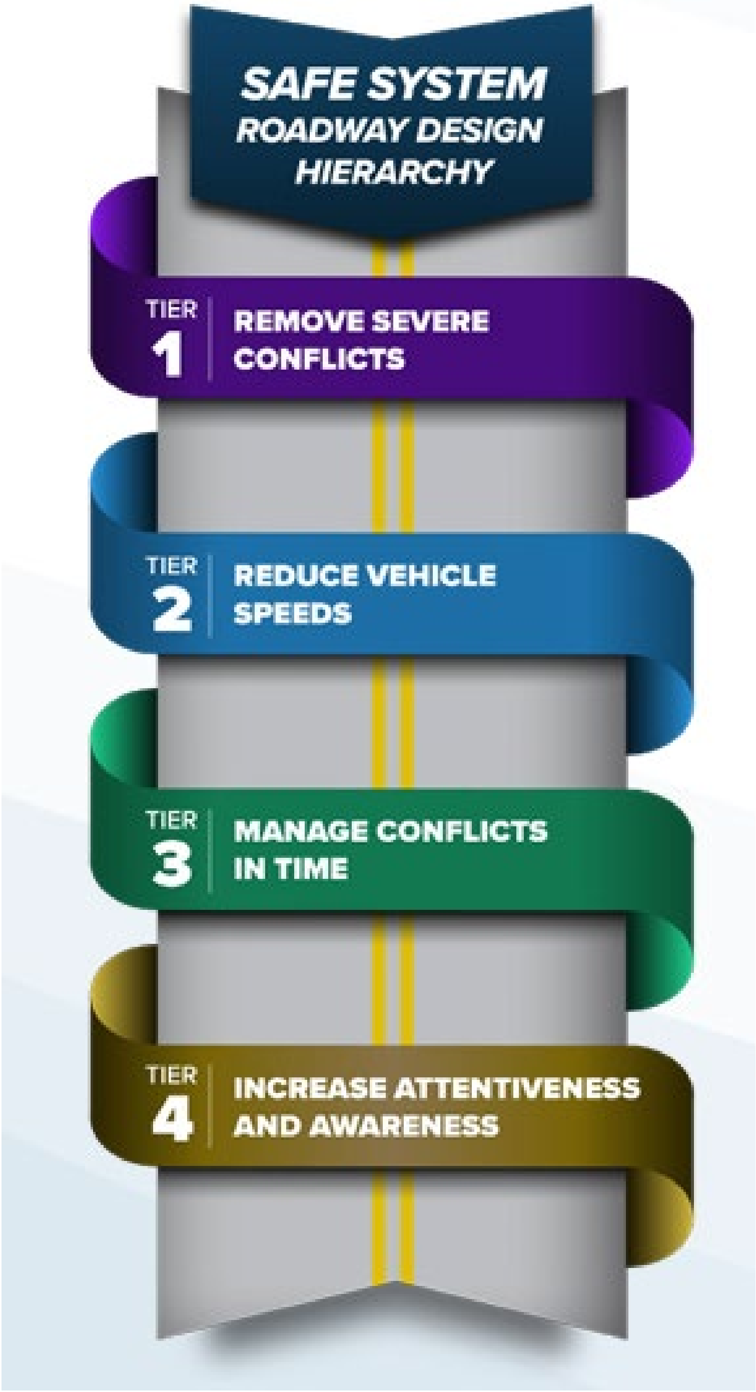
12:30	Review and questions and answers
12:50	Saving time, money, and lives through performance-based intersection evaluation and design – Brian Ray, Sunrise Transportation Strategies
1:35	Calculating safety performance – Gina Lopez and Bernice Chan, HQ Design, Jerry Champa
2:20	Calculating mobility performance – Lilian Wu, HQ Traffic Ops
2:50	Break (10 minutes)

Schedule – June 17

3:00 Intersection pavement design – Mohammad Al-Assi, District 6
3:15 Stage 1 & 2 (District 9) case study – John Liu
3:25 Local sponsored projects and Local Development Review (LDR), roles and responsibilities – John Liu
3:45 Public outreach – John Liu
4:00 ISOAP Exercise – Jerry Champa
4:15 Questions and answers
4:25 Resources and concluding remarks – John Liu
4:30 Conclude


MAKING OUR ROADS SAFER
One Countermeasure at a Time
28 Proven Safety Countermeasures
that offer significant and measurable impacts to improving safety
U.S. Department of Transportation
Federal Highway Administration
ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE
https://safety.fhwa.dot.gov/

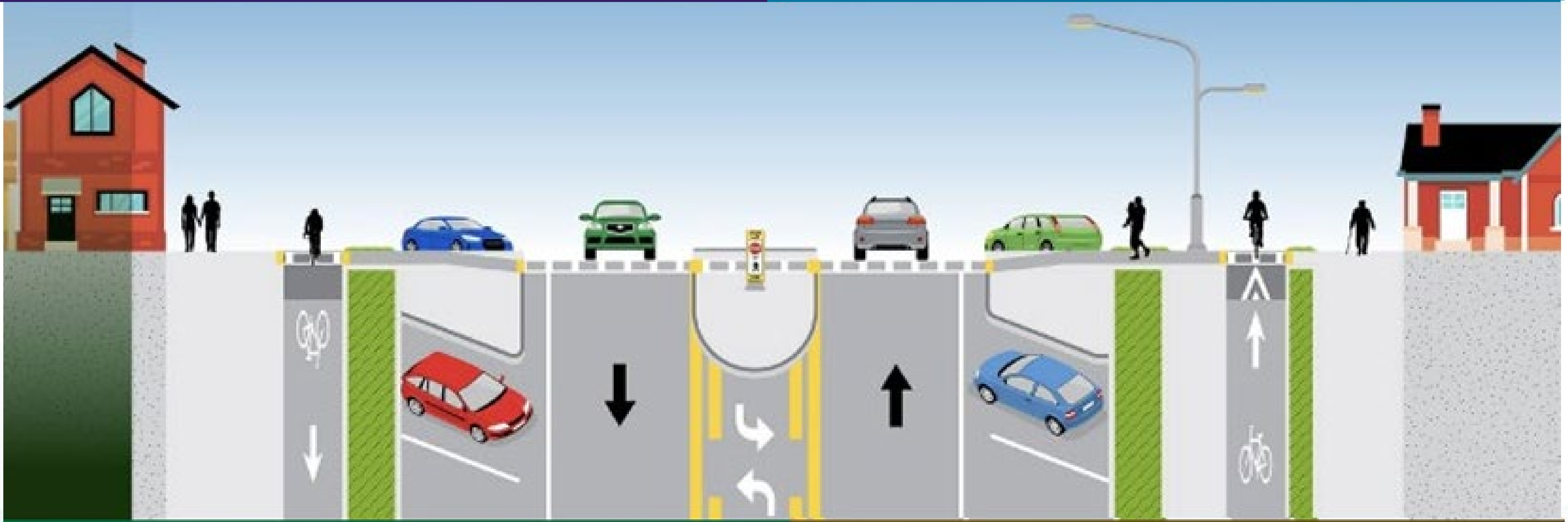

SAFE SYSTEM ROADWAY DESIGN HIERARCHY
ENGINEERING AND INFRASTRUCTURE-RELATED COUNTERMEASURES TO EFFECTIVELY REDUCE ROADWAY FATALITIES AND SERIOUS INJURIES
U.S. Department of Transportation
Federal Highway Administration
ZERO IS OUR GOAL
A SAFE SYSTEM IS HOW WE GET THERE


SAFE SYSTEM ROADWAY DESIGN HIERARCHY
TIER 1
REMOVE SEVERE CONFLICTS
TIER 2
REDUCE VEHICLE SPEEDS
TIER 3
MANAGE CONFLICTS IN TIME
TIER 4
INCREASE ATTENTIVENESS AND AWARENESS

How to use the Hierarchy to produce Complete Streets & Intersections …

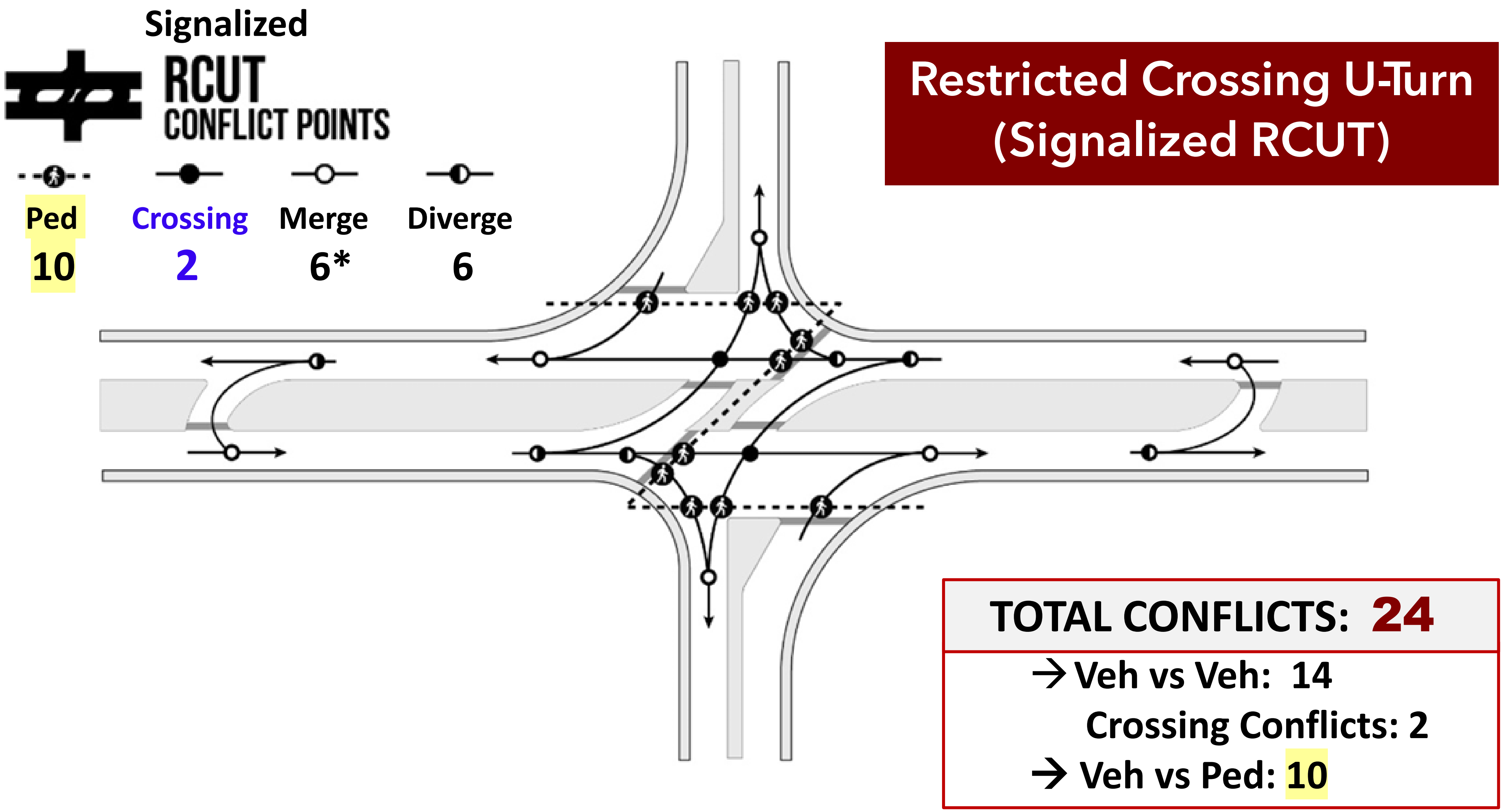
TIER 1: REMOVE SEVERE CONFLICTS
The roadway design provides separation in space to protect all. Road users. Convert intersections to roundabouts

TIER 2: REDUCE VEHICLE SPEEDS
Self-enforcing road design and gateway treatments provide contextual encouragement for motorists to drive at safer speeds. Roundabouts force motorists to slow to safer speeds (<20 mph)



TIER 3: MANAGE CONFLICTS IN TIME
A Pedestrian Hybrid Beacon (PHB) can assist pedestrians crossing at the uncontrolled intersection.

TIER 4: INCREASE ATTENTIVENESS AND AWARENESS
Bicycle treatments and pedestrian signage make motorists aware of crossing cyclists and pedestrians.



Source: FHWA

Figure 38. Graphic. Diagram of movement-based conflict points for Signalized RCUT intersections.

Intersection Conflict Analysis Findings

	Intersection Conflicts					Speed	
	Ped	Crossing	Merge	Diverge	Total	entering	CRF*
Traditional Crossing (2 & AWSC, Signal)	**24**	**16**	8	8	56	L-M-H	
Single-lane **Roundabout**	**8**	**0**	4	4	16	**< 20** (L)	**78-90%**
Two-lane **Roundabout**	**8**	**8**	8	8	32	**< 25** (L)	**67-90%**
RCUT (unsignalized)	**10**	**2**	6	6	24	L-M-H	**54-63%**
MUT (signalized)	**16**	**4**	6	6	32	L-M-H	**30%**
Displaced Left Turn (partial)	**22**	**14**	8	8	52	L-M-H	
Displaced Left Turn (full)	**20**	**12**	8	8	48	L-M-H	
Continuous Green T (only 3 legs)	**10**	**3**	3	3	19 (x2)	M-H	
Bowtie (major + 2 roundabout)	**16**	**4**	8	8	36	L-M-H	
Turbo **Roundabout**	**8**	**4**	6	4	22	**< 25** (L)	
T Intersection (ParClo ramp terminal)	**8**	**1**	3	2	14	L-M-H	

* % of Fatal and Injury Crashes Reduced

TRAFFIC AT SOUTH RIDING ROUNDABOUT

January 12, 2022

Most Views

Photo here and at top, courtesy of Kristina Marcais

ROUNDABOUT ALTERNATIVES:

Conventional single-lane
versus
Mini (traversable)

Northbound I-5 Ramp Terminal
at La Novia Avenue San Juan Capistrano, CA

Diameter = 150'

Mini-roundabout at EB U.S. 50 ramp terminal
for Thompson Creek Rd. | Stevensville, Maryland

Diameter = 75'

Diameter (ICD) is twice (or half) the size!

What is the difference in **project cost?**
What is the difference in **performance?**

City of San Diego Modular Roundabout (Quick Build) Installation

Modular Curb

L = 4 ft

Modesto Quick/Quicker Build Roundabout

Saving Time, Money, and Lives through Performance-Based Intersection Evaluation and Design

Brian Ray

Sunrise Transportation Strategies

Highway Safety Manual (HSM) Application for ISOAP

LTAP Virtual Workshop

June 17, 2025

PROJECT DELIVERY
DOC | DOD | DES | DEA | DPM | DRWLS

Division of Design
Office of Project Support

AGENDA

1. Determine HSM Part C Facility Type to verify if
   a) the intersection control type proposed is available and;
   b) no limitations with AADTs
   c) other Limitations (Roundabouts, DDIs, etc.)
2. Part D used Quantitatively vs Qualitatively
3. Economic Analysis overview
4. Example demonstrating steps to apply the HSM for ISOAP
5. Useful Tips
6. Resources

Parts of the HSM

- Part A – Introduction, Human Factors, and Fundamentals
- Part B – Roadway Safety Management Process
- Part C – Introduction to the HSM Predictive Method
- Part D – Crash Modification Factors

HSM Part C Chapters

Identify the most appropriate HSM facility type for your project:

HSM Guidance:

Classifying an area as urban, suburban, or rural is subject to the roadway characteristics, surrounding population and land uses and is at the user's discretion. In the HSM, the definition of "urban" and "rural" areas is based on Federal Highway Administration (FHWA) guidelines which classify "urban" areas as places inside urban boundaries where the population is greater than 5,000 persons. "Rural" areas are defined as places outside urban areas which have a population less than 5,000 persons. The HSM uses the term "suburban" to refer to outlying portions of an urban area; the predictive method does not distinguish between urban and suburban portions of a developed area.

- Ch. 10: Rural 2-lane, 2-way Roads
- Ch. 11: Rural Multilane Highways
- Ch. 12: Urban & Suburban Arterials
- Ch. 19: Ramps (Contain the ramp terminal intersections @ fwy interchanges)

FHWA National Highway System database (HEPGIS)

- https://hepgis-usdot.hub.arcgis.com/pages/national-highway-system

Part C Facility/Intersection Types and Associated AADT Limits

No Part C Models for Roundabouts, DDIs, RCUTs, etc.

Rural Two-Lane, Two-Way Roads		
Facility Type	$AADT_{major}$ *(veh/day)*	$AADT_{minor}$ *(veh/day)*
Roadway segment	0 to 17,800	
Three-leg stop controlled intersection (3ST)	0 to 19,500	0 to 4,300
Four-leg stop controlled intersection (4ST)	0 to 14,700	0 to 3,500
Four-leg signalized intersection (4SG)	0 to 25,200	0 to 12,500

Reference Section 10.6 Safety Performance Functions

Rural Multilane Highways		
Facility Type	$AADT_{major}$ *(veh/day)*	$AADT_{minor}$ *(veh/day)*
Four-lane undivided segment (4U)	0 to 33,200	
Four-lane divided segment (4D)	0 to 89,300	
Unsignalized three-leg intersection with minor-road stop control (3ST)	0 to 78,300	[illegible] to 23,00[illegible]
Unsignalized four-leg intersection with minor-road stop control (4ST)	0 to 78,[illegible]0	[illegible] 7,400
Signalized four-leg intersection (4SG)	[illegible]	0 to 1[illegible]

Reference Section 11.6 Safety Performance Functions

Urban & Suburban Arterials		
Facility Type	$AADT_{major}$ *(veh/day)*	[illegible]DT minor *(veh/day)*
Two-lane undivided arterial (2U)	[illegible]	
Three-lane arterial including a center [illegible]-way [illegible] lane (TWLTL) (3T)	[illegible]900	
Four-lane undivided arteri[illegible]	[illegible] 40,100	
Four-lane divided [illegible] (including a raised [illegible] median) (4D)	0 to 66,000	
Four-lan[illegible]rial in[illegible]ding a center TWLTL (5T)	0 to 53,800	
Un[illegible]zed [illegible]ree-leg intersection ([illegible] minor-road approaches) (3ST)	0 to 45,700	0 to 9,300
[illegible]ed three-leg intersection (3SG)	0 to 58,100	0 to 16,400
[illegible]signalized four-leg intersection (stop control on minor-road approaches) (4ST)	0 to 46,800	0 to 5,900
Signalized four-leg intersection (4SG)	0 to 67,700	0 to 33,400

Freeway Segments		
Facility Type	Through Lanes	AADT *(veh/day)*
Rural	4	0 to 73,000
	6	0 to 130,000
	8	0 to 190,000
Urban	4	0 to 110,000
	6	0 to 180,000
	8	0 to 270,000
	10	0 to 310,000

Refe[illegible] 18.6 S[illegible]y Performance Functions

Ra[illegible] [illegible]egments		
Facil[illegible] Type	Through Lanes	AADT *(veh/day)*
Rural	1	0 to 7,000
Urban	1	0 to 18,000
	2	0 to 32,000

Reference Section 19.6 [illegible] P[illegible]rmance Functions

Ra[illegible] Terminals			
Fac[illegible] Typ[illegible]	Control Type	Crossroad AADT *(veh/day)*	Total All Ramps AADT *(veh/day)*
Three-leg terminals with diagonal exit ramp	Stop Control (ST)	0 to 22,000	0 to 8,000
	Signal Control (SG)	0 to 34,000	0 to 16,000
Three-leg terminals with diagonal entrance ramp	Stop Control (ST)	0 to 22,000	0 to 15,000
	Signal Control (SG)	0 to 29,000	0 to 21,000
Four-leg terminals with diagonal ramps	Stop Control (ST)	0 to 18,000	0 to 10,000
	Signal Control (SG)	0 to 47,000	0 to 31,000
Four-leg terminals at four-quadrant partial cloverleaf A	Stop Control (ST)	0 to 21,000	0 to 12,000
	Signal Control (SG)	0 to 71,000	0 to 30,000
Four-leg terminals at four-quadrant partial cloverleaf B	Stop Control (ST)	0 to 20,000	0 to 12,000
	Signal Control (SG)	0 to 45,000	0 to 29,000
Three-leg terminals at two-quadrant partial cloverleaf A	Stop Control (ST)	0 to 17,000	0 to 12,000
	Signal Control (SG)	0 to 46,000	0 to 25,000
Three-leg terminals at two-quadrant partial cloverleaf B	Stop Control (ST)	0 to 26,000	0 to 14,000
	Signal Control (SG)	0 to 44,000	0 to 22,000

Part C Screening Process – Site-type, Limitations Can I apply a Quantitative Analysis?

1) Identify the most appropriate HSM facility type for the project
   - Rural 2 lane, Rural multi-lane, or Urban/Suburban arterials?
2) Identify the appropriate HSM site type for the existing and proposed intersection control types
   - E.g., 3-leg stop controlled intersection (3ST), 4-leg signalized intersection (4SG), etc.
3) AADT limitations for the Site-type/Intersection Control
   - Check if the project design year AADT falls within the applicable range
4) Applying CMF
   - Identify which attributes are present within the existing and proposed intersections that aren't accounted for with the Part C models.
   - Part D CMF is applied to a completed Part C analysis that captures a change not available in the Part C models.

PARTS OF THE HSM

- Part A – Introduction, Human Factors, and Fundamentals
- Part B – Roadway Safety Management Process
- Part C – Introduction to the HSM Predictive Method
- Part D – Crash Modification Factors

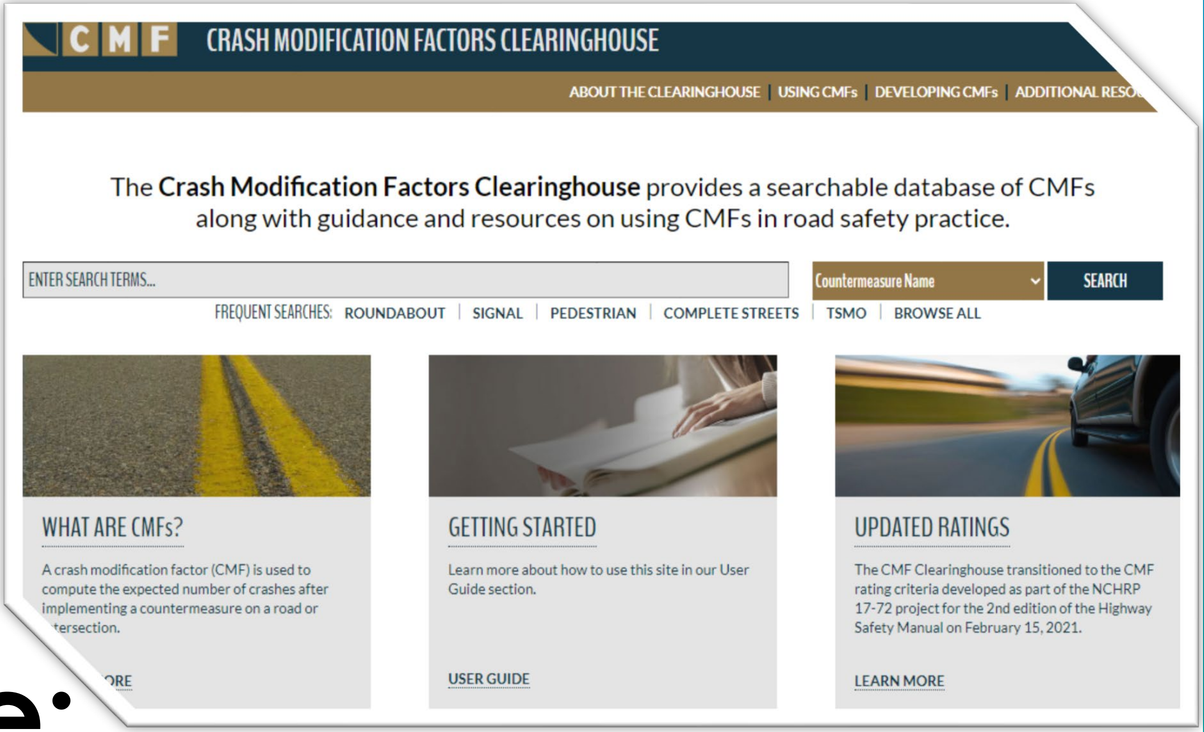
HSM Part D CMFs

- A CMF represents the relative change in crash frequency due to a change in one specific condition (all other conditions & site characteristics remain constant).
- CMFs can be applied (in order of preference):
  1. Quantitatively: part D CMF is applied to a completed Part C analysis that captures a change not available in the Part C models.
  2. Qualitatively: to indicate an anticipated change in crash frequency by applying a specific countermeasure, if a Part C model is not applicable. Therefore, a part D CMF is NOT applied to a completed Part C analysis.

Quantitative or Qualitative Results

HSM Part D CMF Clearinghouse

- Chapter 13: Roadway Segments
- Chapter 14: Intersections
- Chapter 15: Interchanges
- Chapter 16: Special Facilities & Geometric Situations
- Chapter 17: Road Networks



- **CMF Clearinghouse:** https://www.cmfclearinghouse.org/

$$* CRF = 1 - CMF*$$

QUANTITATIVE ANALYSIS IS REQUIRED FOR AN ECONOMIC ANALYSIS

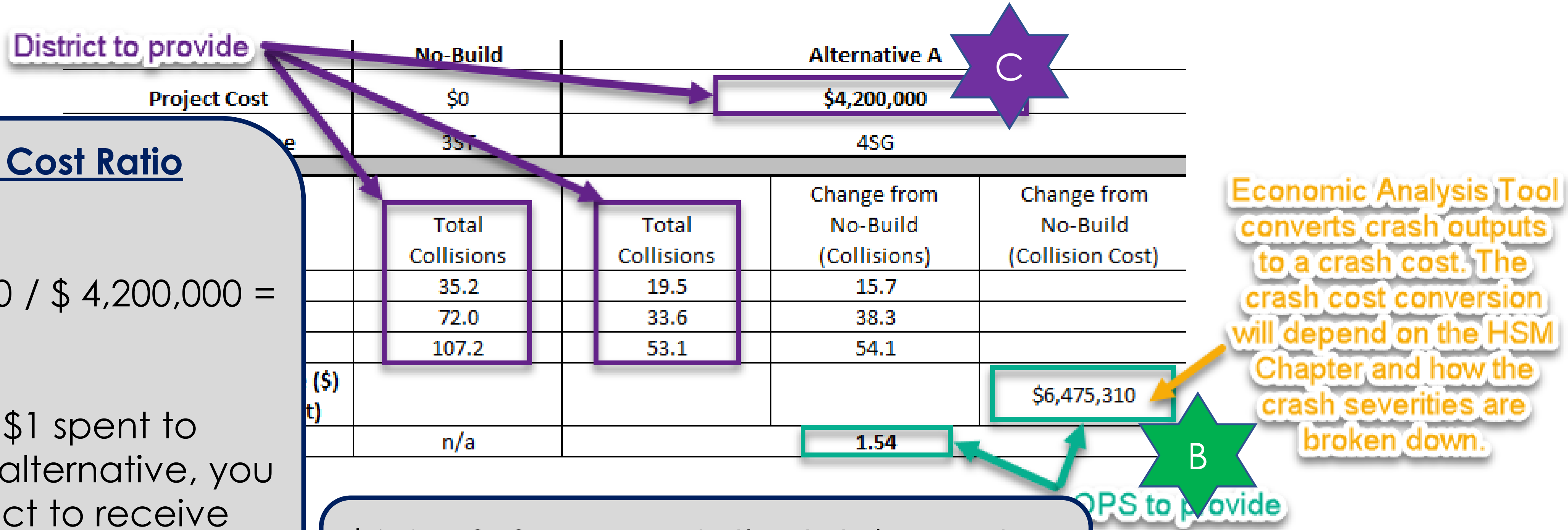
District to provide

		No-Build	Alternative A		
Project Cost		$0	$4,200,000		
Intersection Type		3ST	4SG		
Collision Severity		Total Collisions	Total Collisions	Change from No-Build (Collisions)	Change from No-Build (Collision Cost)
20 Year Design Period	F+I	35.2	19.5	15.7	
	PDO	72.0	33.6	38.3	
	Total	107.2	53.1	54.1	
	Total Change ($) (B = Benefit)				$6,475,310
	B/C Ratio	n/a		1.54	

Economic Analysis Tool converts crash outputs to a crash cost. The crash cost conversion will depend on the HSM Chapter and how the crash severities are broken down.

OPS to provide

Quantitative Analysis is required for an Economic Analysis



Benefit to Cost Ratio (B/C)

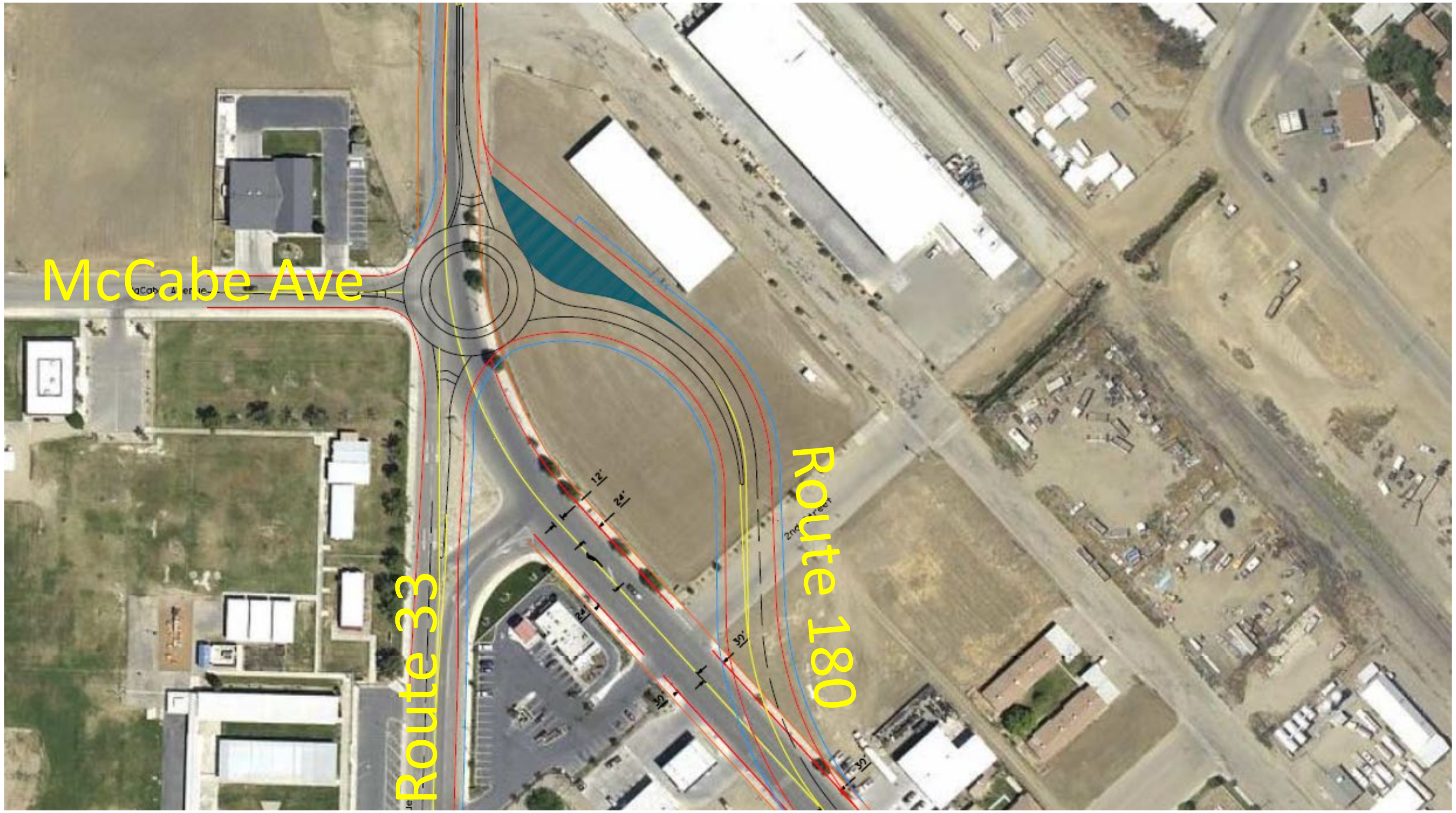
$6,475,310 / $ 4,200,000 = 1.54

For every $1 spent to build the alternative, you can expect to receive $1.54 of safety benefit.

$6,475,310 represents the total monetary benefit (or savings) associated with the decrease in collisions.

Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

- Original roundabout concept, with realignment of SR 180
- McCabe provides access to a residential neighborhood

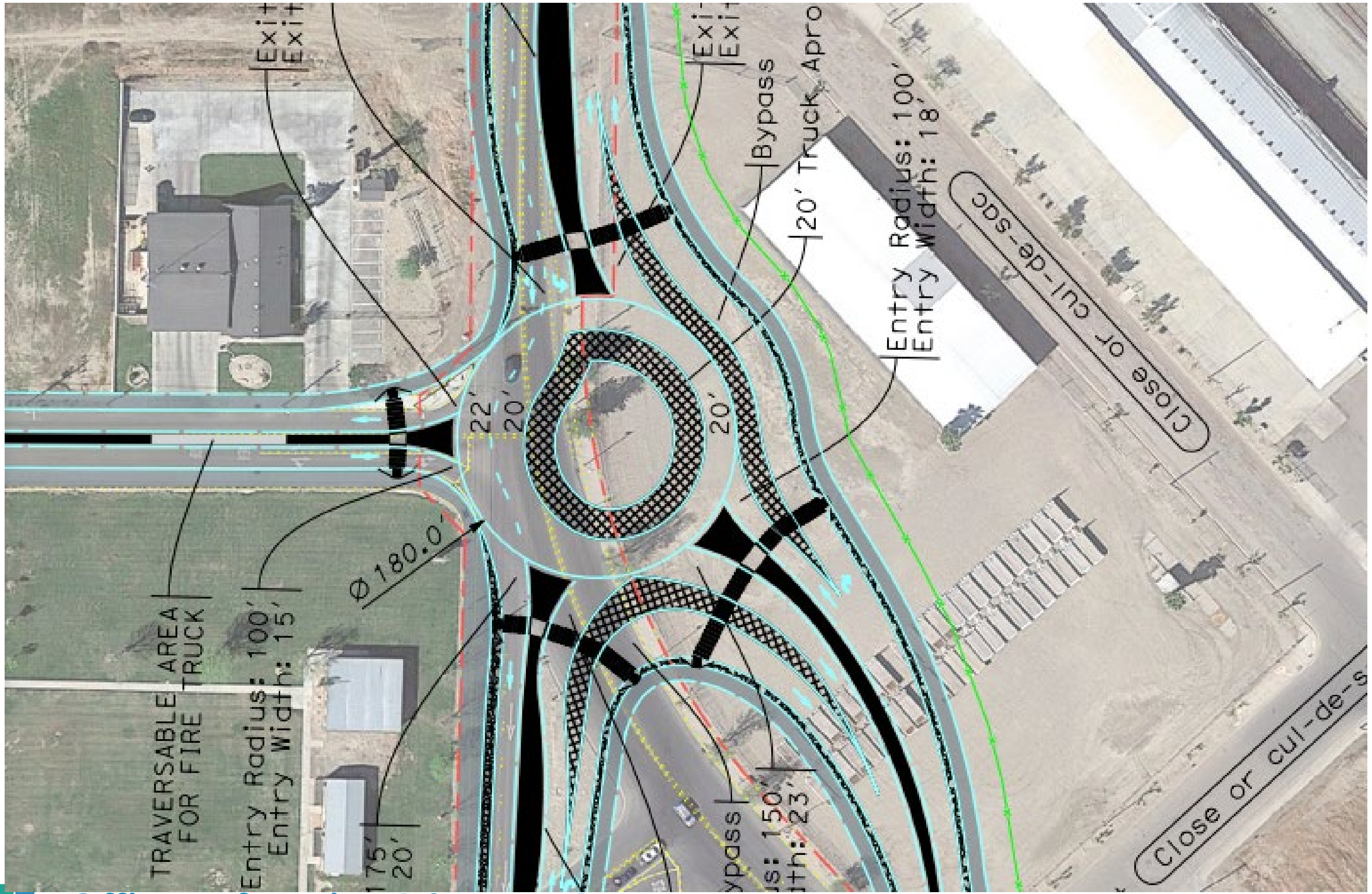


Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

- Signal concept with the realigned SR 180

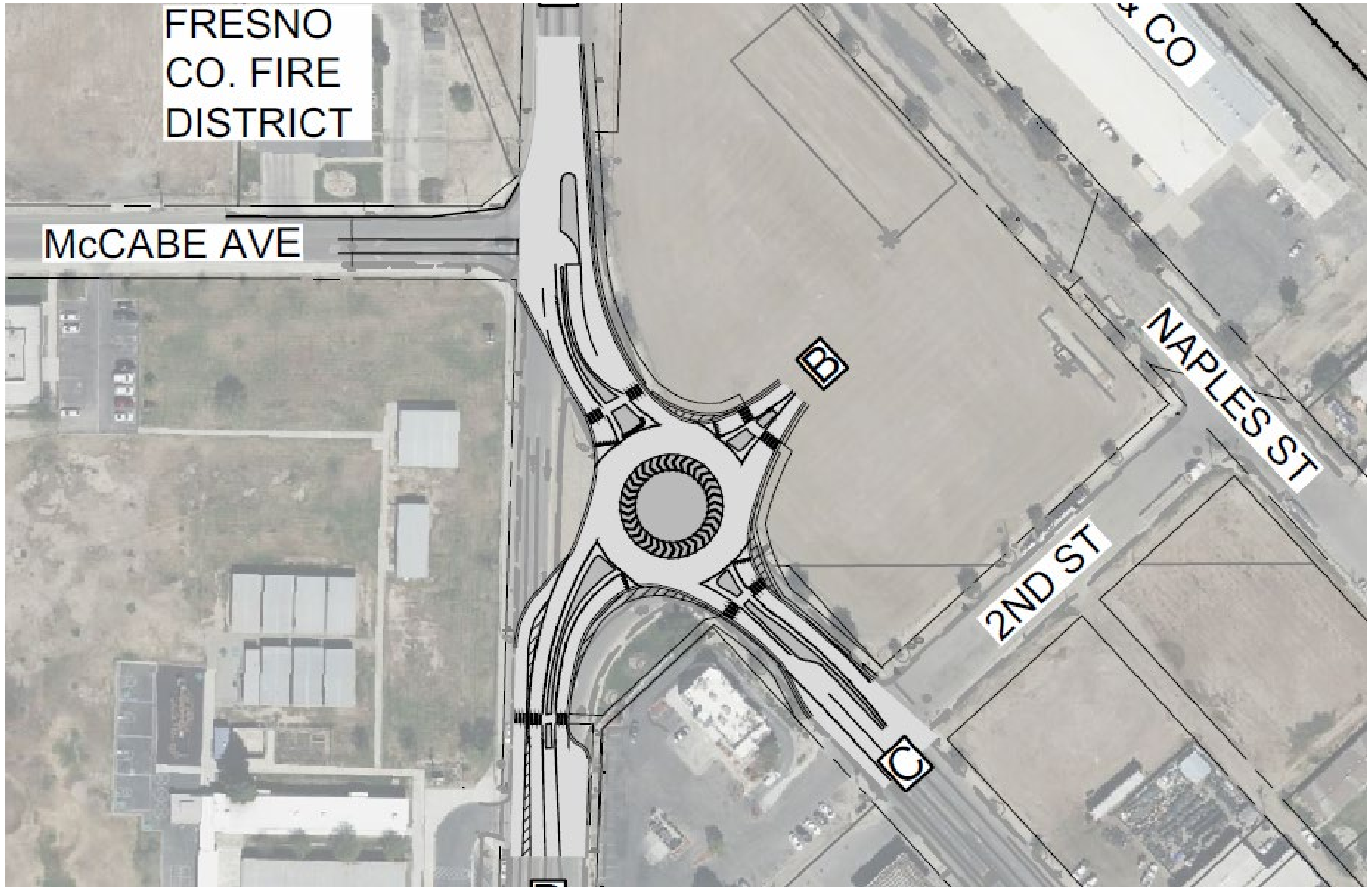
Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

- Roundabout concept from the PSR
- Cost was excessive, and project was no longer viable



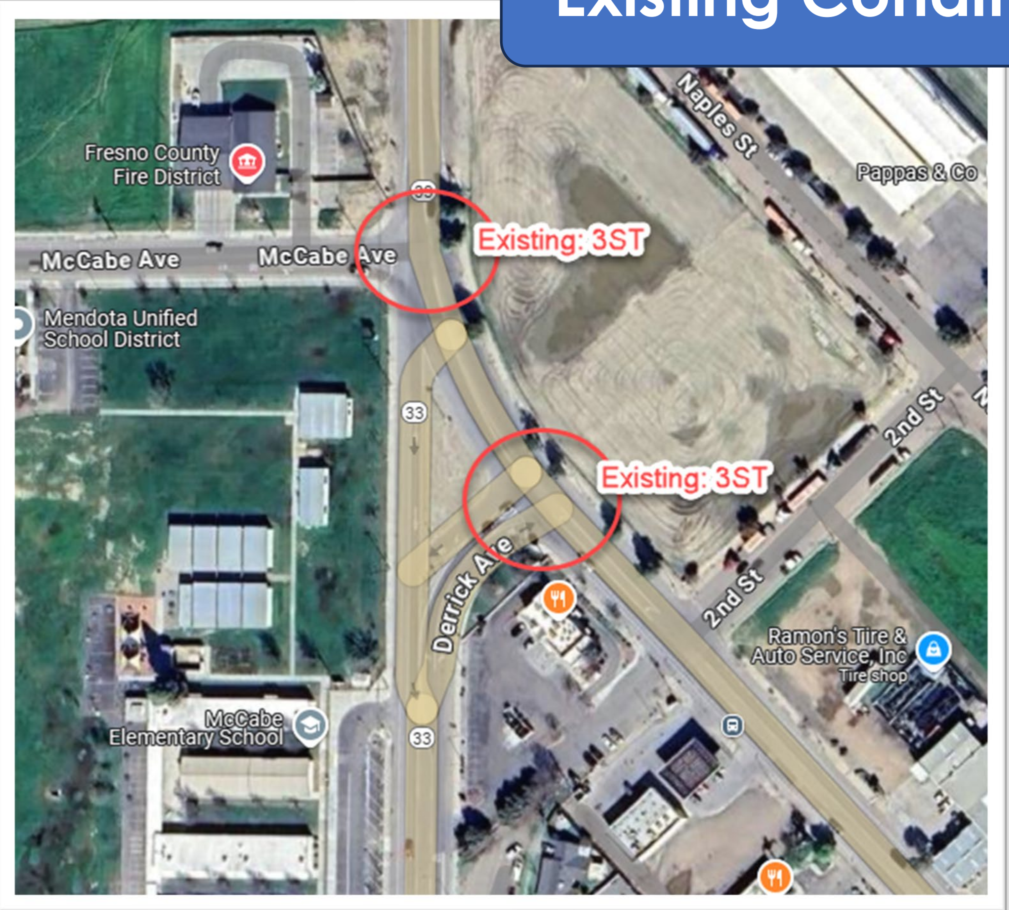
Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

- Design for PS&E
- Does not provide 20-year design life
- No lefts out from McCabe Ave, though fire trucks can go over mountable island
- Bids recently opened, low bid $3.1 million, engineer's estimate $3.9 million



Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

Existing Condition



<u>Existing Condition (No-Build)</u>:

1) Place-type
   - Urban/Suburban -> Chapter 12
2) Existing intersection controls
   - McCabe Ave & SR33
     - 3-leg stop controlled (**3ST**)
   - Derrick Ave & SR180
     - 3-leg stop controlled (**3ST**)
3) 20-year design life
   - Design years: **2026 - 2046**

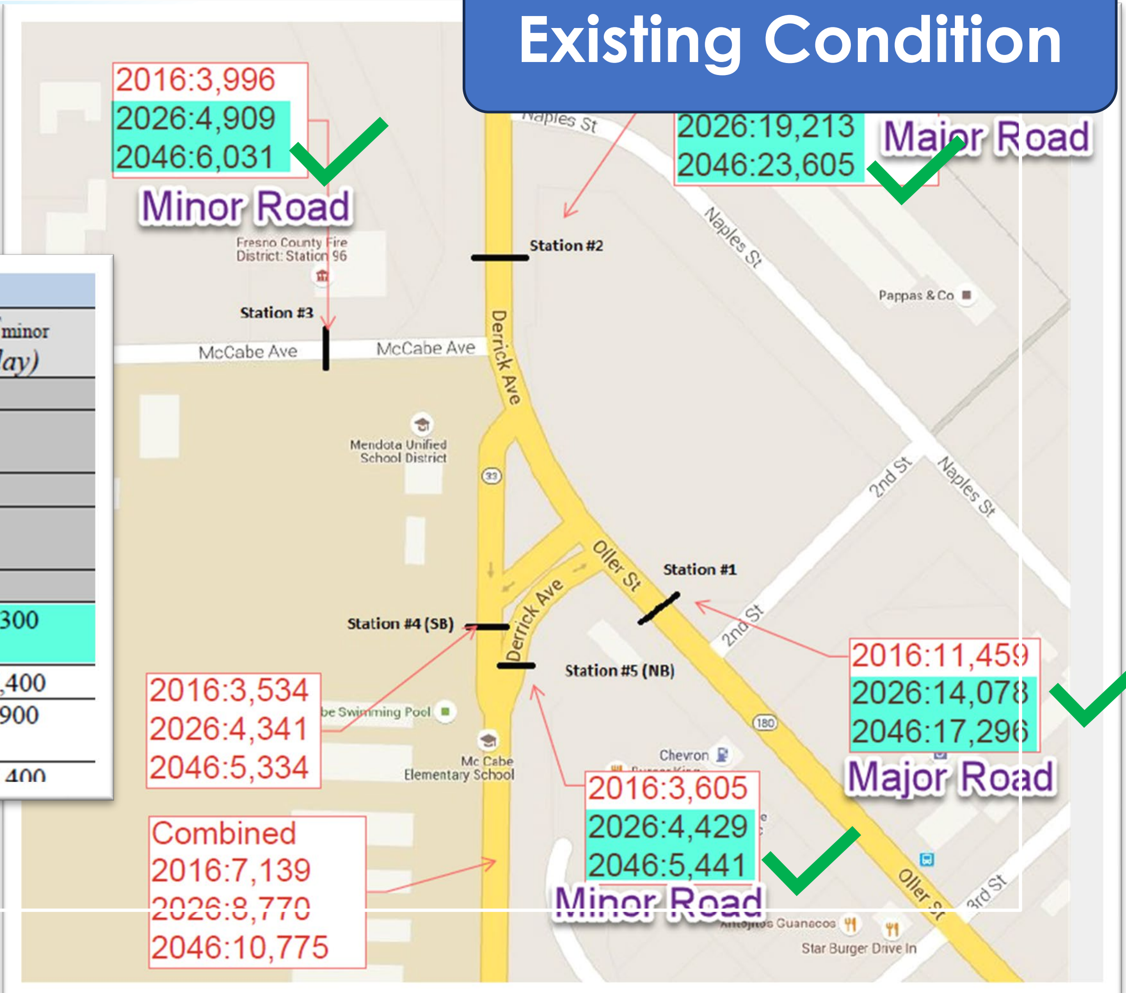
Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

Existing Condition (No-Build):

4) AADT check

Urban & Suburban Arterials		
Facility Type	AADT$_{major}$ *(veh/day)*	AADT$_{minor}$ *(veh/day)*
Two-lane undivided arterial (2U)	0 to 32,600	
Three-lane arterial including a center two-way left-turn lane (TWLTL) (3T)	0 to 32,900	
Four-lane undivided arterial (4U)	0 to 40,100	
Four-lane divided arterial (including a raised or depressed median) (4D)	0 to 66,000	
Four-lane arterial including a center TWLTL (5T)	0 to 53,800	
Unsignalized three-leg intersection (stop control on minor-road approaches) (3ST)	0 to 45,700	0 to 9,300
Signalized three-leg intersection (3SG)	0 to 58,100	0 to 16,400
Unsignalized four-leg intersection (stop control on minor-road approaches) (4ST)	0 to 46,800	0 to 5,900
Signalized four-leg intersection (4SG)	0 to 67,700	0 to 33,400

Existing Condition



Office of Project Support

Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

Alternative A

Proposed **Signal @ McCabe Ave** (Alternative A):

1) Place-type
   - Urban/Suburban -> Chapter 12
2) **Proposed** intersection controls
   - McCabe Ave & SR33
     - **NEW** 4-leg signal controlled (**4SG**)
   - Derrick Ave & SR180
     - eliminated
3) 20-year design life
   - Design years: **2026 - 2046**

QUANTITATIVE EXAMPLE: McCABE AVE, DERRICK AVE & SR 33/180

Alternative A

Proposed **Signal @ McCabe Ave** (Alternative A):

4) AADT check

Urban & Suburban Arterials		
Facility Type	$AADT_{major}$ *(veh/day)*	$AADT_{minor}$ *(veh/day)*
Two-lane undivided arterial (2U)	0 to 32,600	
Three-lane arterial including a center two-way left-turn lane (TWLTL) (3T)	0 to 32,900	
Four-lane undivided arterial (4U)	0 to 40,100	
Four-lane divided arterial (including a raised or depressed median) (4D)	0 to 66,000	
Four-lane arterial including a center TWLTL (5T)	0 to 53,800	
Unsignalized three-leg intersection (stop control on minor-road approaches) (3ST)	0 to 45,700	0 to 9,300
Signalized three-leg intersection (3SG)	0 to 58,100	0 to 16,400
Unsignalized four-leg intersection (stop control on minor-road approaches) (4ST)	0 to 46,800	0 to 5,900
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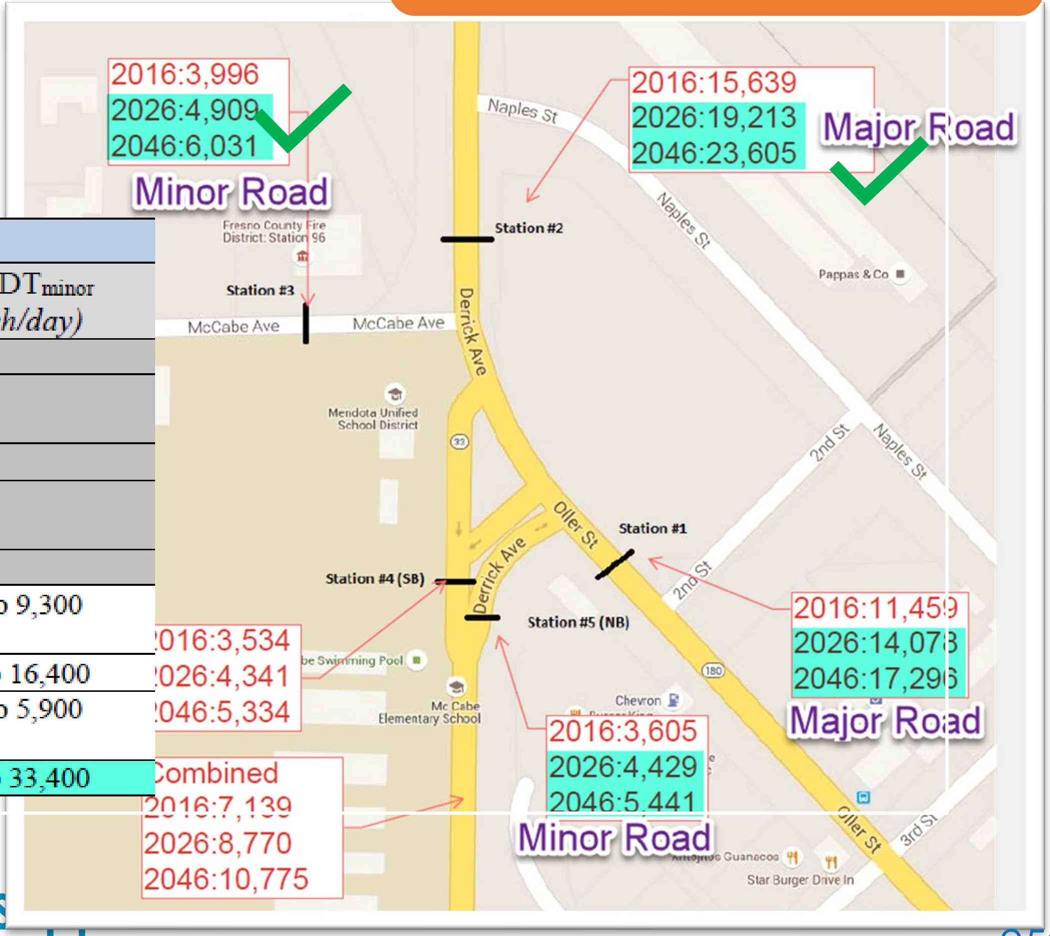
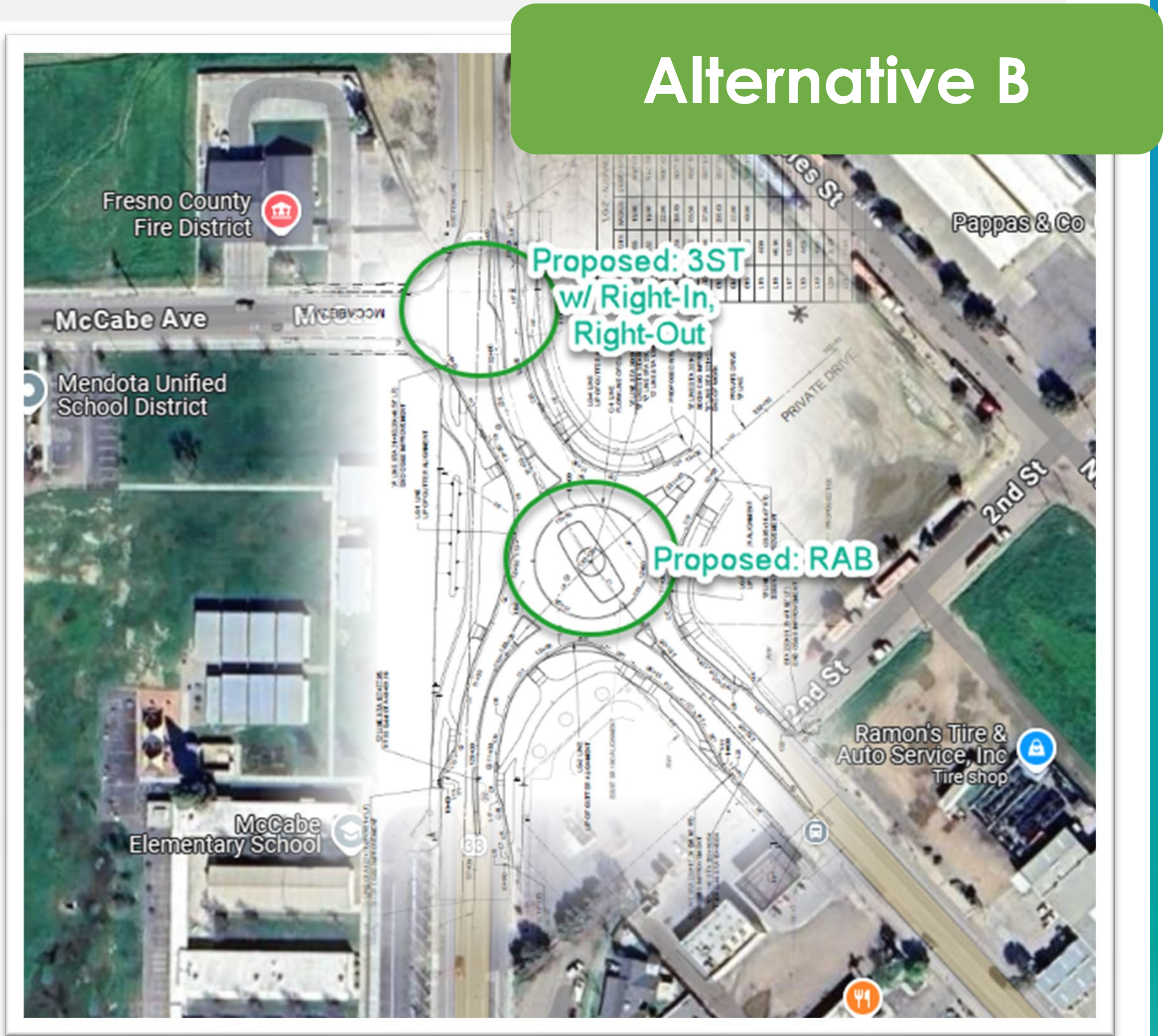


Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

Proposed **RAB @ Derrick Ave** (Alternative B):

1) Place-type
   - Urban/Suburban -> Chapter 12
2) **Proposed** intersection controls
   - McCabe Ave & SR33
     - **NEW** 3-leg stop controlled (**3ST**) w/ Right-in, Right-out
   - Derrick Ave & SR180
     - **NEW** Roundabout (**RAB**)
3) 20-year design life
   - Design years: **2026 - 2046**



Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

Alternative B

Proposed RAB @ Derrick Ave (Alternative B):

Apply Part D CMFs from Clearinghouse

McCabe Ave & SR33

- 3-leg stop controlled (3ST) w/ Right-in, Right-out
- Install right-in-right-out (RIRO) operations at stop-controlled intersections
- **CMF ID = 9821; CMF = 0.55**

Derrick Ave & SR180

- **Roundabout** (**RAB**)
- Convert intersection with minor road stop control to modern roundabout
- **CMF ID = 236; CMF = 0.68**

Countermeasure Name	Install right-in-right-out (RIRO) operations at stop-controlled intersections
CMF ID	9821
CMF	0.55
Study Reference	LE ET AL., 2018
Unadjusted Standard Error AMF	*0.09*
CMFunction	
Star Rating	★★★☆☆
Rating Score Total	*105*
Crash Type	All
Crash Severity	
Crash Time of Day	All
Area Type	Urban
Road Division Type	Divided by Median
Road Type	Not specified
Min Number of Lanes	4
Max Number of Lanes	6
Number of Lanes Direction	
Number of Lanes Comment	4 and 6 Lanes
Intersection Type	Roadway/roadway (not interchange related)
Intersection Geometry	*3-leg*
Traffic Control	*Stop-controlled*
Minimum Speed Limit	

Countermeasure Name	Convert intersection with minor-road stop control to modern roundabout
CMF ID	236
CMF	0.68
Study Reference	RODEGERDTS ET AL., 2007
Unadjusted Standard Error AMF	*0.07*
CMFunction	
Star Rating	★★★☆☆
Rating Score Total	*85*
Crash Type	All
Crash Severity	All
Crash Time of Day	
Area Type	Suburban
Road Division Type	
Road Type	Not Specified
Min Number of Lanes	*1*
Max Number of Lanes	*2*
Number of Lanes Direction	
Number of Lanes Comment	
Intersection Type	Roadway/roadway (not interchange related)
Intersection Geometry	4-leg
Traffic Control	Stop-control
Minimum Speed Limit	
Maximum Speed Limit	

Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

Proposed **RAB @ Derrick Ave** (Alternative B):

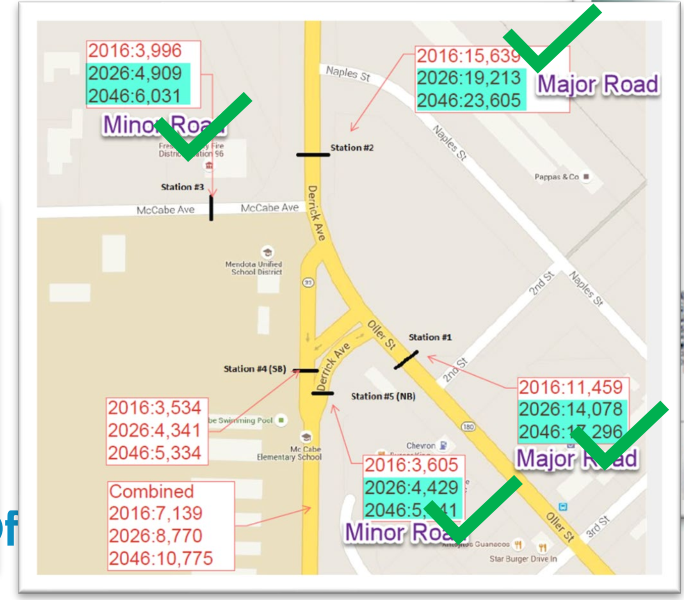
Alternative B

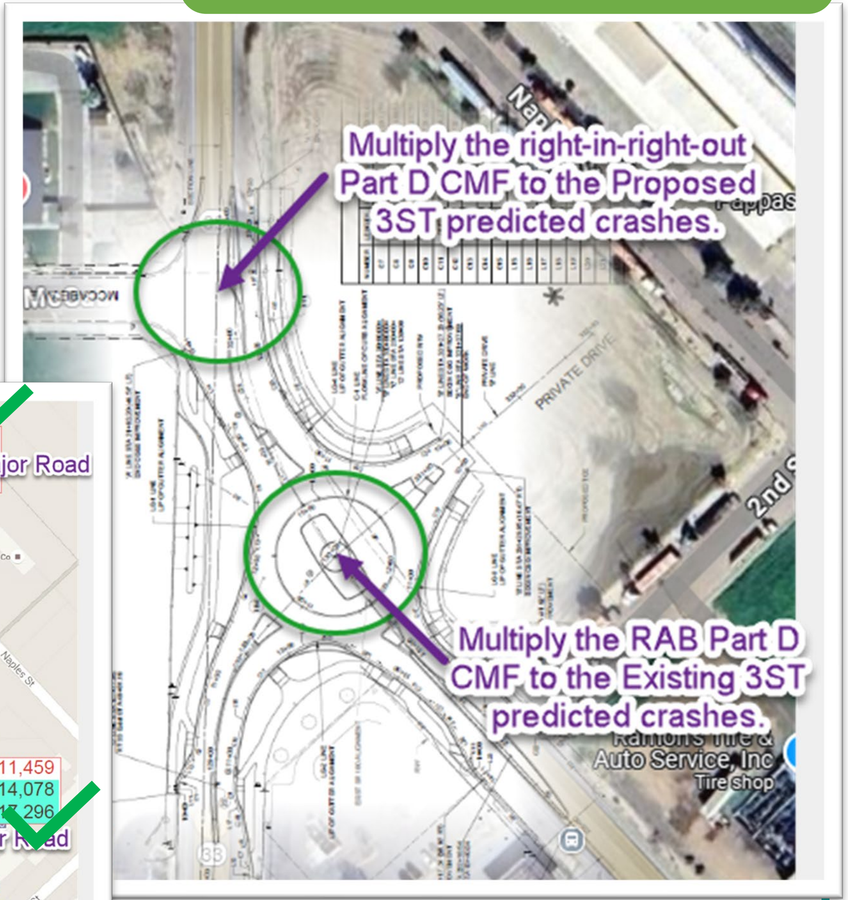
4) AADT check

5) HSM analysis approach

- McCabe Ave & SR33 – Multiply CMF 9821 to proposed 3ST predicted crashes
- Derrick Ave & SR180 – Multiply CMF 236 to existing 3ST predicted crashes

Urban & Suburban Arterials		
Facility Type	AADT major (veh/day)	AADT minor (veh/day)
Two-lane undivided arterial (2U)	0 to 32,600	
Three-lane arterial including a center two-way left-turn lane (TWLTL) (3T)	0 to 32,900	
Four-lane undivided arterial (4U)	0 to 40,100	
Four-lane divided arterial (including a raised or depressed median) (4D)	0 to 66,000	
Four-lane arterial including a center TWLTL (5T)	0 to 53,800	
Unsignalized three-leg intersection (stop control on minor-road approaches) (3ST)	0 to 45,700	0 to 9,300
Signalized three-leg intersection (3SG)	0 to 58,100	0 to 16,400
Unsignalized four-leg intersection (stop control on minor-road approaches) (4ST)	0 to 46,800	0 to 5,900
Signalized four-leg intersection (4SG)	0 to 67,700	0 to 33,400





Quantitative Example:
McCabe Ave, Derrick Ave & SR 33/180
HSM Part C Summary

Compile a summary for submission to HQ DOD OPS:

		No-Build			Alternative A - Signal	Alternative B - Roundabout				
Project Cost		$0			$4,200,000	$2,750,000				
Intersection		Derrick/SR 180	McCabe/SR 33			Derrick/SR 180	Derrick/SR 180 w/Part D Roundabout CMF CMF = 0.68	McCabe/SR 33	McCabe/SR 33 w/ Right In, Right Out Part D CMF CMF = 0.55	
Collision Severity		Collisions	Collisions	Total Collisions	Total Collisions	Collisions	Collisions	Collisions	Collisions	Total Collisions
20 Year Design Period	F+I	11.46	23.78	35.24	19.52	11.46	7.79	15.94	8.77	16.56
	PDO	22.91	49.04	71.95	33.62	22.91	15.58	32.86	18.07	33.65
	Total			107.19	53.14					50.21

results from "...Ex3STInt1.xlsx"

results from "...Ex3STInt2.xlsx"

results from "...Proposed4SGInt2.xlsx"

results from "...Ex3STInt1.xlsx"

results from "...Proposed3STInt2.xlsx"

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Quantitative Example: McCabe Ave, Derrick Ave & SR 33/180

HSM Part C Economic Analysis

HQ DOD OPS will apply the crash prediction numbers into the Economic Analysis Tool:

		No-Build			Alternative A - Signal			Alternative B - Roundabout						
Project Cost		$0			$4,200,000			$2,750,000						
Intersection		Derrick/SR 180	McCabe/SR 33					Derrick/SR 180	Derrick/SR 180 w/Part D Roundabout CMF CMF = 0.68	McCabe/SR 33	McCabe/SR 33 w/ Right In, Right Out Part D CMF CMF = 0.55			
Collision Severity		Collisions	Collisions	Total Collisions	Total Collisions	Change from No-Build (Collisions)	Change from No-Build (Collision Cost)	Collisions	Collisions	Collisions	Collisions	Total Collisions	Change from No-Build (Collisions)	Change from No-Build (Collision Cost)
20 Year Design Period	F+I	11.461	23.78	35.241	19.52	15.721		11.461	7.79348	15.94	8.767	16.56	18.68052	
	PDO	22.91	49.04	71.95	33.62	38.33		22.91	15.5788	32.86	18.073	33.652	38.2982	
	Total			107.19	53.14	54.051						50.212	56.97872	
	Total Change ($) (B = Benefit)						$6,475,310							$6,826,084
	B/C Ratio	n/a				1.54					2.48			

$6,475,310 / $4,200,000 = 1.54

$6,826,084 / $2,750,000 = 2.48

QUESTIONS?

HSM.Support@dot.ca.gov

https://design.onramp.dot.ca.gov/performance-based-design

Thank You!

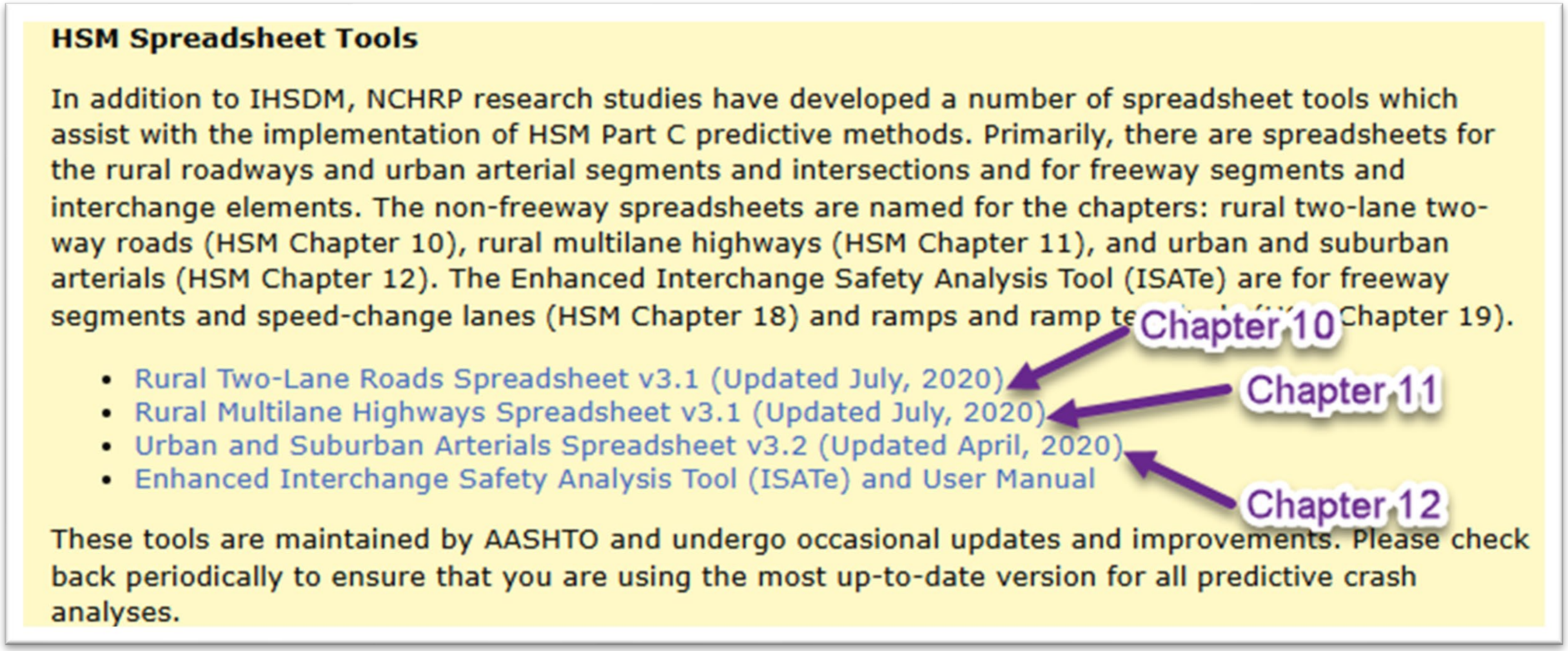
PROJECT DELIVERY
DOC | DOD | DES | DEA | DPM | DRWLS

Division of Design
Office of Project Support

HSM Part C Spreadsheet Tools

Where to find HSM spreadsheet tools?

- https://www.highwaysafetymanual.org/Pages/Tools.aspx



HSM Spreadsheet Tools

In addition to IHSDM, NCHRP research studies have developed a number of spreadsheet tools which assist with the implementation of HSM Part C predictive methods. Primarily, there are spreadsheets for the rural roadways and urban arterial segments and intersections and for freeway segments and interchange elements. The non-freeway spreadsheets are named for the chapters: rural two-lane two-way roads (HSM Chapter 10), rural multilane highways (HSM Chapter 11), and urban and suburban arterials (HSM Chapter 12). The Enhanced Interchange Safety Analysis Tool (ISATe) are for freeway segments and speed-change lanes (HSM Chapter 18) and ramps and ramp te[illegible] Chapter 19).

- Rural Two-Lane Roads Spreadsheet v3.1 (Updated July, 2020)
- Rural Multilane Highways Spreadsheet v3.1 (Updated July, 2020)
- Urban and Suburban Arterials Spreadsheet v3.2 (Updated April, 2020)
- Enhanced Interchange Safety Analysis Tool (ISATe) and User Manual

These tools are maintained by AASHTO and undergo occasional updates and improvements. Please check back periodically to ensure that you are using the most up-to-date version for all predictive crash analyses.

HSM Part C Spreadsheet Inputs

Prior to inputting information into these spreadsheets, conduct your *preliminary research and gather the values* for the required data!

1) AADT can be linearly interpolated for each of the 20 design years between 2026 and 2046.
2) Inputs for the Urban and Suburban Arterials spreadsheet intersection site-types (e.g. 3ST, 4SG) include:
   - # of approaches with right-turn/left-turn lanes/right-turn-on-red, etc.
   - types of signal phasing
   - # of red light cameras
   - Pedestrian crossing volumes and # of lanes crossed by pedestrians
   - Within a 1000ft of the intersection, how many:
     - # of bus stops
     - Presence of schools
     - # of alcohol sales establishments

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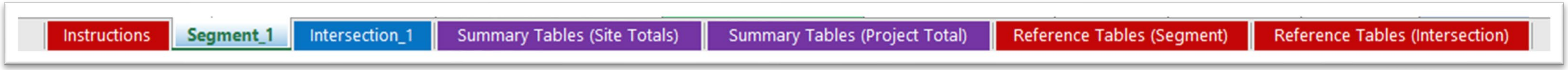
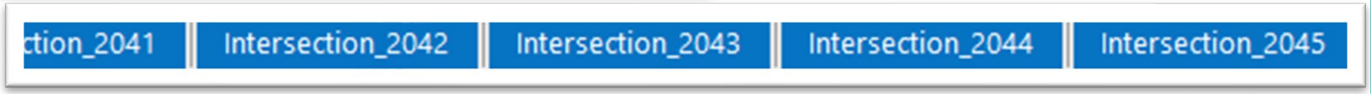
HSM Part C Spreadsheet Inputs

The default spreadsheet file consists of these worksheet tabs:



- One intersection tab is limited to analyzing and providing crash prediction numbers for only (1) one intersection site-type and for only (2) 1 year!
- Recommendation:
  - Each spreadsheet file will analyze only 1 intersection location.
  - The intersection tabs in a spreadsheet file should be renamed accordingly and replicated to account for the entire design life of 20 years.
  - The only difference of input between the tabs should be AADT.



HSM Part C Spreadsheet Inputs

Under the "Summary Tables (Project Total)" tab, expand the number of rows in Worksheet 4A and Worksheet 4B to include all of the 20 years:

INTERSECTIONS												
Multiple-vehicle												
Intersection_2026	1.209	0.381	0.828	--	0.800	1.170	0.984	--	--	--	--	--
Intersection_2027	1.231	0.387	0.843	--	0.800	1.211	0.992	--	--	--	--	--
Intersection_2028	1.252	0.393	0.859	--	0.800	1.253	1.001	--	--	--	--	--
Intersection_2029	1.273	0.399	0.874	--	0.800	1.297	1.009	--	--	--	--	--
Intersection_2030	1.295	0.405	0.889	--	0.800	1.341	1.018	--	--	--	--	--
Intersection_2031	1.316	0.411	0.905	--	0.800	1.386	1.026	--	--	--	--	--
Intersection_2032	1.338	0.417	0.921	--	0.800	1.432	1.035	--	--	--	--	--
Intersection_2033	1.360	0.423	0.936	--	0.800	1.479	1.043	--	--	--	--	--
Intersection_2034	1.381	0.429	0.952									
Intersection_2035	1.404	0.435	0.968									
Intersection_2036	1.426	0.441	0.984									
Intersection_2037	1.448	0.447	1.001									
Intersection_2038	1.470	0.454	1.017									
Intersection_2039	1.493	0.460	1.033									
Intersection_2040	1.516	0.466	1.050									
Intersection_2041	1.538	0.472	1.066									
Intersection_2042	1.561	0.478	1.083									
Intersection_2043	1.584	0.485	1.100									
Intersection_2044	1.607	0.491	1.116									
Intersection_2045	1.630	0.497	1.133									
Intersection Totals:	28.332	8.772	19.559									
Single-vehicle												
Intersection_2026	0.224	0.069	0.156	--	1.140	0.057	0.506	--	--	--	--	--
Intersection_2027	0.226	0.069	0.157	--	1.140	0.058	0.508	--	--	--	--	--
Intersection_2028	0.228	0.070	0.158	--	1.140	0.059	0.509	--	--	--	--	--
Intersection_2029	0.229	0.070	0.159	--	1.140	0.060	0.511	--	--	--	--	--
Intersection_2030	0.231	0.071	0.161	--	1.140	0.061	0.513	--	--	--	--	--
Intersection_2031	0.233	0.071	0.162	--	1.140	0.062	0.515	--	--	--	--	--
Intersection_2032	0.234	0.071	0.163	--	1.140	0.063	0.517	--	--	--	--	--
Intersection_2033	0.236	0.072	0.164	--	1.140	0.064	0.519	--	--	--	--	--
Intersection_2034	0.238	0.072	0.165									
Intersection_2035	0.239	0.073	0.167									
Intersection_2036	0.241	0.073	0.168									
Intersection_2037	0.243	0.074	0.169									
Intersection_2038	0.244	0.074	0.170									
Intersection_2039	0.246	0.074	0.172									
Intersection_2040	0.248	0.075	0.173									
Intersection_2041	0.249	0.075	0.174									
Intersection_2042	0.251	0.076	0.175									
Intersection_2043	0.253	0.076	0.176									
Intersection_2044	0.254	0.077	0.178									
Intersection_2045	0.256	0.077	0.179									
Intersection Totals:	4.804	1.458	3.345									
COMBINED (sum of column)	33.135	10.231	22.905	0	--	11.052	12.205	0.750	24.848	0.731	24.216	24.532

Intersection_2045 | AADTs | Summary Tables (Site Totals) | Summary Tables (Project Total) | Reference Tables (Segment) | Reference Tables (Interse ...

Worksheet 4B -- Predicted Pedestrian and Bicycle Crashes for Urban and Suburban Arterials		
(1)	(2)	(3)
Site Type	N_{ped}	N_{bike}
ROADWAY SEGMENTS		
Segment 1	0.000	0.000
Segment 2	0.000	0.000
Segment 3	0.000	0.000
Segment 4	0.000	0.000
Segment 5	0.000	0.000
Segment 6	0.000	0.000
Segment 7	0.000	0.000
Segment 8	0.000	0.000
INTERSECTIONS		
Intersection_2026	0.030	0.023
Intersection_2027	0.031	0.023
Intersection_2028	0.031	0.024
Intersection_2029	0.032	0.024
Intersection_2030	0.032	0.024
Intersection_2031	0.033	0.025
Intersection_2032	0.033	0.025
Intersection_2033	0.034	0.026
Intersection_2034	0.034	0.026
Intersection_2035	0.035	0.026
Intersection_2036	0.035	0.027
Intersection_2037	0.036	0.027
Intersection_2038	0.036	0.027
Intersection_2039	0.037	0.028
Intersection_2040	0.037	0.028
Intersection_2041	0.038	0.029
Intersection_2042	0.038	0.029
Intersection_2043	0.039	0.029
Intersection_2044	0.039	0.030
Intersection_2045	0.040	0.030
COMBINED (sum of column)	0.696	0.530

HSM Part C Spreadsheet Results

Under the "Summary Tables (Project Total)" tab, Worksheet 4C will give you the crash prediction results or your intersection location, aggregated over the 20-year design life:

Worksheet 4C -- Project-Specific EB Method Summary Results for Urban and Suburban Arterials

(1)	(2)	(3)	(4)	(5)	(6)
Crash severity level	**N predicted**	**N ped**	**N bike**	N expected (vehicle)	N expected
Total	(2)COMB from Worksheet 4A	(2)COMB from Worksheet 4B	(3)COMB from Worksheet 4B	(13)COMB Worksheet 4A	(3)+(4)+(5)
	33.135	0.696	0.530	24.532	25.758
Fatal and injury (FI)	(3)COMB from Worksheet 4A	(2)COMB from Worksheet 4B	(3)COMB from Worksheet 4B	(5)TOTAL * (2)FI / (2) TOTAL	(3)+(4)+(5)
	10.231	0.696	0.530	7.574	8.800
Property damage only (PDO)	(4)COMB from Worksheet 4A	--	--	(5)TOTAL * (2)PDO / (2) TOTAL	(3)+(4)+(5)
	22.905	0.000	0.000	16.958	16.958

... AADTs | Summary Tables (Site Totals) | Summary Tables (Project Total) | Reference Tables (Segment) | Reference Tables (Intersection)

HSM Part C File Organization

To obtain your B/C ratio you will have to submit a (1) summary of your crash prediction results, (2) HSM spreadsheets, and (3) relevant backup files to HQ Design – Office of Project Support. OPS will run the Economic Analysis tool and provide you with the results.

- Please choose consistent naming convention for your files.
- Organize your files in a manner that facilitates reviewers to quickly identify which files are relevant to which alternative.
- Submit all relevant backup information used for the analysis:
  - AADT information
  - CMF research
  - #'s of bus stops, schools, alcohol establishments
  - Etc.

Office of Project Support

Part D CMF Application Criteria & Tips

Criteria (see HSM Implementation Memo Attachment 1[1] for more info):

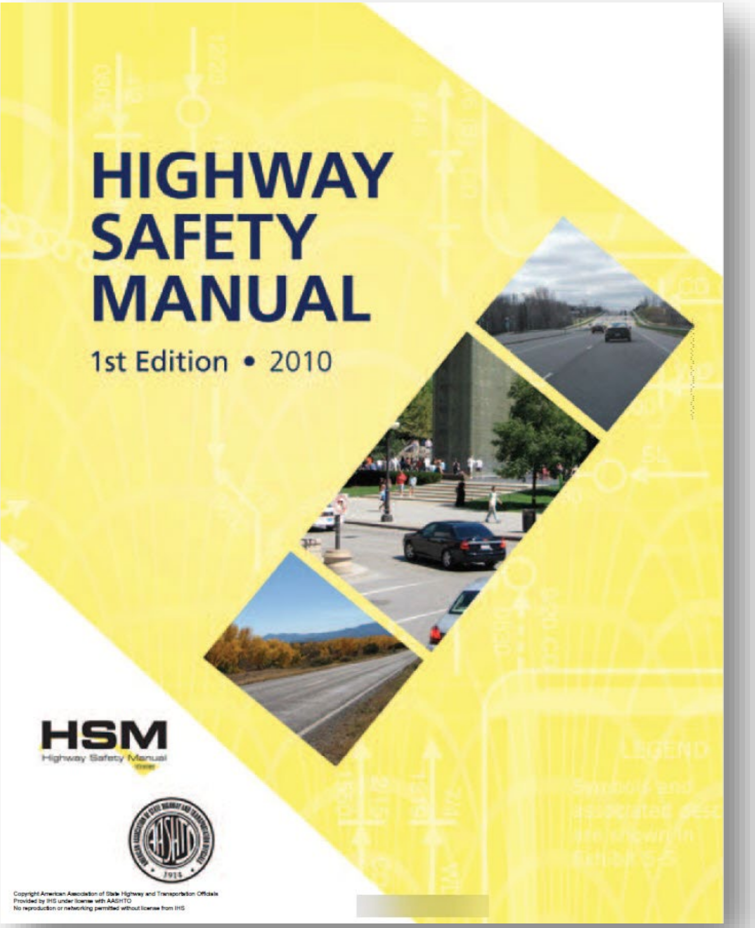
- CMF should coincide with project's before & after conditions
- CMF should be statistically significant
  - CMF does NOT pass through 1.0 w/ standard error applied
- District HSM SMEs must concur on Part D CMF chosen/applied
- Only one Part D CMF per segment and intersection

Tips:

- Filters available for country, area type, crash type, crash severity, etc.
- Star rating can be used to determine quality of CMF
- Utilize the Comparison Tool

(1) https://dot.ca.gov/-/media/dot-media/programs/design/documents/attachment-1_decision-making-guidelines-using-the-hsm_2022-04-04-a11y.pdf

Resources – AASHTO Guidance



- The HSM is available for free to Caltrans employees via the Transportation Library website:
  - https://ctlibrary.onramp.dot.ca.gov/
- Search & download using the "Engineering Workbench" link on the page. A one-time registration is required for new users.
- Current Version:
  - 1st Edition 2010 with the 2014 Supplement

Resources – Caltrans Guidance

Application of the Highway Safety Manual Methodology for Project Development

California Department of Transportation

Division of Design

March 30, 2023

This Highway Safety Manual is neither intended as, nor does it establish, a legal standard for the concepts, guidelines, and computational procedures for predicting safety performance of various highway facilities. The guidelines discussed herein for the information and guidance of the officers and employees of the Department. It is not intended that any standard of conduct or duty toward the public shall be created or imposed by the publication of this manual. This Manual is

https://dot.ca.gov/-/media/dot-media/programs/design/documents/application-of-the-hsm-methodolgy-for-project-development_2023-03_final-a11y.pdf

Supplement to the Application of the Highway Safety Manual Methodology for DIB 94 Eligible Projects

January 16, 2024

Purpose of using the HSM for DIB 94 projects

The reasons for using the Highway Safety Manual (HSM) methodologies for DIB 94 projects are to: (1) provide a scientific quantitative or qualitative safety analysis and (2) inform engineering judgement and discretion when balancing roadway cross section elements. Engineering judgment is needed when applying the HSM to the various place types described in DIB 94 in combination with the geometric design flexibility

https://dot.ca.gov/-/media/dot-media/programs/design/documents/hsm-application-for-dib-94-projects_2024-01-16_final-a11y.pdf

State & Local HSIP Methodology

Collision Cost Analysis (CCA) and Benefit / Cost Ratio

- Originally created as an extension of the State HSIP Safety Index methodology to predict the crash cost savings for intersection control evaluation alternatives;

- This methodology is currently used by Caltrans to calculate the safety index and B/C Ratio for State ***and Local*** HSIP roundabout proposals.

Intersection Control Evaluation

Collision Cost Analysis and B/C

-- Fill in tan boxes along with 'Area' --

County	Rte	Postmile	Location Description
Ker	58	0.114	SR 223

Area: (●) Rural ( ) Suburban ( ) Urban

Intersection Types:
F - Four-Legged
M - Multi-Legged
S - Offsett -Tee
Y - "Y" Wye
Z - Others

Existing Condition	# of Years for Analysis	Rate Group
Stop Control (Minor Leg), Type T, Y or Z	20	I17

Existing ADT (x1000)		Future ADT (x1000)			
Mainline	Cross St	Mainline	Cross St	Average ADT	VCF
27.0	2.0	25.4	6.0	30.2	1.04

Est. Capital Cost (x1000) for Desired Improvement

Desired Improvement	Const	R/W	Total
Yield Control (Roundabout 1-Lane)	$ 10,000	$ -	$ 10,000
Yield Control (Roundabout 2-Lane)	$ 12,000	$ -	$ 12,000
Traffic Signal, Type F, M or S	$ 3,000		$ 3,000
All Way Stop, Type F, M or S		.	$ -

Existing Collision Data

Number of Years	5	Total Collisions	26
Injury	13	PDO	12
Fatal	1	Fat + Inj	14

Inputs

Outputs **(Crash Cost Analysis Results)**

	Collision Cost (x1000)						
	Existing Condition		Desired Improvement		Projected Savings	B/C
1	Stop Control (Minor Leg), Type T, Y or Z	$38,189	Yield Control (Roundabout 1-Lane)	$1,754	$36,435	3.64
2	Stop Control (Minor Leg), Type T, Y or Z	$38,189	Yield Control (Roundabout 2-Lane)	$4,332	$33,857	2.82
3	Stop Control (Minor Leg), Type T, Y or Z	$38,189	Traffic Signal, Type F, M or S	$22,528	$15,661	5.22
4	Stop Control (Minor Leg), Type T, Y or Z	$38,189	All Way Stop, Type F, M or S	$17,823	$20,366	0.00

NOTE: Only average collision costs are used for calculation purposes.

Excel filename: ICE CCA 6_22_18 (1).xlsm

Sample Worksheet

State & Local
HSIP Methodology

Collision Cost Analysis
and
Benefit / Cost Ratio

Information & Data entry fields

Enter location, area, existing conditions (control and ADT), cost and crash data, and area (U, S, R)

Automatically "populated"

Intersection Control Evaluation

Collision Cost Analysis and B/C

-- Fill in tan boxes along with 'Area' --

County	Rte	Postmile	Location Description

Area
- Rural
- Suburban
- Urban

Intersection Types:
- F - Four-Legged
- M - Multi-Legged
- S - Offsett -Tee
- Y - "Y" Wye
- Z - Others

Existing Condition	# of Years for Analysis	Rate Group
	20	

Existing ADT (x1000)		Future ADT (x1000)			
Mainline	Cross St	Mainline	Cross St	Average ADT	VCF

Est. Capital Cost (x1000) for Desired Improvement			
Desired Improvement	Const	R/W	Total
Yield Control (Roundabout 1-Lane)	$	$ -	$
Yield Control (Roundabout 2-Lane)	$	$ -	$
Traffic Signal, Type F, M or S	$	$	$
All Way Stop, Type F, M or S	$	$	$

Existing Collision Data			
Number of Years	3 or 5 (select)	Total Collisions	
Injury		PDO	
Fatal		Fat + Inj	

EXAMPLE Project

Safety Improvement

(HSIP Funding Candidate)

Collision Cost Analysis and Benefit / Cost Ratio

**Data / Information has been entered for**

- **location / area**
- **service life**
- **volumes (ADT)**
- **crash data**
- **cost for each Alt**

Intersection Control Evaluation

Collision Cost Analysis and B/C

-- Fill in tan boxes along with 'Area' --

County	Rte	Postmile	Location Description
Ker	1001	0.114	SR 223

Area: (●) Rural ( ) Suburban ( ) Urban

Intersection Types:
F - Four-Legged
M - Multi-Legged
S - Offsett -Tee
Y - "Y" Wye
Z - Others

Existing Condition	# of Years for Analysis	Rate Group
Stop Control (Minor Leg), Type T, Y or Z	20	I17

Existing ADT (x1000)		Future ADT (x1000)			
Mainline	Cross St	Mainline	Cross St	Average ADT	VCF
27.0	2.0	32	6.0	30.2	1.04

Est. Capital Cost (x1000) for Desired Improvement

Desired Improvement	Const	R/W	Total
Yield Control (Roundabout 1-Lane)	$ 10,000	$ -	$ 10,000
Yield Control (Roundabout 2-Lane)	$ 12,500	$ -	$ 8,500
Traffic Signal, Type F, M or S	$ 3,000		$ 3,000
All Way Stop, Type F, M or S		.	$ -

Existing Collision Data

Number of Years	5	Total Collisions	26
Injury	13	PDO	12
Fatal	1	Fat + Inj	14

Collision Cost Analysis and Benefit / Cost Ratio

OUTPUTS: Project Savings ($) and B/C Ratio

	Collision Cost (x1000)					B/C
	Existing Condition		Desired Improvement		Projected Savings	
1	Stop Control (Minor Leg), Type T, Y or Z	$38,189	Yield Control **Roundabout** (single-lane)	$1,754	$36,435	**3.64**
2	Stop Control (Minor Leg), Type T, Y or Z	$38,189	Yield Control **Roundabout** (2-lane)	$4,332	$33,857	2.82
3	Stop Control (Minor Leg), Type T, Y or Z	$38,189	**New Traffic Signal**	$22,528	$15,661	**5.22**
4	Stop Control (Minor Leg), Type T, Y or Z	$38,189	All Way Stop, Type F, M or S	$17,823	$20,366	0.00

NOTE: Only average collision costs are used for calculation purposes.

ICE CCA 6_22_18 (1).xlsm

Collision Cost Analysis and Benefit / Cost Ratio

OUTPUTS: Crash Cost Savings ($) and B/C Ratio

	Collision Cost (x1000)					B/C
	Existing Condition		Desired Improvement		Projected Savings	
1	Stop Control (Minor Leg), Type T, Y or Z	$38,189	Yield Control **Roundabout** (single-lane)	$1,754	$36,435 ($36.4 M)	3.64
2	Stop Control (Minor Leg), Type T, Y or Z	$38,189	Yield Control **Roundabout** (2-lane)	$4,332	$33,857	2.82
3	Stop Control (Minor Leg), Type T, Y or Z	$38,189	**New Traffic Signal**	$22,528	$15,661 ($15.7 M)	5.22
4	Stop Control (Minor Leg), Type T, Y or Z	$38,189	All Way Stop, Type F, M or S	$17,823		

NOTE: Only average collision costs are used for calculation purposes.

Performance Benefit

Value ROI

ICE CCA 6_22_18 (1).xlsm

Which *measure* is directly related to our safety mission & goal?

Internal Worksheet (within CCA and B/C Ratio Tool)

Existing Intersection

Existing Travel (MV)	Collision Rate (Cols/MV)	Anticipated # of Future Collisions
52.93	0.49	108

Area	Rate Group	Base Rate	Base # of Collisions	Avg Collision Cost (x1000)	Total Collision Cost (x1000)	Area	Rate Group	Base Rate	Base # of Collisions	CMF	Anticipated # of Future Collisions	Collisions Used for Estimating	Avg Collision Cost (x1000)	After Collision Cost (x1000)
Area	Rate Group	Base Rate	Base # of Collisions	Stop Control Minor Leg (F, M, S)		To Yield Control - Single Lane Roundabout (F, M, S)								
Rural	I 02	0.22	49	$ 353.6	$ 38,189	Rural	I 31	0.22	49	0.29	31	49	$ 35.8	$ 1,754
Suburban	I 07	0.23	51	$ 267.5	$ 28,890	Suburban	I 32	0.22	49	0.22	24	49	$ 36.7	$ 1,798
Urban	I 12	0.13	29	$ 191.9	$ 20,725	Urban	I 33	0.32	71	0.61	66	71	$ 35.7	$ 2,535
Area	Rate Group	Base Rate	Base # of Collisions	Stop Control Minor Leg (F, M, S)		To Yield Control -Two Lane Roundabout (F, M, S)								
Rural	I 02	0.22	49	$ 353.6	$ 38,189	Rural	I 34	0.55	121	0.8	86	121	$ 35.8	$ 4,332
Suburban	I 07	0.23	51	$ 267.5	$ 28,890	Suburban	I 35	0.55	121	0.8	86	121	$ 36.7	$ 4,441
Urban	I 12	0.13	29	$ 191.9	$ 20,725	Urban	I 36	0.55	121	0.8	86	121	$ 35.7	$ 4,320
Area	Rate Group	Base Rate	Base # of Collisions	Stop Control Minor Leg (F, M, S)		To Signal Control (F, M, S)								
Rural	I 02	0.22	49	$ 353.6	$ 38,189	Rural	I 04	0.58	128	0.8	86	128	$ 176.0	$ 22,528
Suburban	I 07	0.23	51	$ 267.5	$ 28,890	Suburban	I 09	0.43	95	0.8	86	95	$ 102.6	$ 9,747
Urban	I 12	0.13	29	$ 191.9	$ 20,725	Urban	I 14	0.24	53	0.8	86	86	$ 123.3	$ 10,653
Area	Rate Group	Base Rate	Base # of Collisions	Stop Control Minor Leg (F, M, S)		To ALL-Way Stop Control (F, M, S)								
Rural	I 02	0.22	49	$ 353.6	$ 38,189	Rural	I 03	0.55	121	0.5	56	121	$ 147.3	$ 17,823
Suburban	I 07	0.23	51	$ 267.5	$ 28,890	Suburban	I 08	0.27	60	0.3	32	60	$ 248.3	$ 14,898
Urban	I 12	0.13	29	$ 191.9	$ 20,725	Urban	I 13	0.19	42	0.3	32	42	$ 93.4	$ 3,923
Area	Rate Group	Base Rate	Base # of Collisions	Stop Control Minor Leg (T, Y, Z)		To Yield Control - Single Lane Roundabout (F, M, S)								
Rural	I 17	0.16	35	$ 270.1	$ 29,171	Rural	I 31	0.22	49	0.29	31	49	$ 35.8	$ 1,754
Suburban	I 22	0.14	31	$ 187.2	$ 20,218	Suburban	I 32	0.22	49	0.22	24	49	$ 36.7	$ 1,798
Urban	I 27	0.08	18	$ 183.6	$ 19,829	Urban	I 33	0.32	71	0.61	66	71	$ 35.7	$ 2,535

From an existing (specific) traffic control strategy to alternative strategies

(Stop Control Minor Leg to 1 and 2-lane Roundabout, signal & AWSC)

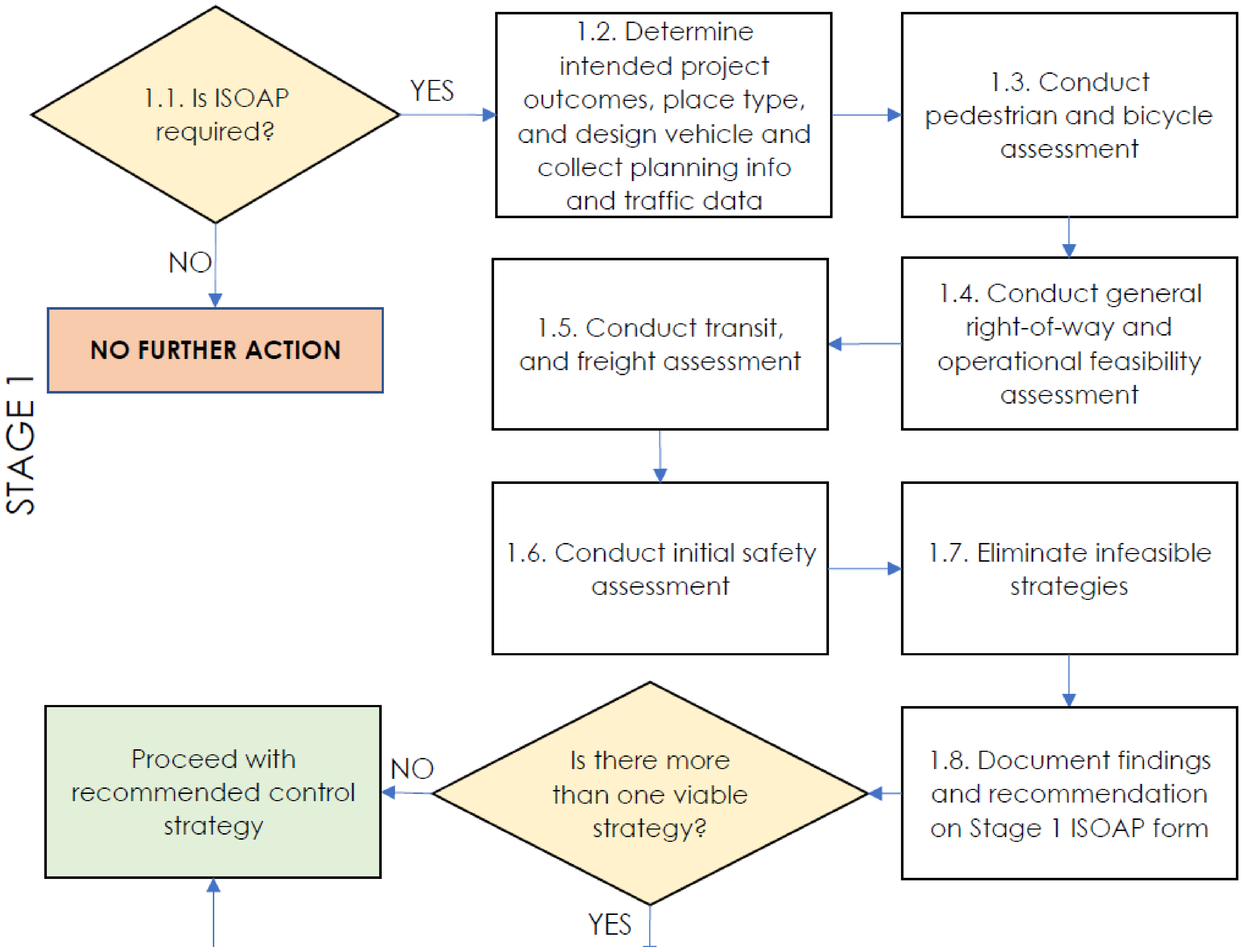
Operational Analysis for ISOAP

Calculating Mobility Performance

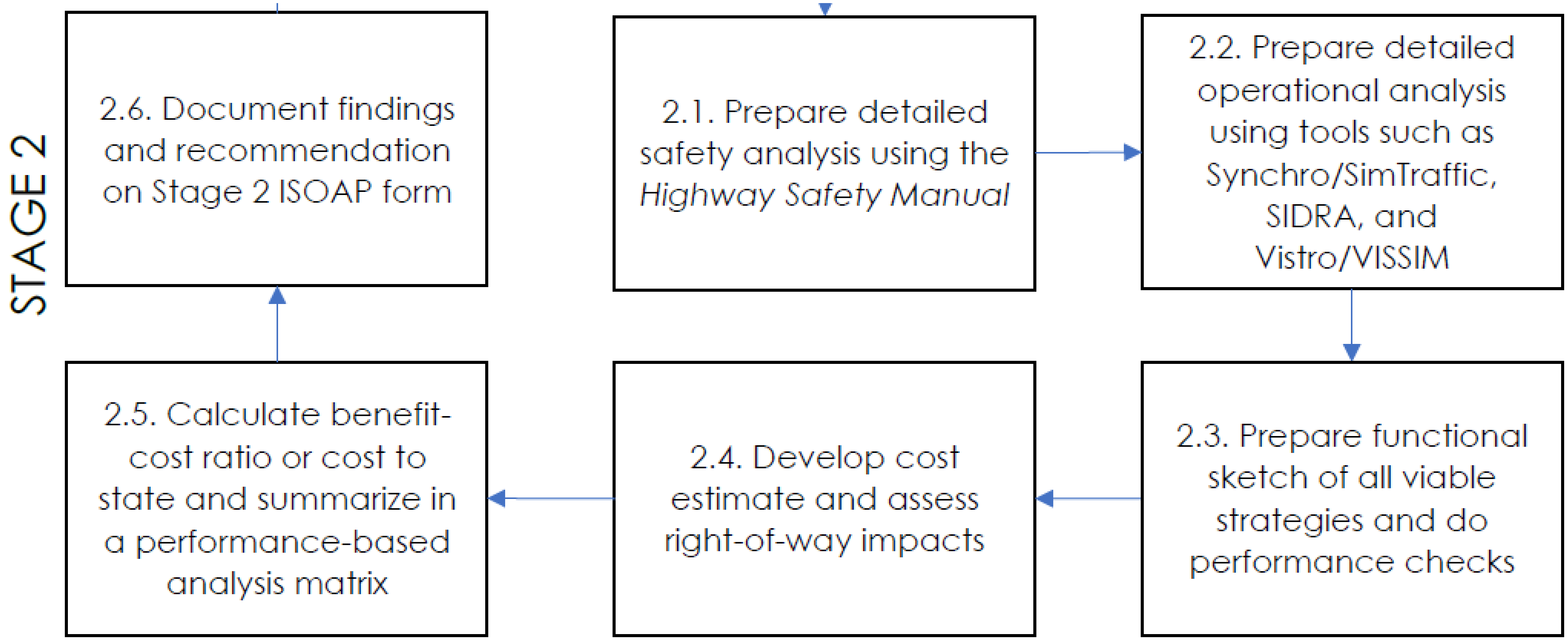
LTAP Virtual Workshop
June 18, 2025

Zifeng (Lilian) Wu, PE, TE, PhD.
Office of Mobility and System Performance

ISOAP Stage 1



ISOAP Stage 2



ISOAP – Operational Analysis

Table 1. Typical Tools Used in ISOAP

ISOAP Stage	Typical Tools Used	Project Phase
Stage 1	CAP-X, Safety Performance for Intersection Control Evaluation (SPICE), Safe System Intersection methodology	Pre-PID, PID
Stage 2	Synchro/SimTraffic, Vistro/VISSIM, SIDRA, Rodel, Highway Capacity Software, *HSM*	PA&ED

- ISOAP Operational Analysis
  - Recommended to be as early as possible. Required in Stage 2.
  - **Required in Stage 1 for SHOPP Project under Program 310 – Operational Improvement** in terms of Daily Person Hour Delay (DPHD) saving.

ISOAP – Operational Analysis

- ISOAP and memo signed on September 10, 2024
- DPHD guideline released in September 2024
    - Updated as the appendices for Transportation Analysis Guide, Chapter 175 of Caltrans Traffic Operations Manual, released
    - DPHD adopted by Asset Management SHSMP as the performance measure for SHOPP Projects under Program 310 – Operational Analysis
    - DPHD saving is required in PID phase to get project programmed (i.e., ISOAP Stage 1)
    - DPHD calculation spreadsheet tool is available.

SHOPP Project ISOAP Operational Analysis

Stage 1

OI Project Review

- 201.310 Program
- 2026 SHOPP Cycle

- ✓ District to update DPHD to match with the concurred value.
- ✓ HQ to concur in Asset Management Tool
- ✓ JUNE 30 2025 – submit PID

4/15/2025	Districts to submit DPHD analysis
4/30/2025	HQ to send comments
5/15/2025	Districts address comments / update analysis
5/30/2025	HQ to review and concur in Asset Management Tool

SHOPP Project – ISOAP Operational Analysis

Stage 1 – DPHD Analysis Spreadsheet Tool

DAILY PERSONS HOURS OF DELAY (DPHD) SAVINGS WORK SHEET (Intersection-Delay Based)

LOCATION / DESCRIPTION:	SR 26/49, in Mokelumne, Calaveras County
	Traffic Signal Alternative

COUNTY-RTE :	*	CAL 26-49
P.M. LIMITS :	*	18.1
EA :	*	10-1k820
R/W+CONST $:	*	$ 3,819,543
CALC. BY :	*	Vu H Nguyen
DATE:	*	5/4/2021
PHONE NO. :	*	(209) 603-5126

INSTRUCTIONS: Fill in the areas that are marked in blue or with an asterisk.

NOTE: For certain parameters that are in the blue boxes or have asterisks, if there is no valid da

NOTE: For reference to the parameters used in this DPHD spreadsheet, please refer to the DP

Opening Year

FACTORS

"L1" BEFORE MILES			
"L2" AFTER MILES			
PRESENT AADT	(Existing)	*	8096
FUTURE AADT	(Opening)	*	8584
AVERAGE AADT			8340
% TRAFFIC BENEFITED		*	100
AVE. AADT BENEFITED			8340
% TRUCKS		*	4.0
% RV'S			
ALTITUDE (FEET)			
DIRECTIONAL SPLIT			
Ave Vehicle Occupancy (AVO)		*	1.73
Ave Persons Benefitted			14428.2
Present Transit Volume		*	40.5
Future Transit Volume		*	12.5
Transit Capacity		*	40
Ave Transit Pas Volume			529.8
Present Ped/Bike Volume		*	140
Future Ped/Bike Volume		*	180
Ave Ped/Bike Benefitted			160

CALCULATIONS

Daily Delay Calculation (Opening Year)

Inputs - to measure off peak variation[1]		
Key Movement		CAL 26-49
ADT		3307
AM Peak Hour Vol	(VPH)	210
PM Peak Hour Vol	(VPH)	330

1. Vehicle count

No-build Configuration AWSC (Opening Year)		
AM Peak Hr Intersection Delay (vehicular)	(sec/veh)	68.0
PM Peak Hr Intersection Delay (vehicular)	(sec/veh)	80.0
Ave Off Peak Delay (vehicular)	(sec/veh)	34.47
Ave Vehicular Hours of Delay (vehicular)	(sec/veh)	37.8
Ave Transit Delay	(sec/veh)	40.0
Ave Ped/Bike Delay	(sec/person)	15.0

Build - Roundabout (Opening Year)		
AM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	19.0
PM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	26.0
Ave Off Peak Delay (vehicular)	(sec/veh)	10.48
Ave Vehicular Hours of Delay (vehicular)	(sec/veh)	11.5
Ave Transit Delay	(sec/veh)	25.0
Ave Daily Ped/Bike Delay	(sec/person)	12.0

DPHD OUTPUT

Delay Outputs			
Average off-peak hourly vol	(vph)	126	
% of peak delay in "average" off-peak hour		0.47	
Delay without improvement (vehicular)	(min/veh)	0.629	
Delay with improvement (vehicular)	(min/veh)	0.191	
Delay Savings (vehicular)	(min/veh)	0.438	
Ave Daily Vehicular Delay Savings	(minutes)	3653.3	DVHD = 60.9
DPHD (Vehicles)	(minutes)	6320.1	
Ave Transit Delay Savings	(min/veh)	0.250	
DPHD (Transit)	(minutes)	132.5	
Ave Ped/Bike Delay Savings	(min per ped/bike)	0.050	
DPHD (Ped/Bike)	(minutes)	8.0	
DPHD (Total)	(minutes)	6460.6	DPHD = 107.7

Documenting the Input Assumptions

DAILY PERSONS HOURS OF DELAY (DPHD) SAVINGS WORK SHEET (Intersection-Delay B

LOCATION / DESCRIPTION:

Roundabout Alternative

INSTRUCTIONS: Fill in the areas that are marked in blue or with an asterisk.

NOTE: For certain parameters that are in the blue boxes or have asterisks, if there is no valid data, districts can place zero or use engineering judgment.

NOTE: For reference to the parameters used in this DPHD spreadsheet, please refer to the DPHD guideline here:

FACTORS

PRESENT AADT	(Existing)	*	15800
FUTURE AADT	(Opening)	*	18300
AVERAGE AADT			17050
% TRAFFIC BENEFITED		*	100
AVE. AADT BENEFITED			17050
% TRUCKS		*	8.0
% RV'S		*	0.0
DIRECTIONAL SPLIT			
Ave Vehicle Occupancy (AVO)			1.74
Ave Persons Benefitted			29667.0
Present Transit Volume			0.0
Future Transit Volume			0.0
Transit Capacity			0
Ave Transit Pas Volume			0.0
Present Ped/Bike Volume			0
Future Ped/Bike Volume			0
Ave Ped/Bike Benefitted			0

CALCULATIONS

Daily Delay Calculation (Opening Year)

Inputs - to measure off peak variation[1]

Key Movement		SR 198 EB
ADT		8640
AM Peak Hour Vol	(VPH)	644
PM Peak Hour Vol	(VPH)	864

1. Vehicle count

Existing & Opening Year AADT: Demand Data, All Movements

% Traffic Benefited: typically 100% for intersection

% Truck & RVs: Demand Data

AVO: Justification if not using defaults

Transit Capacity, speed, share in%: needed

Ped/Bike Volume: Demand Data

Opening Year 2028

AADT volumes to Design, from Tech Planning, shown in PR 7/9/2020 (attached).
Total intersection AADT is used.

Peak hour volume provided by Forecasting branch (attached).

Truck percent from 2021 AADT Truck Census at TUL-198 PM 19.762 (attached).

AVO based on the Visalia area from the table on page 14 of DPHD Guideline

22	Truckee-Grass Valley, CA	98,606	1.75
23	Visalia-Porterville, CA	451,108	1.74
24	San Luis Obispo-Paso Robles, CA	274,184	1.74
25	Madera, CA	152,452	1.75

No transit routes or bike/ped data found in the project area.

Delay calculations from Synchro for signal and SIDRA for roundabout (attached).

Documenting the Input Assumptions

CALCULATIONS

Daily Delay Calculation (Opening Year)

Inputs - to measure off peak variation[1]		
Key Movement		SR 198 EB
ADT		8640
AM Peak Hour Vol	(VPH)	644
PM Peak Hour Vol	(VPH)	864

1. Vehicle count

No-build - Signal (Opening Year 2028)		
AM Peak Hr Intersection Delay (vehicular)	(sec/veh)	69
PM Peak Hr Intersection Delay (vehicular)	(sec/veh)	76.7
Ave Off Peak Delay (vehicular)	(sec/veh)	31.32
Ave Vehicular Hours of Delay (vehicular)	(sec/veh)	34.8
Ave Transit Delay	(sec/veh)	0.0
Ave Ped/Bike Delay	(sec/person)	0.0

Build - Roundabout (Opening Year 2028)		
AM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	9.7
PM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	9.0
Ave Off Peak Delay (vehicular)	(sec/veh)	4.02
Ave Vehicular Hours of Delay (vehicular)	(sec/veh)	4.5
Ave Transit Delay	(sec/veh)	0.0
Ave Daily Ped/Bike Delay	(sec/person)	0.0

DPHD OUTPUT

Delay without improvement (vehicular)	(min/veh)	0.580
Delay with improvement (vehicular)	(min/veh)	0.074
DPHD (Transit)	(minutes)	0.0
Ave Ped/Bike Delay Savings	(min per ped/bike)	0.000
DPHD (Ped/Bike)	(minutes)	0.0
DPHD (Total)	(minutes)	14990.9

DPHD ...249.8

ADT & Peak Hour Volume: **Opening Year, Key Movement**

No-build Intersection Delay: Synchro Output

Build Condition Intersection Delay: Synchro/Sidra Output

Intersection Delay for Transit, Bike & Ped

NOT worst movement delay

Opening ...

... shown in PR 7/9/2020 (attached).

... ch (attached).

... s at TUL-198 PM 19.762 (attached).

... area from the table on page 14 of DPHD Guideline

22	Truckee-...alley, CA	98,606	1.75
23	Visalia-Porterville, CA	451,108	1.74
24	San Luis Obispo-Paso Robles, CA	274,184	1.74
25	Madera, CA	152,452	1.75

No transit routes or bike/ped data found in the project area.

Delay calculations from Synchro for signal and SIDRA for roundabout (attached).

SHOPP Project – ISOAP Operational Analysis

Stage 1

- **DPHD Calculation with Inputs Documented**
  - Length (Uninterrupted Facility)
  - AADT (Existing and Opening Year), Growth Factor
  - Peak Hour Volume
  - Truck %
  - Benefited Traffic %
  - Before & After Speed (Uninterrupted) or Delay (Interrupted)
  - AVO
  - Transit
  - Bike/Ped
- **Update DPHD Saving from Concurred Results in AM Tool**
- **Completed!**

ISOAP – Operational Analysis

Stage 2

Step 2.5 Performance-Based Analysis Matrix

Prepare a matrix showing operational and safety performance, life-cycle cost estimate, and benefit-cost ratio of each viable strategy.

Cost to State, which is the sum of the construction cost and all crashes for 20 years after opening to traffic, may be used as an alternative to the benefit-cost ratio for new construction.

Intersection Control Strategy	Capital Cost ($1,000)	Service Life (years)	Delay Benefit ($1,000)	Collision Benefit ($1,000)	Maint Cost ($1,000)	Life-Cycle Cost ($1,000)	Benefit/ Cost Ratio (BCR)
Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text
Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text
Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text
Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text

Comment as needed: Enter text

ISOAP – Operational Analysis

Stage 2

- DPHD – operation cost calculated for 20 years after opening to traffic
- DPHD saving

Intersection Control Strategy	Capital Cost ($1,000)	Service Life (years)	Delay Benefit ($1,000)	Collision Benefit ($1,000)	Maint Cost ($1,000)	Life-Cycle Cost ($1,000)	Benefit/ Cost Ratio (BCR)
Traffic Signal	4,200	20	11,357	6,475	Enter text	Enter text	4.2
Roundabout	2,750	20	40,487	6,826	Enter text	Enter text	17.2
Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text
Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text	Enter text

TRAVEL TIME VALUE			
Automobile	($/person-hr)	19.45	2024 $, Updated Jan 2025, Caltrans Transportation Economics Branch
Truck	($/person-hr)	40.80	2024 $, Updated Jan 2025, Caltrans Transportation Economics Branch
Ped/Bike	($/person-hr)	38.80	2023 $, USDOT Benefit-Cost Analysis Guidance, Nov 2024

ISOAP – Operational Analysis

Stage 2

Opening Year

OPENING YEAR

FACTORS			
"L1" BEFORE MILES			
"L2" AFTER MILES			
PRESENT AADT			
FUTURE AADT	(Opening Yr)	▪	8584
AVERAGE AADT			8584
% TRAFFIC BENEFITED		▪	100
AVE. AADT BENEFITED			8584
% TRUCKS		▪	4
% RV'S			
ALTITUDE (FEET)			
DIRECTIONAL SPLIT			
Ave Vehicle Occupancy (AVO)		▪	1.73
Ave Persons Benefitted			14850.3
Present Transit Volume		▪	40.5
Future Transit Volume		▪	12.5
Transit Capacity		▪	40
Ave Transit Pas Volume			529.8
Present Ped/Bike Volume		▪	140
Future Ped/Bike Volume		▪	180
Ave Ped/Bike Benefitted			160

CALCULATIONS

Daily Delay Calculation (Opening Year)

Inputs - to measure off peak variation[1]		
Key Movement		CAL 26-49
ADT		3307
AM Peak Hour Vol	(VPH)	210.0
PM Peak Hour Vol	(VPH)	330.0

1. Vehicle count

No-build Configuration AVSC (Opening Year)		
AM Peak Hr Intersection Delay (veh	(sec/veh)	68.0
PM Peak Hr Intersection Delay (veh	(sec/veh)	80.0
Ave Off Peak Delay (vehicular)	(sec/veh)	34.47
Ave Vehicular Hours of Delay (vehic	(sec/veh)	37.8
Ave Transit Delay	(sec/veh)	40.0
Ave Ped/Bike Delay	(sec/person)	15.0

Build - Roundabout (Opening Year)		
AM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	19.0
PM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	26.0
Ave Off Peak Delay (vehicular)	(sec/veh)	10.48
Ave Vehicular Hours of Delay (vehic	(sec/veh)	11.5
Ave Transit Delay	(sec/veh)	25.0
Ave Daily Ped/Bike Delay	(sec/person)	12.0

DPHD OUTPUT

Delay Outputs		
Average off-peak hourly vol	(vph)	126
% of peak delay in "average" off-peak hour		0.47
Delay without improvement (vehic	(min/veh)	0.629
Delay with improvement (vehicula	(min/veh)	0.191
Delay Savings (vehicular)	(min/veh)	0.438
Ave Daily Vehicular Delay Savings	(minutes)	3760.1
DPHD (Vehicles)	(minutes)	6505.1
Ave Transit Delay Savings	(min/veh)	0.250
DPHD (Transit)	(minutes)	132.5
Ave Ped/Bike Delay Savings	(min per ped/bike)	0.050
DPHD (Ped/Bike)	(minutes)	8.0
DPHD (Total)	(minutes)	6645.5

DELAY BENEFIT

Mode	DPHD Savings	'ime Value ($/hr)	aily Benefit ($)
Auto	105.9	19.5	2060.0
Trucks	2.5	40.8	102.3
Transit	2.2	19.5	42.9
Ped/Bike	0.1	38.8	5.2
Total	110.8		2210.4

ISOAP – Operational Analysis

Stage 2

Design Year
(20 years after)

DESIGN YEAR

FACTORS			
"L1" BEFORE MILES			
"L2" AFTER MILES			
PRESENT AADT			
FUTURE AADT	(Design Yr)	▪	11852
AVERAGE AADT			11852
% TRAFFIC BENEFITED		▪	100
AVE. AADT BENEFITED			11852
% TRUCKS		▪	4.0
% RV'S			
ALTITUDE (FEET)			
DIRECTIONAL SPLIT			
Ave Vehicle Occupancy (AVO)		▪	1.73
Ave Persons Benefitted			20504.0
Present Transit Volume		▪	0.0
Future Transit Volume		▪	118.5
Transit Capacity		▪	40
Ave Transit Pas Volume			1185.2
Present Ped/Bike Volume		▪	140
Future Ped/Bike Volume		▪	430
Ave Ped/Bike Benefitted			285

CALCULATIONS

Daily Delay Calculation (Design Year)

Inputs - to measure off peak variation[1]		
Key Movement		CAL 26-49
ADT		4567
AM Peak Hour Vol	(VPH)	293
PM Peak Hour Vol	(VPH)	457

1. Vehicle count

No-build Configuration AWSC (Design Year)		
AM Peak Hr Intersection Delay (veh	(sec/veh)	135
PM Peak Hr Intersection Delay (veh	(sec/veh)	155.5
Ave Off Peak Delay (vehicular)	(sec/veh)	67.20
Ave Vehicular Hours of Delay (vehic	(sec/veh)	73.7
Ave Transit Delay	(sec/veh)	60.0
Ave Ped/Bike Delay	(sec/person)	20.0

Build - Roundabout (Design Year)		
AM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	25.0
PM Peak Hr Intrsn Delay (vehicular)	(sec/veh)	31.0
Ave Off Peak Delay (vehicular)	(sec/veh)	12.95
Ave Vehicular Hours of Delay (vehic	(sec/veh)	14.2
Ave Transit Delay	(sec/veh)	30.0
Ave Daily Ped/Bike Delay	(sec/person)	15.0

DPHD OUTPUT

Delay Outputs		
Average off-peak hourly vol	(vph)	174
% of peak delay in "average" off-peak hour		0.46
Delay without improvement (vehic	(min/veh)	1.228
Delay with improvement (vehicula	(min/veh)	0.237
Delay Savings (vehicular)	(min/veh)	0.992
Ave Daily Vehicular Delay Savings	(minutes)	11752.8
DPHD (Vehicles)	(minutes)	20332.4
Ave Transit Delay Savings	(min/veh)	0.500
DPHD (Transit)	(minutes)	592.6
Ave Ped/Bike Delay Savings	(min per ped/bike)	0.083
DPHD (Ped/Bike)	(minutes)	23.8
DPHD (Total)	(minutes)	20948.7

DELAY BENEFIT

Mode	DPHD Savings	ime Value ($/hr)	aily Benefit ($
Auto	331.0	19.5	6438.7
Trucks	7.8	40.8	319.7
Transit	9.9	19.5	192.1
Ped/Bike	0.4	38.8	15.4
Total	349.1		6965.8

ISOAP – Operational Analysis

Stage 2

Delay Benefit & Operational B/C Calculations

INPUTS AND ASSUMPTIONS	
Opening Year Daily Delay Benefit (	2210.4
Design Year Daily Delay Benefit ($	6965.8
Discount Rate	4.9%
Project Life (Years)	20
Days Per Year Applied (Days)	250
Total Project Life Cycle Cost ($1,(	3,820

BENEFIT AND B/C OUTPUTS	
Compound Annual Growth Rate (CAGR)	6.2%
Total Delay Benefit ($1,000)	12,487
Operational Benefit/Cost (B/C) Ratio	3.27

NOTES: For "Discount Rate", 4.9% is assumed based on Chapter 7 in TSIP guideline.
For "Days Per Year Applied", see Chapter 7 in TSIP guideline: **115** for Weekend & holiday traffic; **250** for Recurrent weekday traffic; **365** for All year.
For "Total Project Life Cycle Cost", use Capital Cost (Construction Cost + R/W Cost) + Maintenance Cost.

ISOAP – Operational Analysis

Stage 2

DELAY BENEFIT			
Mode	DPHD Savings	Time Value ($/hr)	Daily Benefit ($)
Auto	105.9	19.5	2060.0
Trucks	2.5	40.8	102.3
Transit	2.2	19.5	42.9
Ped/Bike	0.1	38.8	5.2
Total	110.8		**2210.4**

DELAY BENEFIT			
Mode	DPHD Savings	Time Value ($/hr)	Daily Benefit ($)
Auto	331.0	19.5	6438.7
Trucks	7.8	40.8	319.7
Transit	9.9	19.5	192.1
Ped/Bike	0.4	38.8	15.4
Total	349.1		**6965.8**

Delay Benefit & Operational B/C Calculations

INPUTS AND ASSUMPTIONS	
Opening Year Daily Delay Benefit ($)	2210.4
Design Year Daily Delay Benefit ($)	6965.8
Discount Rate	4.9%
Project Life (Years)	20
Days Per Year Applied (Days)	250
Total Project Life Cycle Cost ($1,000)	3,820

Year	Daily Benefit Constant Dollars	Days Per Year Applied	Annual Benefit Constant Dollars ($1,000)	Present Value ($1,000)
1	**$ 2,210.35**	**250**	$ 552.59	$ 552.59
2	$ 2,348.00	250	$ 587.00	$ 559.58
3	$ 2,494.23	250	$ 623.56	$ 566.66
4	$ 2,649.56	250	$ 662.39	$ 573.83
5	$ 2,814.56	250	$ 703.64	$ 581.10
6	$ 2,989.84	250	$ 747.46	$ 588.45
7	$ 3,176.04	250	$ 794.01	$ 595.90
8	$ 3,373.83	250	$ 843.46	$ 603.44
9	$ 3,583.94	250	$ 895.98	$ 611.08
10	$ 3,807.13	250	$ 951.78	$ 618.81
11	$ 4,044.22	250	$ 1,011.06	$ 626.64
12	$ 4,296.08	250	$ 1,074.02	$ 634.57
13	$ 4,563.63	250	$ 1,140.91	$ 642.61
14	$ 4,847.83	250	$ 1,211.96	$ 650.74
15	$ 5,149.74	250	$ 1,287.43	$ 658.97
16	$ 5,470.44	250	$ 1,367.61	$ 667.31
17	$ 5,811.12	250	$ 1,452.78	$ 675.76
18	$ 6,173.01	250	$ 1,543.25	$ 684.31
19	$ 6,557.44	250	$ 1,639.36	$ 692.97
20	**$ 6,965.82**	250	$ 1,741.45	$ 701.74
Total				**$ 12,487.08**
			CAGR =	6.23%
			Discount Rate =	4.90%

ISOAP – Operational Analysis

Summary

Pre-PID
- Identify project needs
- **Inputs needed for DPHD**

PID
- General -> Step 1.1-1.8
- **SHOPP 310 -> DPHD**

PA/ED
- **Step 2.5 DPHD based delay benefit**
- Additional considerations

- Additional performance measures
  - Average Delay
  - Queue
  - Volume Capacity Ratio
- Worst/key movements
- Warrant analysis
- Adjacent Intersections


THANK YOU

- 10 Minute Break

Roundabout and Intersection Pavement Design

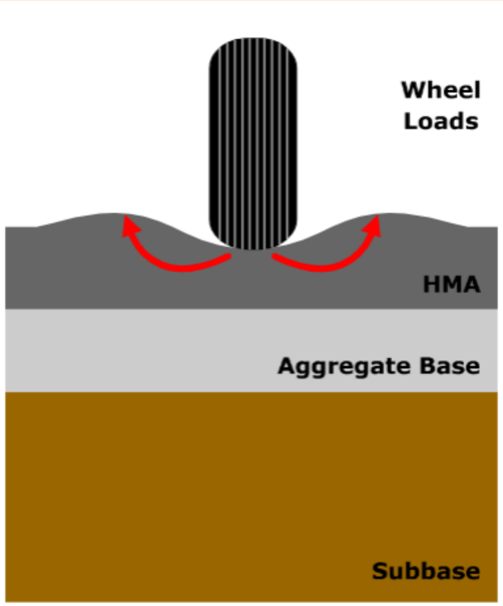
DISTRICT 06- DIVISION OF CONSTRUCTION

MATERIALS ENGINEERING UNIT

Pavement Distresses at intersections

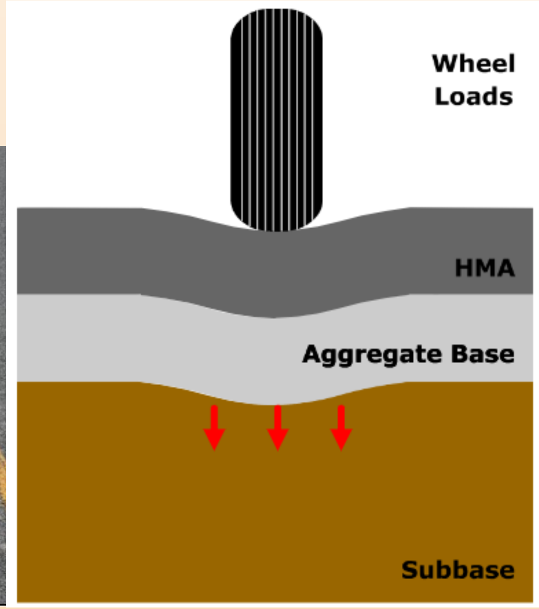
Rutting: Depression in the wheel path due to heavy traffic loads.

- Asphalt concrete Surface Rutting.
- Subgrade Rutting.

Source (Pavement Interactive)

Surface Rutting of the Asphalt Concrete

Source (Pavement Interactive)

Rutting Associated with Base/Subgrade Failure

Pavement Distresses at intersections

Shoving: longitudinal displacement of a localized area of the pavement surface.

caused by:

- ➢ Traffic action (starting and stopping)
  - ▪ Less common at roundabouts compared to signalized/stop controlled intersections
- ➢ Unstable (i.e. low stiffness) HMA layer
  - Mix contamination
  - Poor mix design
  - Poor HMA manufacturing
  - Lack of aeration of liquid asphalt emulsions)
- ➢ Excessive moisture in the subgrade (Binder Striping)

Pavement Design Considerations at intersections

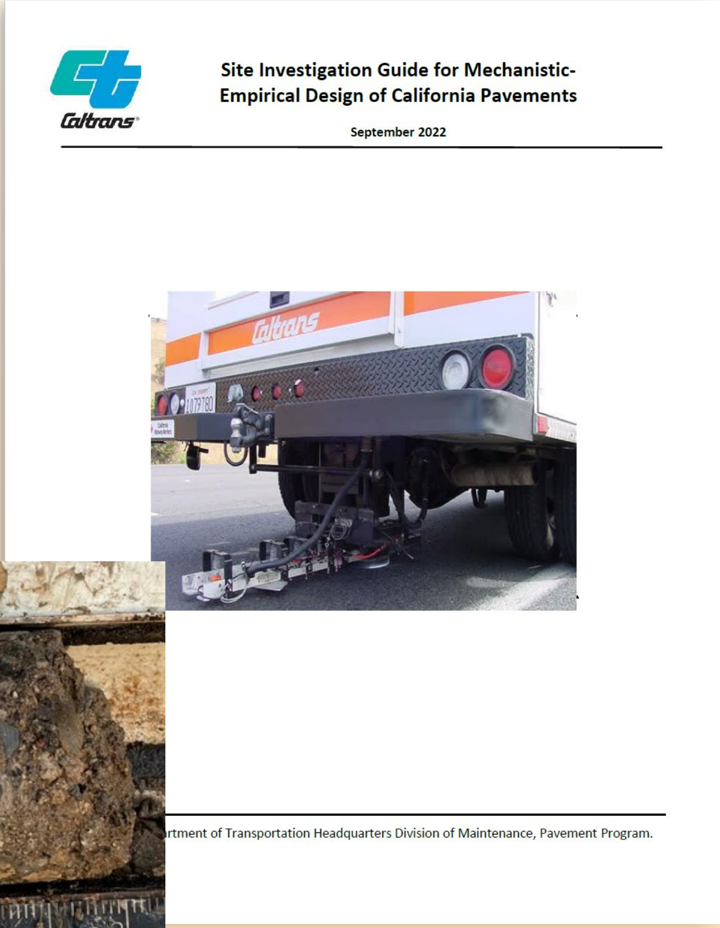
Site Visit: Identify existing pavement deficiencies.

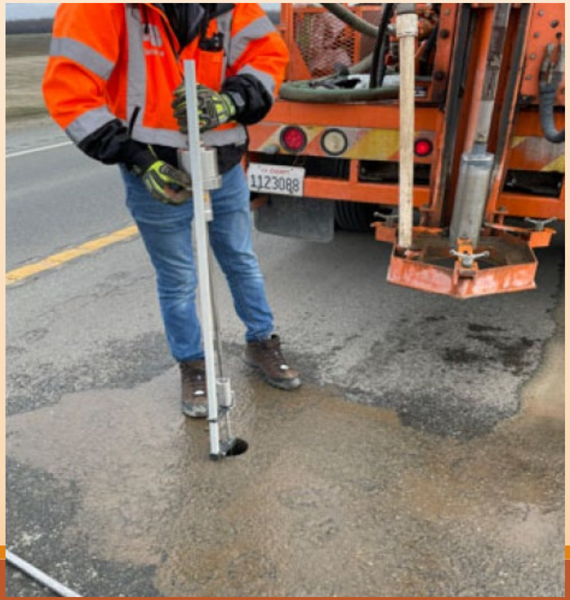
As-builts, Pavement Coring.

Maintenance and Rehabilitation History

Traffic Load; (i.e. TI, ESALs, Initial Year AADTT, % Truck Traffic).

Basement Soil Classification and Modulus (ksi)

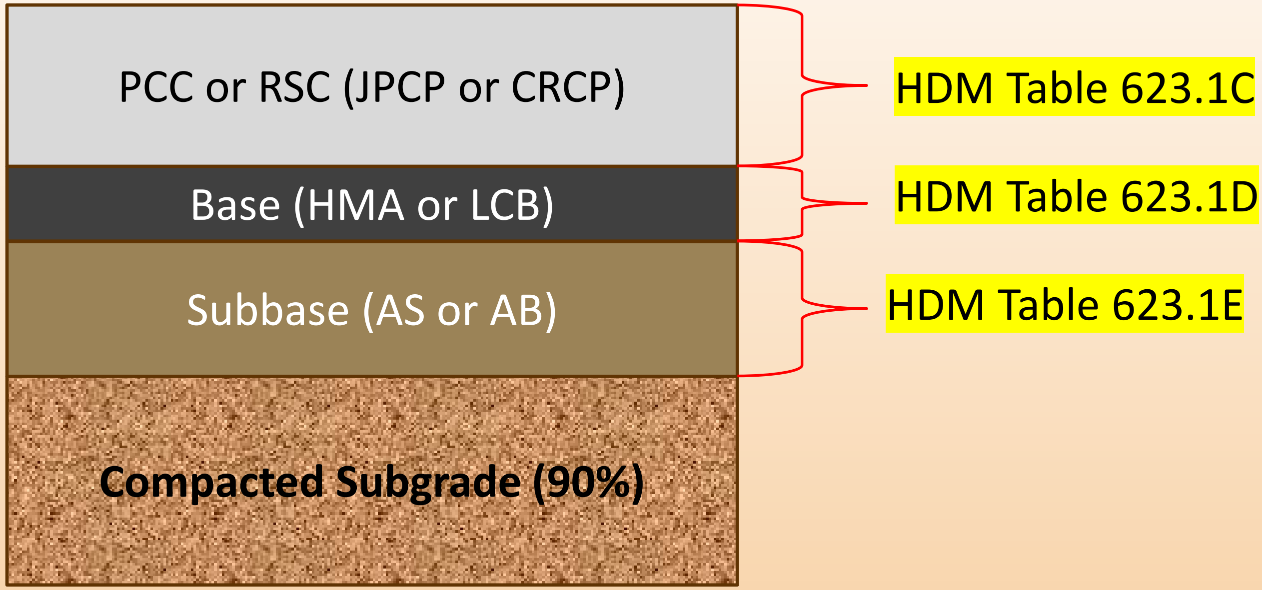




Mitigation of pavement Distresses at intersections

Rigid Pavement Design:

- Best performance
- Minimize future maintenance
- Design Life 40+ years
- Highest cost



Group III Climate (IV and DE) and WIM 4-5

	Minimum Thickness of Concrete Surface Layer (ft)							
	Widened Slab			Tied Concrete Shoulder			Untied Shoulder	
AADTT [1]	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA	CRCP HMA	JPCP LCB	JPCP HMA
100	0.65	0.65		0.65	0.65		0.70	0.65
200	0.65	0.65		0.65	0.65		0.70	0.70
500	0.65	0.65		0.70	0.70		0.80	0.80
1,000	0.70	0.70	0.75	0.75	0.75	0.75	0.80	0.85
2,000	0.75	0.75	0.75	0.80	0.80	0.80	0.90	0.90
4,000	0.80	0.85	0.80	0.85	0.90	0.85	0.95	0.95
8,000	0.85	0.90	0.85	0.90	0.95	0.90	1.00	1.05
12,000	0.90	0.95	0.90	0.95	1.00	0.90	1.05	1.05
16,000	0.90	0.95	0.90	0.95	1.00	0.95	1.05	1.10
20,000	0.95	1.00	0.90	1.00	1.05	0.95	1.10	1.10

(1) Initial (year 1) AADTT of the design lane.

Requirements for JPCP and CRCP Bases

Base	Material	Minimum Thickness
HMA [1] [2]	Hot mix asphalt, type A Standard Specifications Section 39	0.25 ft
LCB [3] [4] [5]	Lean concrete base Standard Specifications Section 28	0.35 ft

Mitigation of pavement Distresses at intersections

Flexible Pavement Design:

- Mechanistic Empirical Design
- Special Design Considerations
  - Speed (Lower speed = More pavement damage)
  - Stiff asphalt binder (PG 70-10)
  - Increased Base layer thickness to Mitigate subgrade rutting
- Design Life 20 or 40 years
- Feasible option when properly designed

Table 632.1

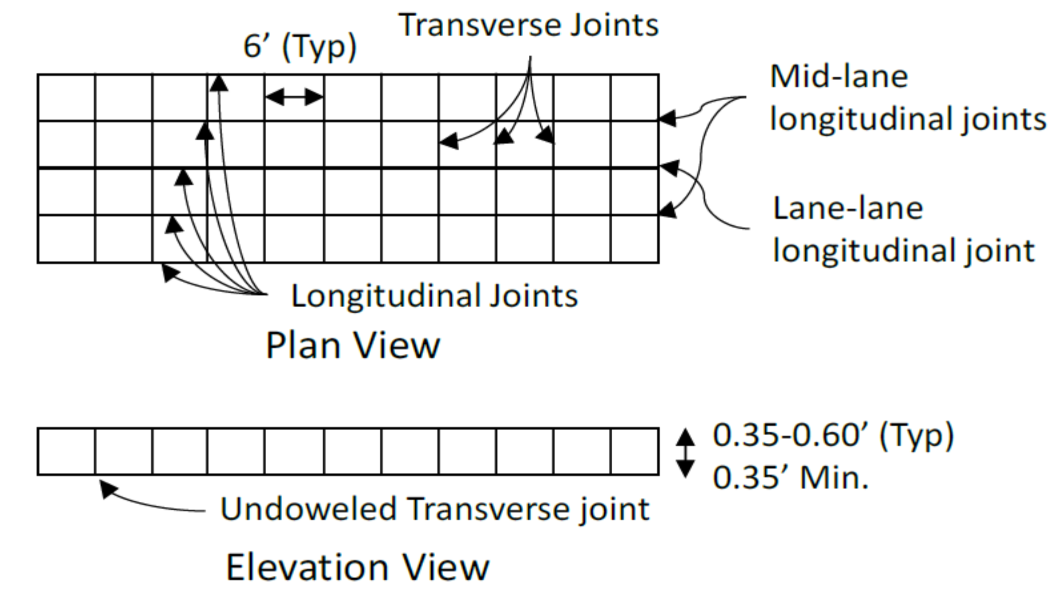
Asphalt Binder Performance Grade Selection

Climate Region [6]	Binder Grade for Hot Mixed Asphalt (HMA)[1, 2]				
	Dense Graded HMA		Open Graded HMA		Gap and Open Graded Rubberized Hot Mix Asphalt (RHMA)
			Placement Temperature		
	Typical	Special[3]	> 70°F	≤ 70°F	
South Coast Central Coast Inland Valley	PG 64-10	PG 70-10 or PG 64-28 M	PG 64-10	PG 58-34 M	PG 64-16

Mitigation of pavement Distresses at intersections

Short JPCP – Concrete Overlay over Asphalt (SJPCP-COA)

- HMA Base Or Cold Recycling Base
- Maximum initial year AADTT of 2,000
- Maintain Joints 10-15 years



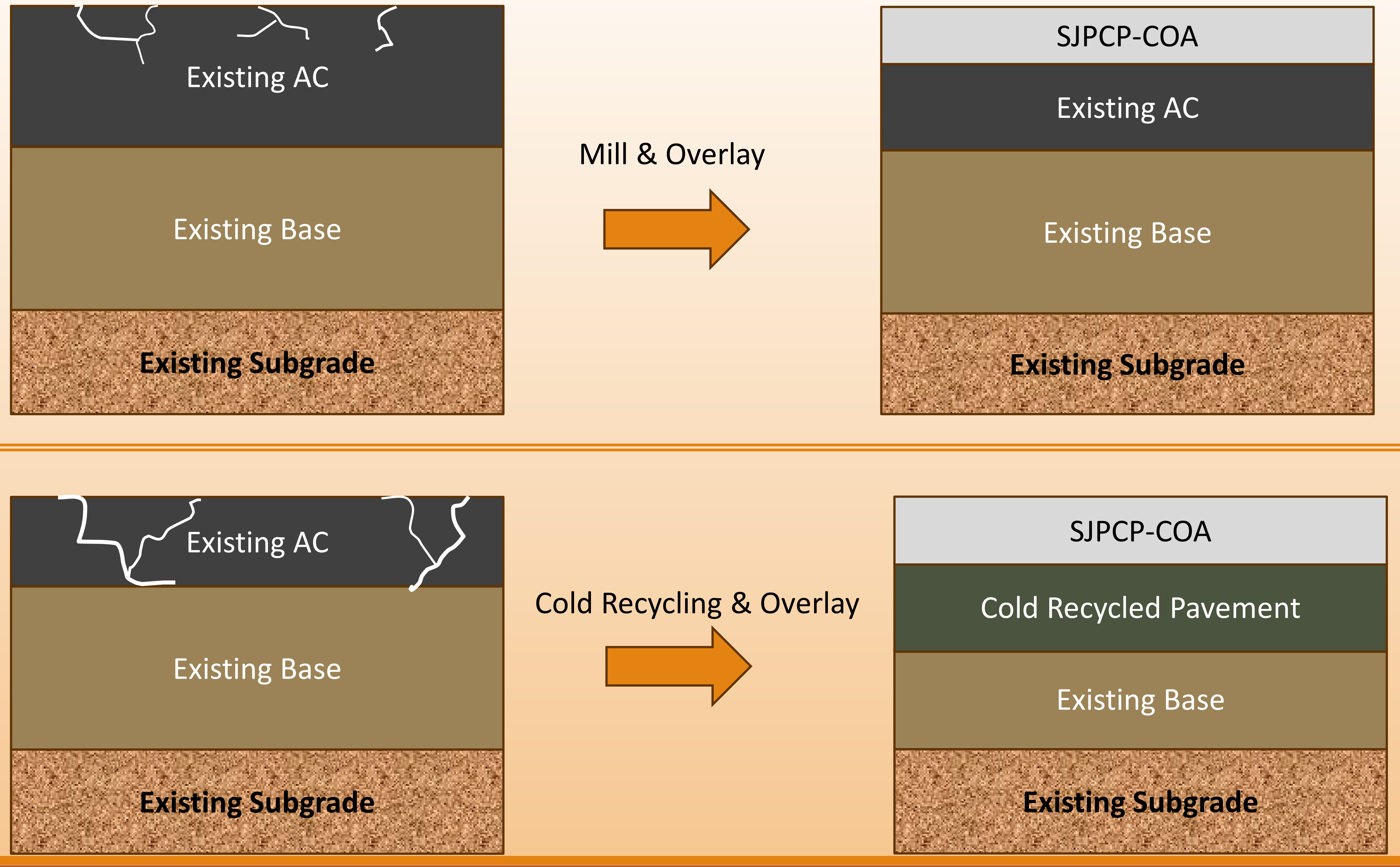
Short JPCP - Concrete Overlay over Asphalt (SJPCP-COA)

Table 623.1F(b)

Type I Subgrade and Group II Climate (SM, DE, HD, IV, LM, SC, and HM)

AADTT [1]	Subbase	Minimum Thickness of Concrete Surface Layer (ft)					
		HMA Base			CR Base		
		HMA 0.25 ft	HMA 0.35 ft	HMA 0.45 ft	CR 0.25 ft	CR 0.35 ft	CR 0.45 ft
50	CTB, LCB	0.40	0.35	0.35	0.45	0.40	0.40
	Others	0.40	0.40	0.35	0.45	0.40	0.40
100	CTB, LCB	0.45	0.40	0.35	0.45	0.45	0.40
	Others	0.45	0.40	0.35	0.45	0.45	0.40
200	CTB, LCB	0.45	0.45	0.35	0.50	0.45	0.45
	Others	0.45	0.45	0.40	0.50	0.45	0.45
500	CTB, LCB	0.50	0.45	0.40	0.50	0.50	0.50
	Others	0.50	0.50	0.45	0.55	0.50	0.50
1,000	CTB, LCB	0.55	0.50	0.45	0.55	0.55	0.50
	Others	0.55	0.50	0.50	0.55	0.55	0.50
2,000	CTB, LCB	0.55	0.50	0.50	0.60	0.55	0.55
	Others	0.55	0.55	0.50	0.60	0.55	0.55

[1] Initial (year 1) AADTT of the design lane.


Existing AC
Existing Base
Existing Subgrade
Mill & Overlay
SJPCP-COA
Existing AC
Existing Base
Existing Subgrade
Existing AC
Existing Base
Existing Subgrade
Cold Recycling & Overlay
SJPCP-COA
Cold Recycled Pavement
Existing Base
Existing Subgrade

Short JPCP – Concrete Overlay over Asphalt (SJPCP-COA)

Construction Completed in 2012

District 9 Roundabout Project
US-6 and Wye Road, Bishop, CA

ISOAP Training Case Study

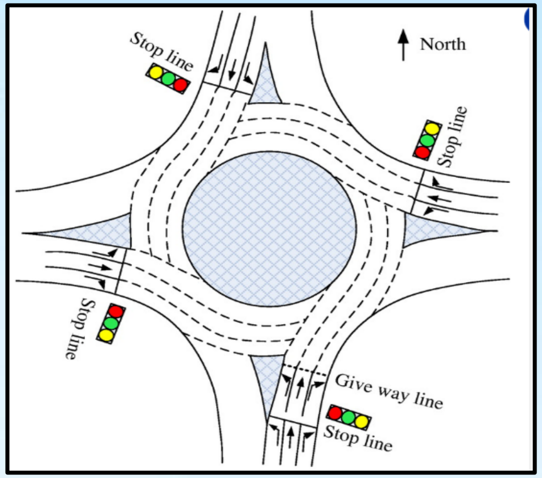
Prepared by Tom Liu and Enrique Rodriguez

Step 1.1 Is ISOAP Required?

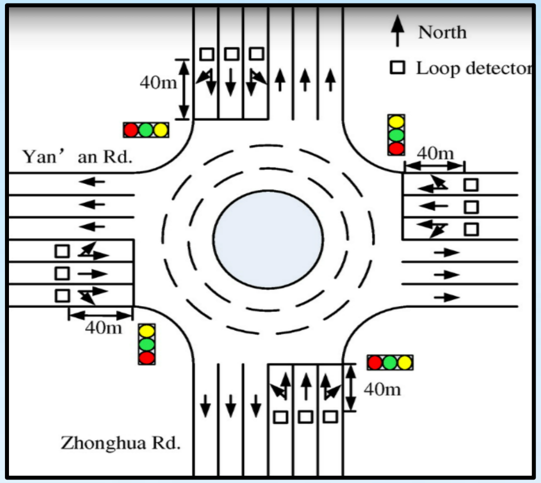
Applicability criteria

	New public road, private road, or high-volume (1000 ADT) driveway
	New freeway interchange
x	Change in type of traffic control (stop, yield, signal)
	Pedestrian hybrid beacon (PHB) at an intersection
	Major physical changes to intersection approaches (including ramp terminals), such as adding a leg to an intersection or widening to provide an additional through or turn lane.

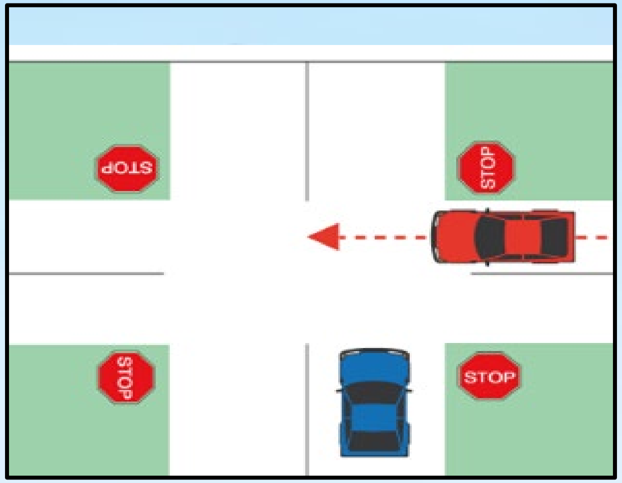
Step 1.2 Determine Intended Project outcome, Place Type, Design Vehicle and Gather data



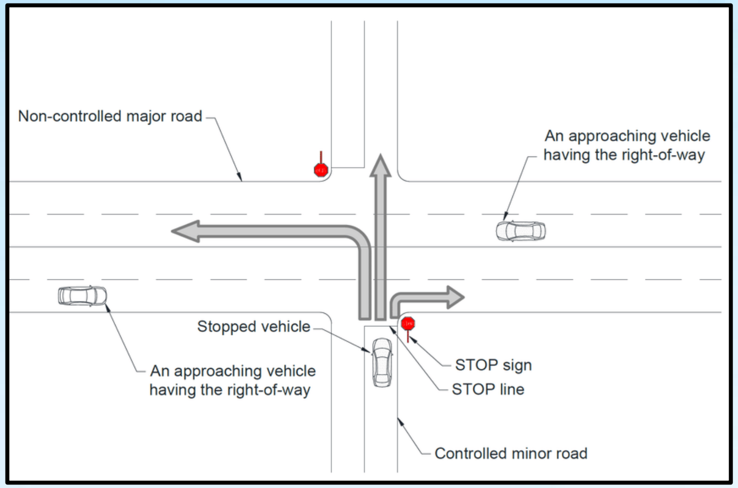
Roundabout



Signalized Intersection



All-Way Stop



No-Build

Step 1.2 Gathering Data Project Overview

- Location: US-6 and Wye Road, Bishop, CA
- Purpose: Improve safety, operational efficiency, and multimodal accessibility
- Key Issues: High crash rates, poor pedestrian/bicycle facilities
- Solution: Intersection control improvements via a roundabout

Step 1.2 Gathering Data Existing Conditions

- Two-way stop control at Wye Road
- High-speed traffic on US-6 creates safety concerns
- Lack of pedestrian crossings & bicycle accommodations
- Truck traffic (10% AADT)
- Utilities and Driveways

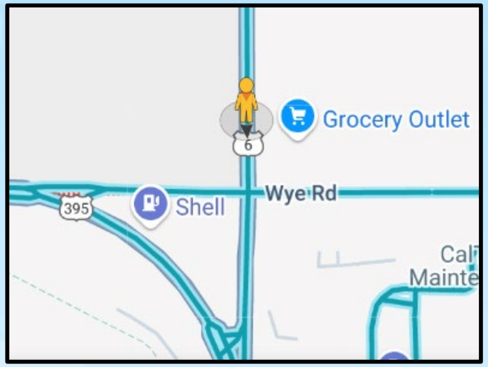
Step 1.2 Gathering Data Existing Conditions

Major/ Minor Street	US-6	Wye Road
Route Classification	Conventional Highway	Local Road
Lane Configuration	SB-Left, Through-Right; NB-Left, Through, Right	EB-Left, Through, Bike, Right
Existing ADT	ADT 2022 -4040Veh; (ADT 2024 - 4264 Veh)	ADT 2024-2327Veh (Derived from 5 day traffic count performed by D09)
Future ADT	ADT 2044-7307 Veh Use Annual Growth Rate 2.73%	ADT 2044-3988 Veh Use Annual Growth Rate 2.73%
Speed Limit	35	35
Existing Land Use	N/A	Local Road
Future Land Use	N/A	Local Road

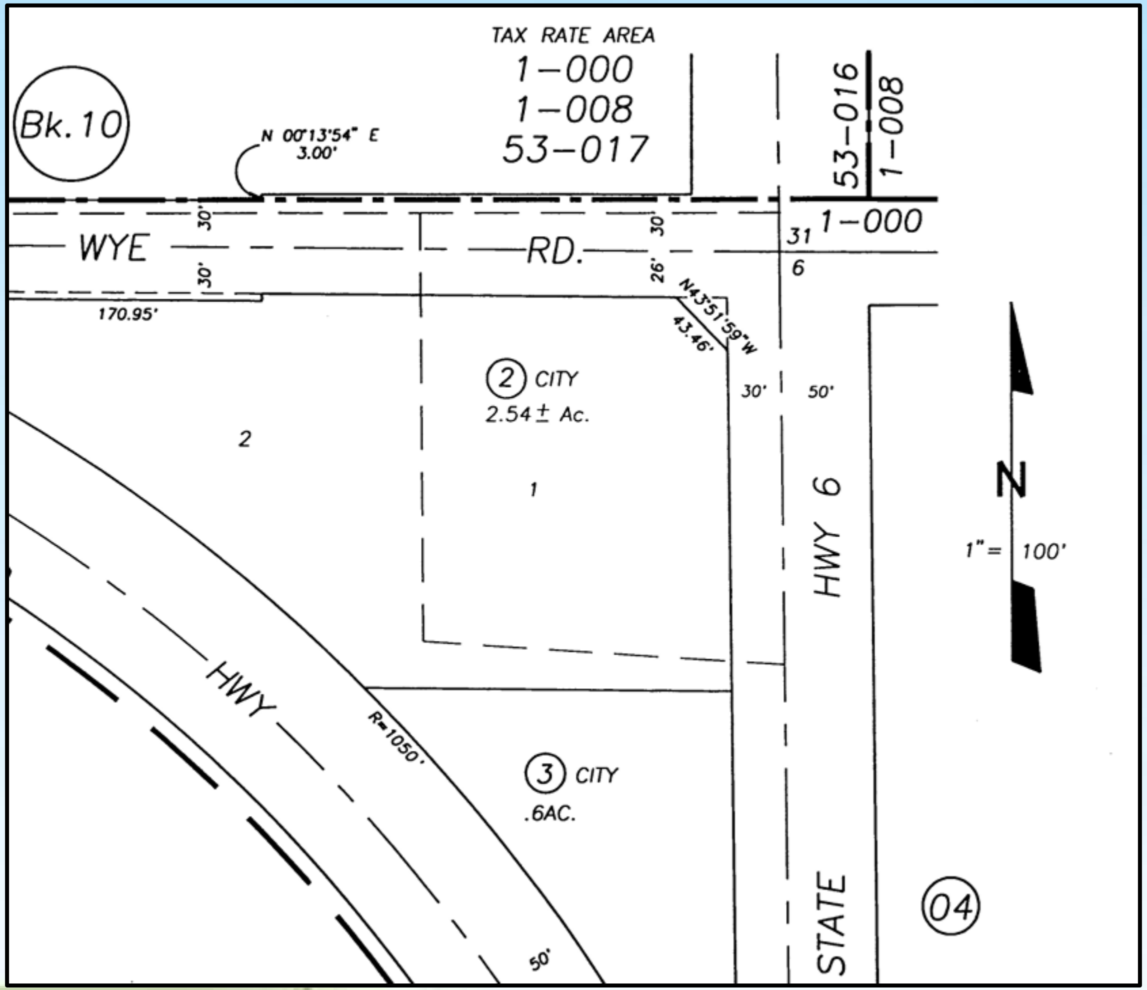
Step 1.2 Gathering Data Truck Network

Route /Movement	STAA 67' Radius	45' Bus	OSOW HDM Fig 405.10(B)	Superload Transporter (20' axle width, 320' length)	80' Mobile Home
N/S along US-6	All Movements	All Movements	N/S Through Movements	Uses opposite lane for N/S Through	N/S Movement
E/W Wye Rd	All Movements	All Movements	EB Through/ Left and WB Through /Right	Not Specified	Not Specified

Step 1.3 Ped and Bike Planning and Feasibility Assessment

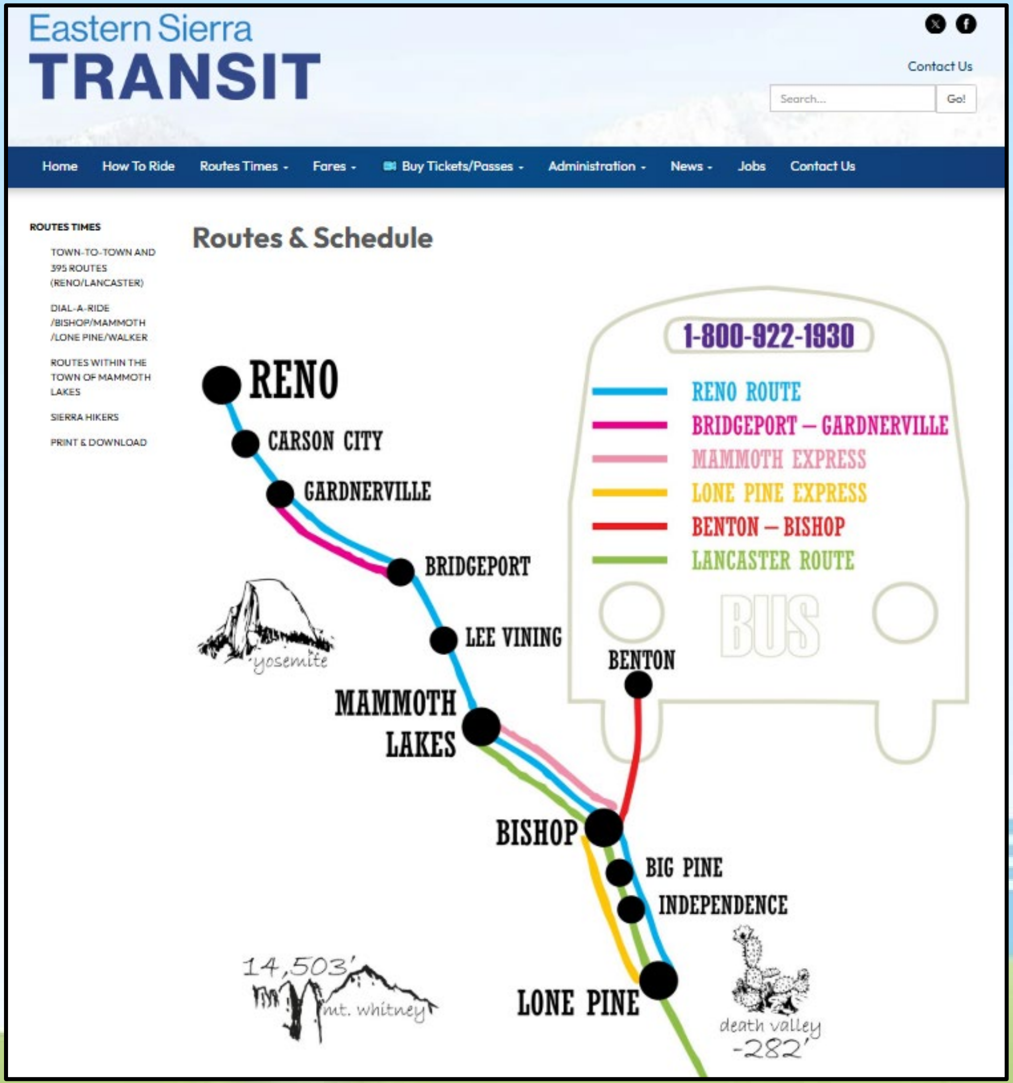


Step 1.4 General R/W and Operational Feasibility Assessment



Step 1.5 Transit and Freight Assessment

- Eastern Sierra Transit Authority was established in 2006
- Eastern Sierra operates public transportation for the Eastern Sierra Region in California
- Has begun transition of its bus fleet to hydrogen fuel cell vehicles



Step 1.6 Initial Safety Assessment

Table 1. TASAS Table B Collision Rates

Intersection	TOTAL No. of Collisions	ACTUAL (per million vehicles)			AVERAGE (per million vehicles)		
		Fatal Collisions	Fatal + Injury Collisions	Total (1)	Fatal Collisions	Fatal + Injury Collisions	Total (1)
US-06 PM 0.130 and Wye St Intersection	9	0.000	0.53	1.19	0.009	0.17	0.36

(1) All reported collisions (includes Property Damage Only (PDO) Collisions)

Analysis of the TASAS Table B records shows a total of 9 collisions at the intersection of US-06 PM 0.130, within the study periods summarized above.

Table 1 reflects the following:

- Actual Fatal collision rate is below the average for similar facilities statewide.
- Actual Fatal + Injury and Total collision rates are above the average for similar facilities statewide.

Step 1.7 Eliminate Infeasible Strategies
Step 1.8 Findings and Recommendations

- No-Build (Existing Condition)(Eliminated in Stage 1)
- Four-Way Stop Control (Eliminated in Stage 1)
- Signalized Intersection (Design Option 2)
- Single-Lane Roundabout (Preferred Alternative)

Step 2.1 Detailed Safety Analysis (HSM)

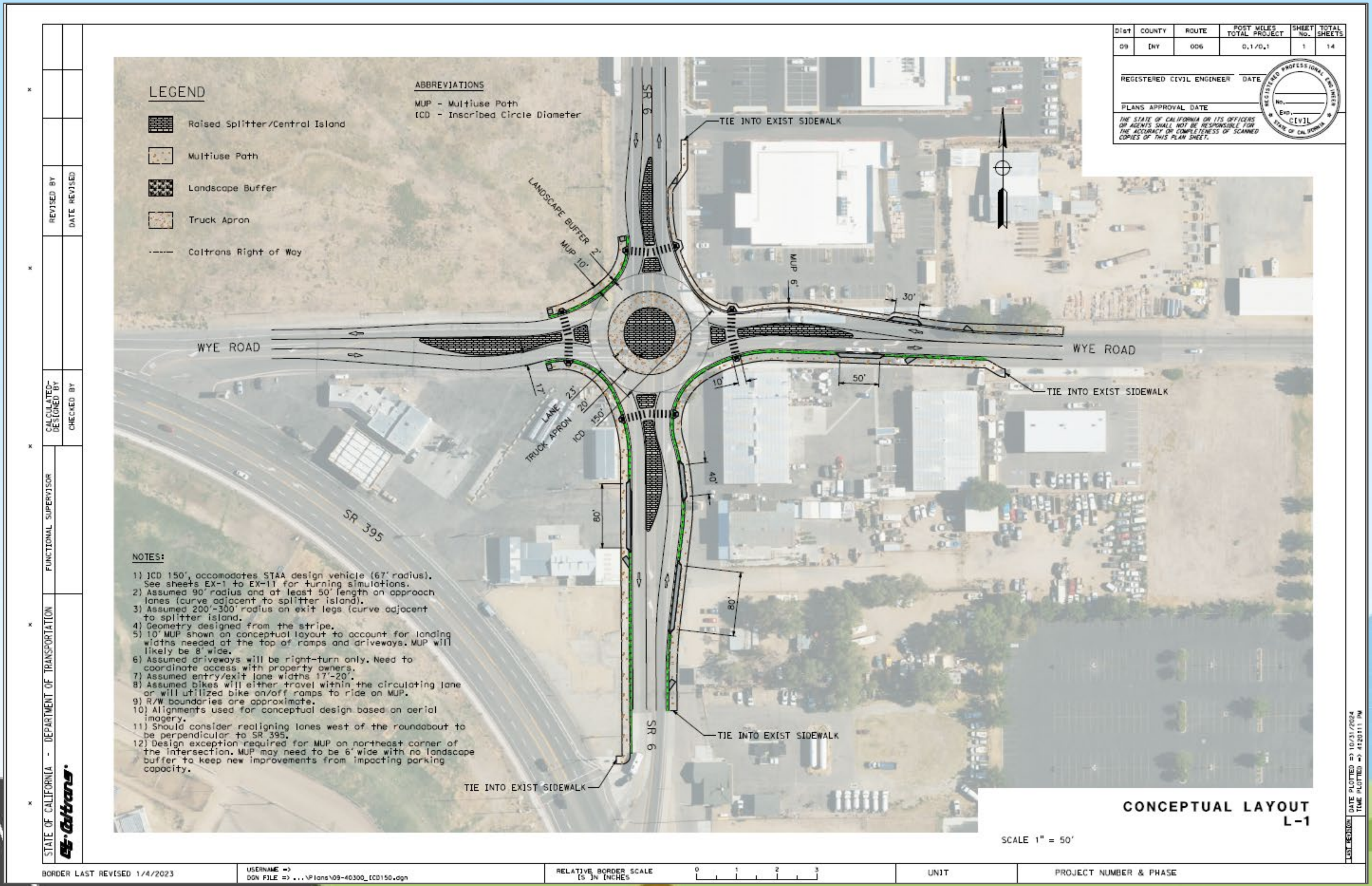
HSM (Highway Safety Manual)

Total Expected Collisions Through The Year 2044 (20yrs)			
	Predicted Average Crash Frequency (total crashes)		
Crash Severity Level	Alt 1: Roundabout Alternative	Alt 2 : Design Option:Signalized Intersection	Alt 3 : No Build Alt: Two-way Stop
Total	6.9	9.9	12.6
Fatal and Injury (FI)	2.6	3.3	4.6
Property Damage Only (PDO)	4.4	6.6	8.0

Step 2.2 Detailed Operational Analysis

ALTERNATIVE	INTERSECTION CONFIGURATION	LOS		95%Queue Length (ft)		Degree of Saturation (v/c)		Control Delay (s/v)	
		AM	PM	AM	PM	AM	PM	AM	PM
Alternative 1	Roundabout Conversion	A	A	49.6	58.8	0.338	0.40	6.8	8.1
Alternative 2	Four-Way Stop Control	Eliminated in Stage 1							
Alternative 2 Design Option	Signalized Intersection	B	C	173	215	0.33	0.45	28.2	29.8
Alternative 3 No Build	Two-Way Stop Control	C	C	35.1	44.9	0.32	0.37	18.5	22.6

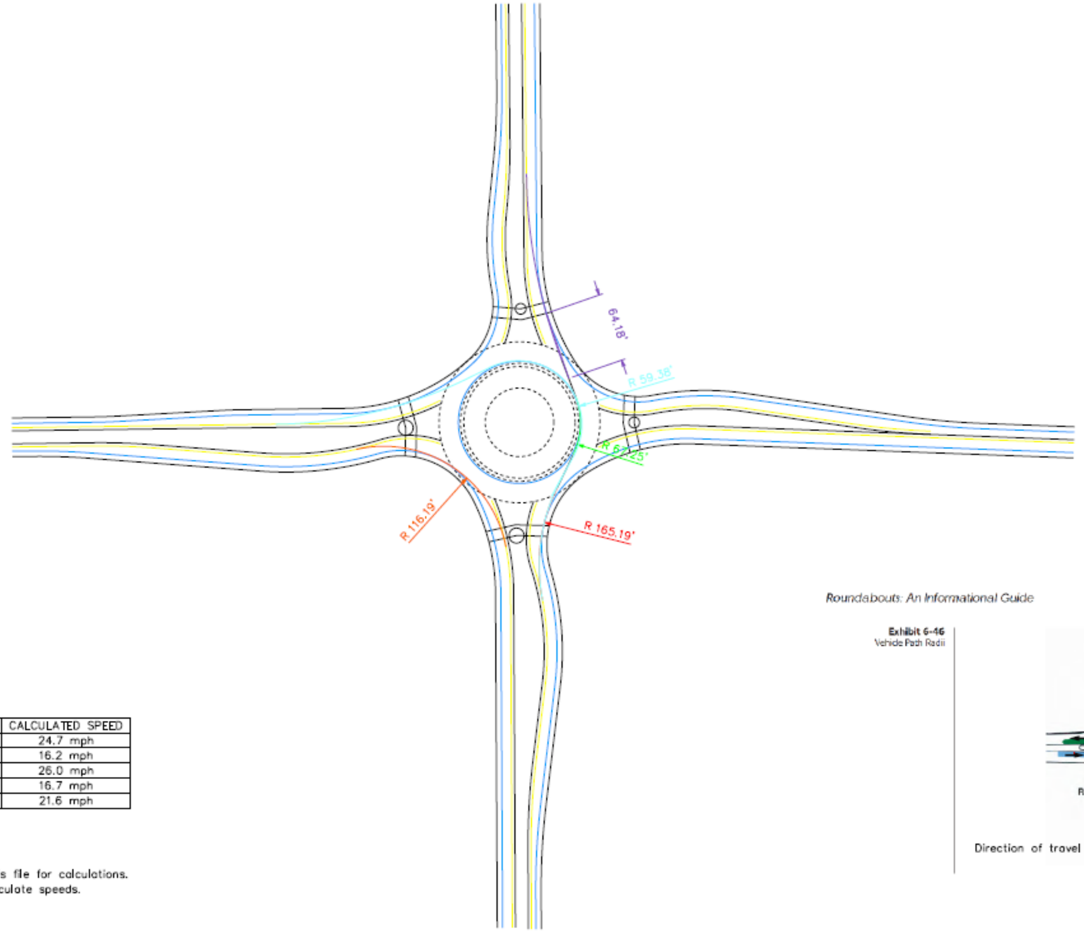
Step 2.3 Functional Sketches and Performance Checks



Step 2.3 Functional Sketches and Performance Checks

PERFORMANCE CHECK: FASTEST PATH

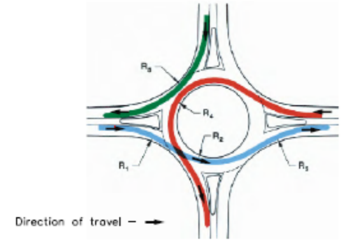
SOUTH LEG



PATH RADIUS	CALCULATED SPEED
R1	24.7 mph
R2	16.2 mph
R3	26.0 mph
R4	16.7 mph
R5	21.6 mph

Roundabouts: An Informational Guide

Exhibit 6-46
Vehicle Path Radii

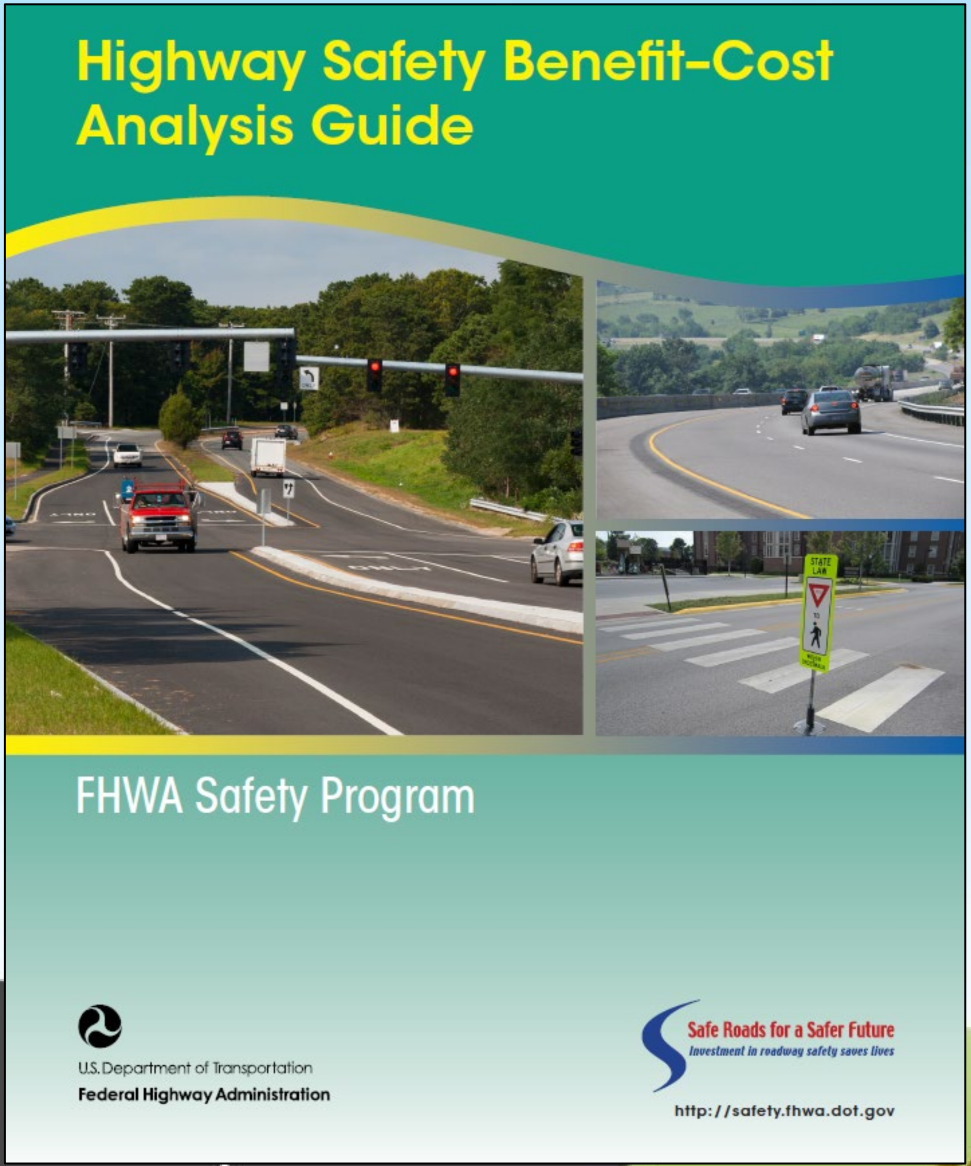


NOTES:

1) See RDI 17–01 roundabout fastest paths.xls file for calculations.
2) Used ACHD Fastest Path Procedure to calculate speeds.

Step 2.3 Functional Sketches and Performance Checks

Step 2.4 Cost Estimate and Lifecycle Costs



Purpose: Helps evaluate the cost-effectiveness of roadway safety improvements.
Methodology: Compares project costs with expected crash reduction benefits.
Key Components:

- **Crash Cost Estimation** – Assigns monetary values to different crash types.
- **Safety Benefit Calculation** – Estimates potential crash reductions from countermeasures.
- **Benefit-Cost Ratio (BCR)** – Determines whether safety improvements are cost-effective.

Application: Supports data-driven decision-making for highway safety investments.

Step 2.4 Cost Estimate and Lifecycle Costs

Table 1. Cost and benefit categories.

Project Costs (Agency Costs)	Project Benefits (User Benefits)	Externalities (Non-User Benefits)
• Design and engineering. • Land acquisition. • Construction. • Reconstruction/ Rehabilitation. • Preservation. • Routine maintenance. • Mitigation (e.g., noise barriers). • Utility relocation. • Energy.	• Reduced travel time and delay. • Improved travel time reliability. • Reduced crash frequency and/or severity. • Reduced vehicle operating cost.	• Reduced air emissions. • Reduced noise. • Reduced impacts to natural habitat and wetlands.

Step 2.4 Cost Estimate and Lifecycle Costs

Wye St and US-6 Intersection Selection

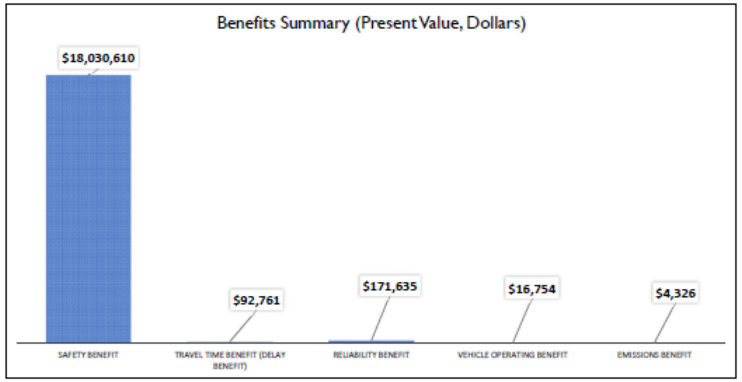
Benefit-Cost Analysis Summary Results

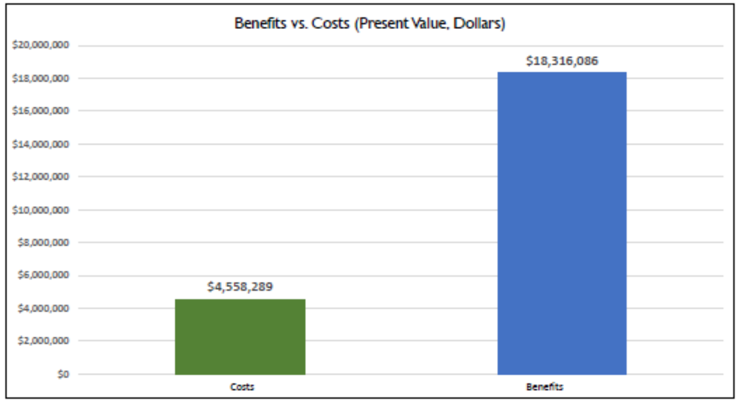
AGENCY CA DOT
ANALYST Tom Liu

DATE 1/27/2025
BUILD ALT ANME Alt 1- Roundabout Alternative

Present Value Costs ($ Dollars)	$4,558,289
Present Value Benefits ($ Dollars)	$18,316,086
Net Present Value ($ Dollars)	$13,757,797
Benefit / Cost Ratio:	4.02
Discount Rate	4.0%

ITEMIZED BENEFITS ($ Dollars)	Present Value
Safety Benefit	$18,030,610
Travel Time Benefit (Delay Benefit)	$92,761
Reliability Benefit	$171,635
Vehicle Operating Benefit	$16,754
Emissions Benefit	$4,326
TOTAL BENEFITS	$18,316,086





Wye St and US-6 Intersection Selection

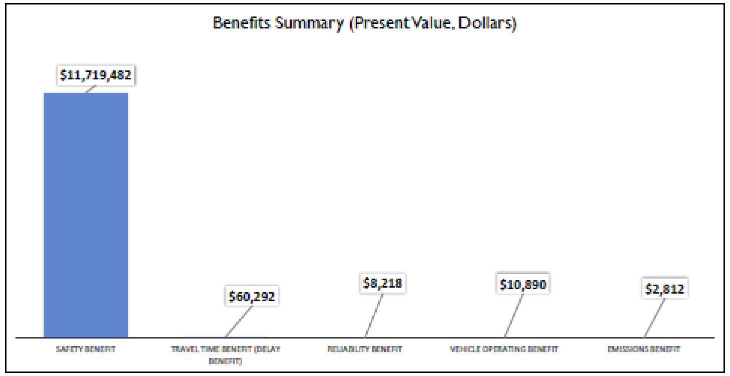
Benefit-Cost Analysis Summary Results

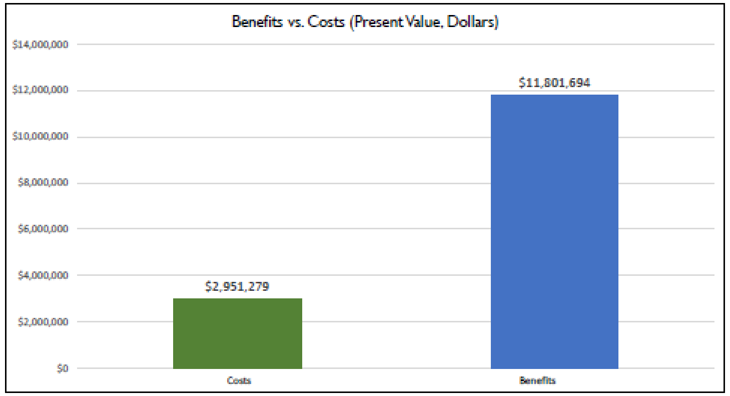
AGENCY CA DOT
ANALYST Tom Liu

DATE 1/27/2025
BUILD ALT NAME Alt 3- Design Option- Signalized Intersection

Present Value Costs ($ Dollars)	$2,951,279
Present Value Benefits ($ Dollars)	$11,801,694
Net Present Value ($ Dollars)	$8,850,415
Benefit / Cost Ratio:	4.00
Discount Rate	4.0%

ITEMIZED BENEFITS ($ Dollars)	Present Value
Safety Benefit	$11,719,482
Travel Time Benefit (Delay Benefit)	$60,292
Reliability Benefit	$8,218
Vehicle Operating Benefit	$10,890
Emissions Benefit	$2,812
TOTAL BENEFITS	$11,801,694





Step 2.5 Performance-Based Analysis Matrix

Step 2.5 Performance-Based Analysis Matrix

Intersection Control Strategy	Capital Cost ($1,000)	Safety Benefit ($1,000)	Travel Time Benefit ($1,000)	Reliability Benefit ($1,000)	Vechile Operating Benefit ($1,000)	Emission Benefit ($1,000)	Benefit/Cost Ratio (BCR)
Alt 1 Roundabout Conversion	$4,558	$18,030	$92	$171	$16	$4	4.02
Alt 2 Four-Way Stop Control	Eliminated in Stage 1						
Alt 2 Dsgn Option Signalized Intersection	$2,951	$11,719	$60	$8	$10	$2	4.00
Alt 3 No Build Two-Way Stop Control (Baseline)	$0	$0	$0	$0	$0	$0	$0

Step 2.6 Findings and Recommendations

Preferred Alternative single-lane roundabout

- Safety Improvements
- Operational Efficiency
- Multimodal Accomodation
- Cost-Effectiveness
- Environmental Benefits
- Future Scalability
- Community and Aesthetic Enhancements
- Alignment with Policy Goals

Any Questions?

Locally Sponsored Projects and Local Development Review (LDR)

1. Project proponent (local agency or developer) proposes new or improved intersection meeting ISOAP applicability
2. Planning staff seeks feedback from Traffic staff, who make a cursory assessment of the potential viability of the improvement (early consultation)
3. If viable, project proponent conducts ISOAP during LDR if QMAP (Quality Management Assessment Process) will be followed for constructing the improvement
4. If a PID is to be prepared, then ISOAP may be conducted during the PID development

Roles and Responsibilities

- Preparing ISOAP – Caltrans staff, local agency, consultant
  - ISOAP Engineer
  - Traffic Operations Engineer
  - Traffic Safety Engineer
- Reviewing and supporting – Caltrans staff
  - District ISOAP Coordinator
  - District Traffic Operations Engineer
  - District Traffic Safety Engineer

Roles and Responsibilities

- **Preparing (Caltrans staff or external)**
  - **ISOAP Engineer**
    - Performs the ISOAP, engages with functional units as needed, and submits completed ISOAP documents to the District ISOAP Coordinator
    - Within Caltrans, will typically be in a Traffic Operations functional unit
    - Does not need to be an engineer, but if not, should be under the guidance of an engineer
  - **Traffic Operations Engineer**
    - Performs the operational analysis

Roles and Responsibilities

- **Preparing (Caltrans staff or external)**
  - **Traffic Safety Engineer**
    - Performs the safety analysis
  - **Project Engineer**
    - Develops geometrics for alternative strategies and cost estimates for construction and right-of-way working with other functional units as needed

Roles and Responsibilities

- **Reviewing and supporting (Caltrans staff)**
  - **District ISOAP Coordinator**
    - Reviews ISOAP documents
    - Provides technical support
    - Gets concurrence by District Traffic Safety Engineer
    - Approves ISOAP submittals
    - May be the ISOAP Engineer, but an additional reviewer is recommended in such cases

Roles and Responsibilities

- **Reviewing and supporting (Caltrans staff)**
  - **District Traffic Operations Engineer**
    - Reviews traffic operational analyses
    - Provides guidance for operational analyses performed by consulting engineers or other agencies
  - **District Traffic Safety Engineer**
    - Provides guidance as needed for calculating the safety benefit
    - Reviews and concurs with the recommendations in ISOAP Stages 1 and 2

Insufficient Funding for Desired Solution

If the available funding is insufficient, consider:

- Combining with planned SHOPP work, SHOPP safety funding, CMAQ, Local Highway Safety Improvement Program (HSIP), ATP, Minor A or B funding for components with independent utility, Regional Transportation Improvement Program (RTIP), developer fees or mitigation, local transportation sales tax measures
- A phased implementation of recommended strategy
- Cost-effective interim improvements

District 6 Affordable Roundabouts

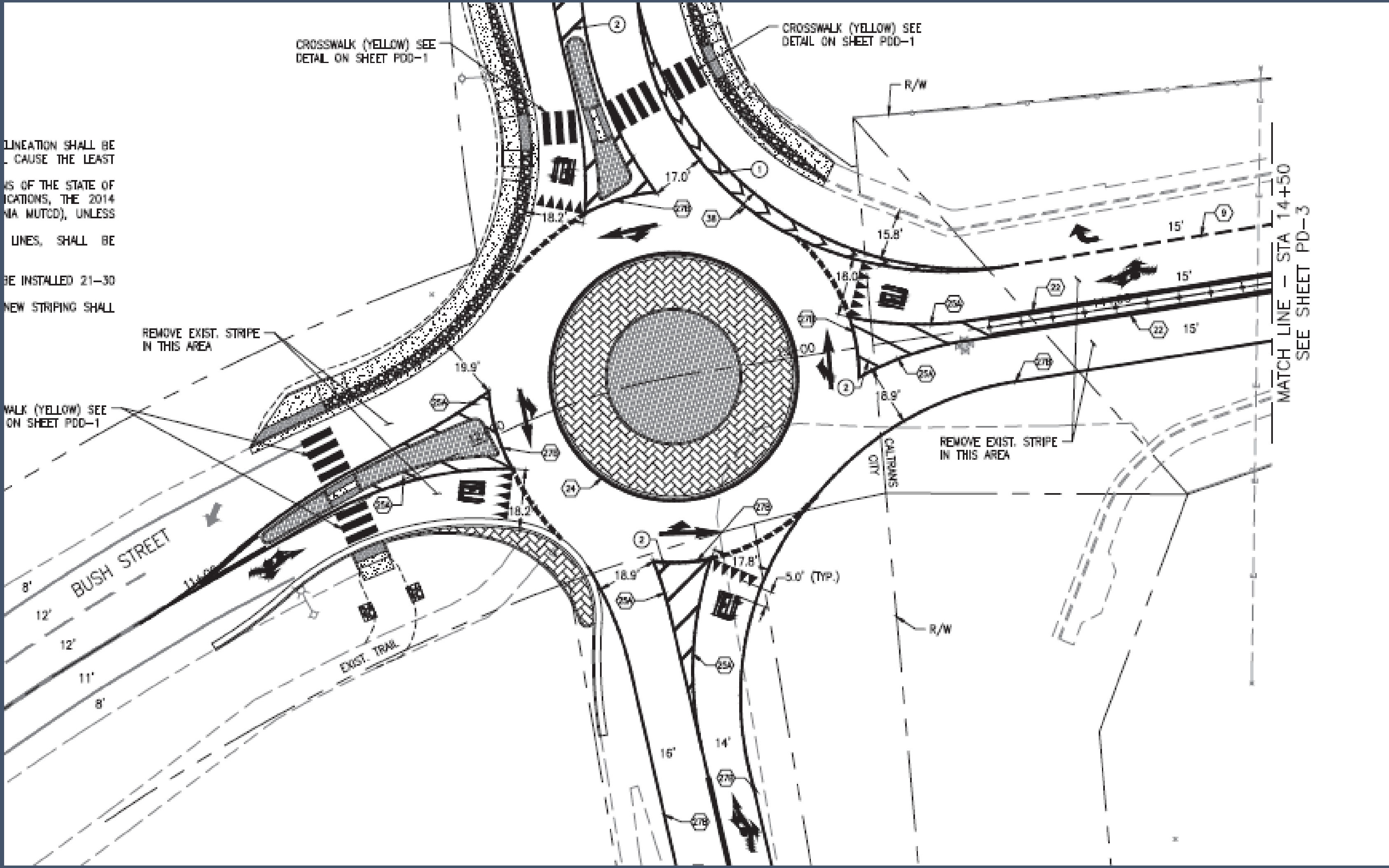
- Kin-41 Bush Street interchange – interim improvement, developer funds
- Tul-137 and Morrison – Minor A and developer funds

Interim Roundabout
SR-41 Bush St Interchange in Lemoore

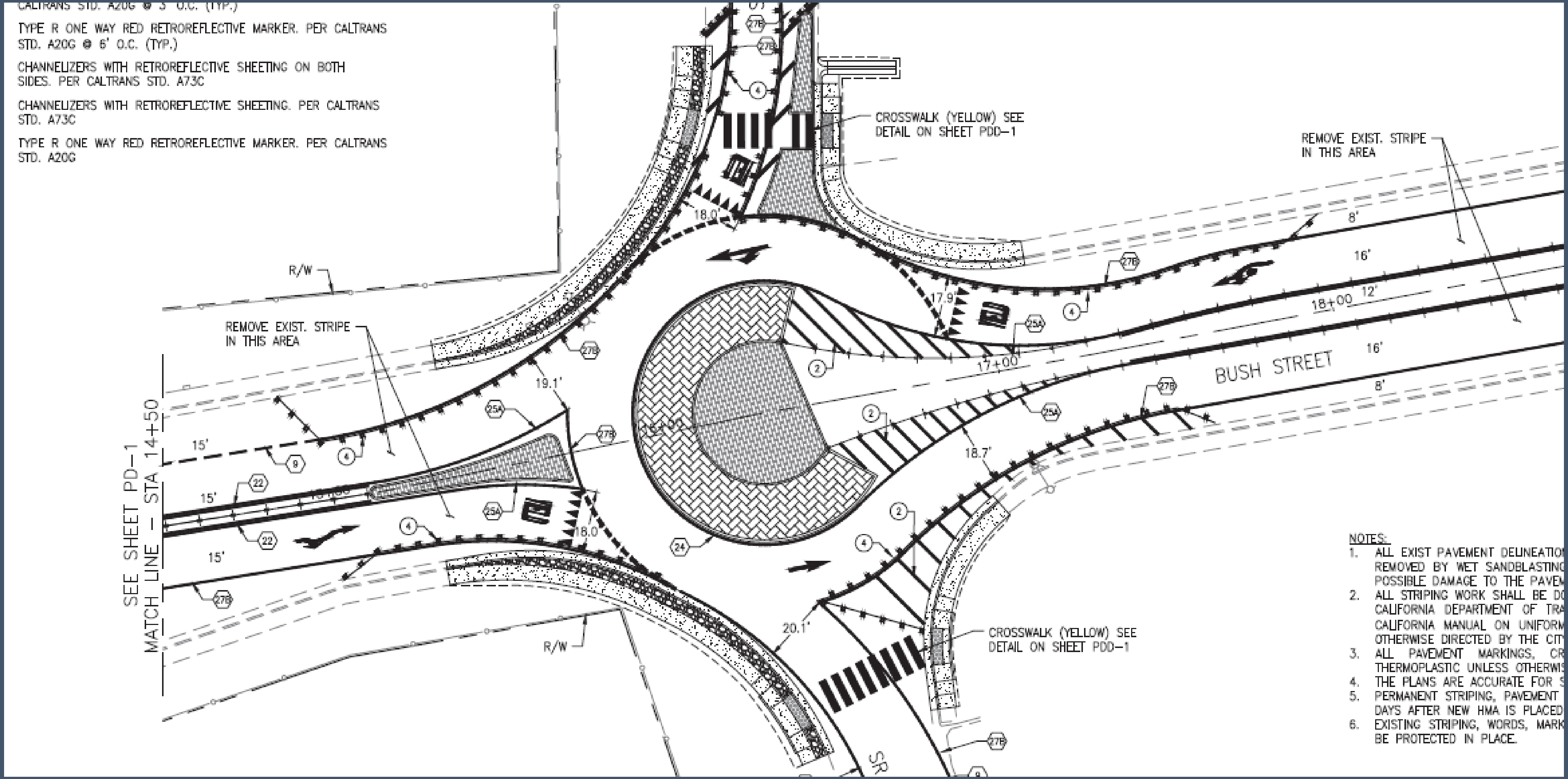
SR-41 Bush Street Interchange

- NB off-ramp backs up
- City was interested to build a DDI or add roundabouts to the ramp terminals but could not afford those
- Developer required to improve interchange prior to additional residential construction
- 3 interim roundabouts, including closely space local intersection

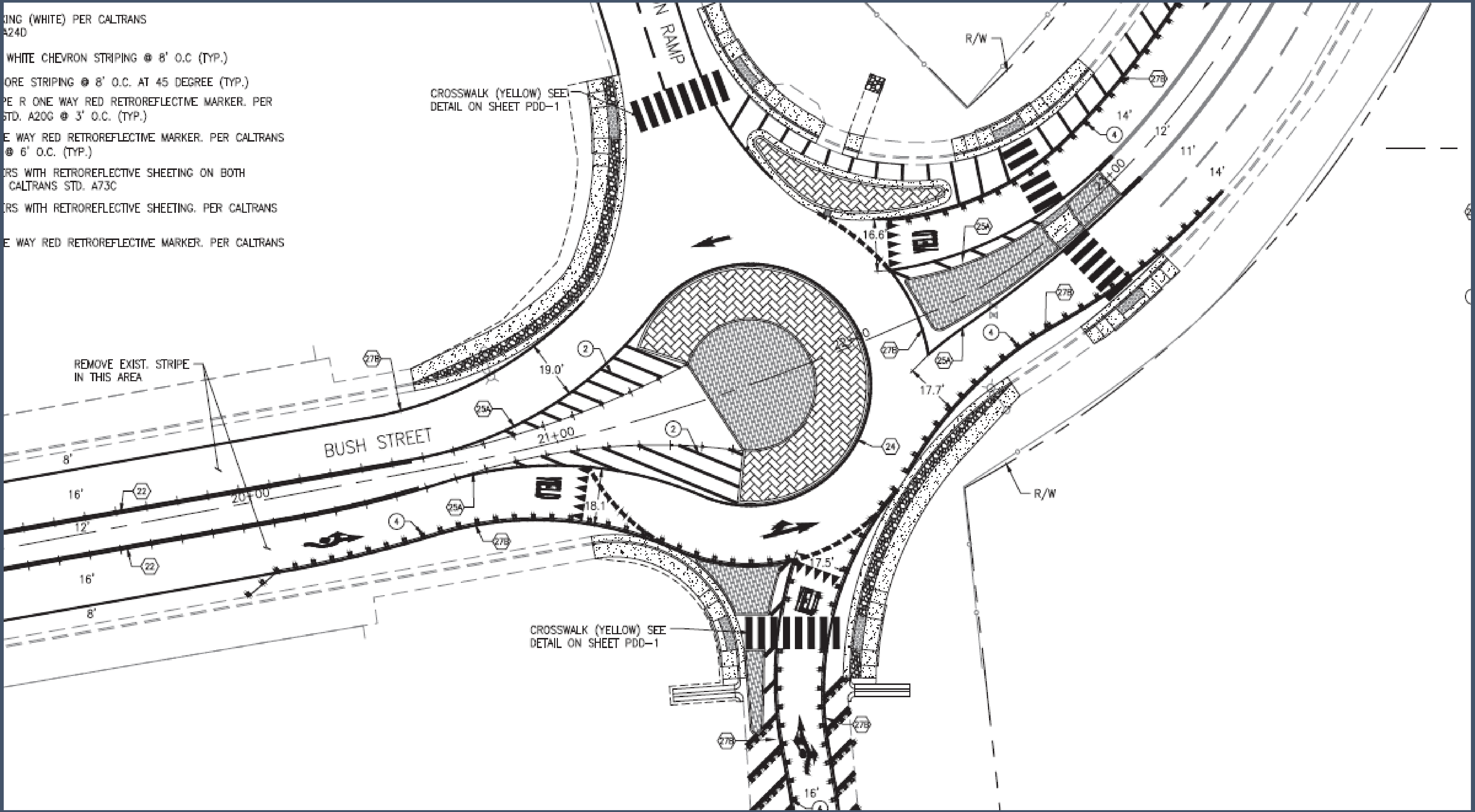
Bush Street and Belle Haven Drive



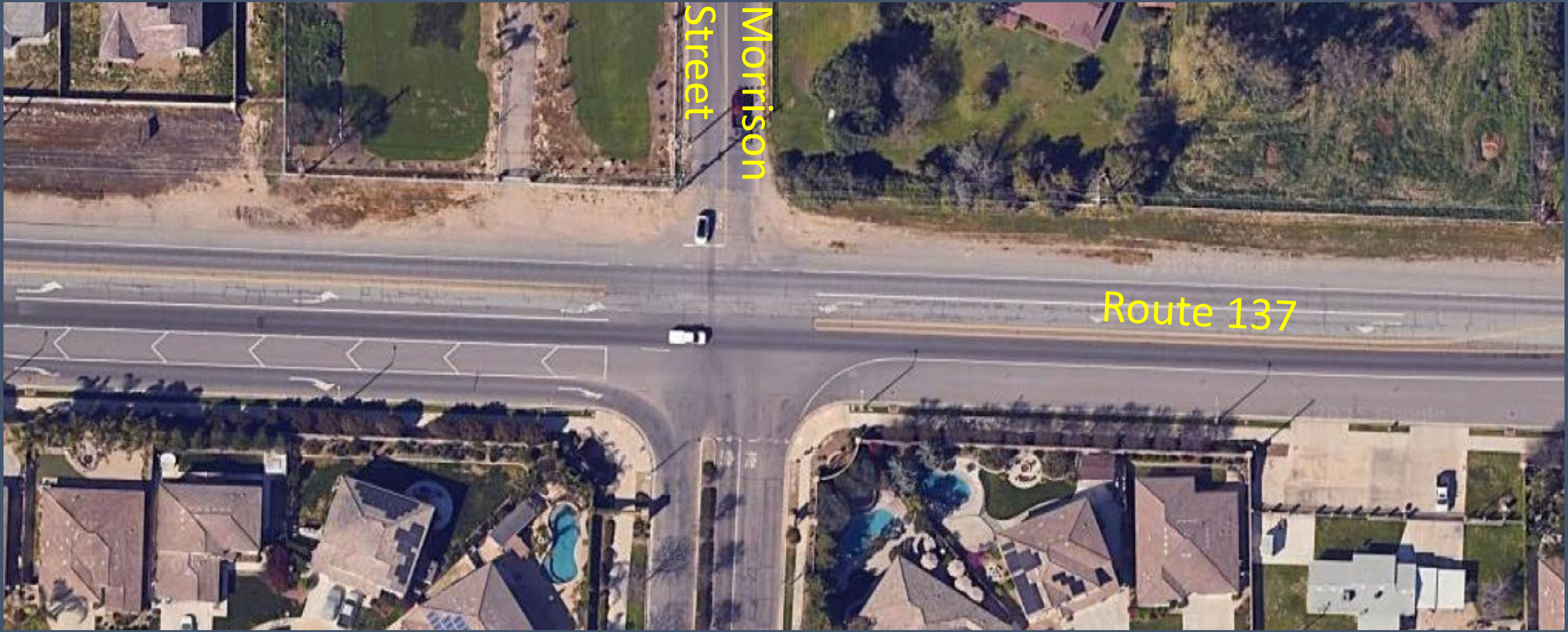
Bush Street and SB Off-Ramp



Bush Street and NB Off-Ramp



Interim Roundabout
SR-137 Morrison Street in Tulare



SR-137 at Morrison Street

- Developer was required to install a permanent traffic signal after completion of a specific phase of a nearby residential subdivision
- Because of the length of time required to implement the traffic signal, a quick-build temporary roundabout was proposed
- Temporary roundabout was changed to a permanent roundabout, will eventually need to be replaced with a multilane roundabout

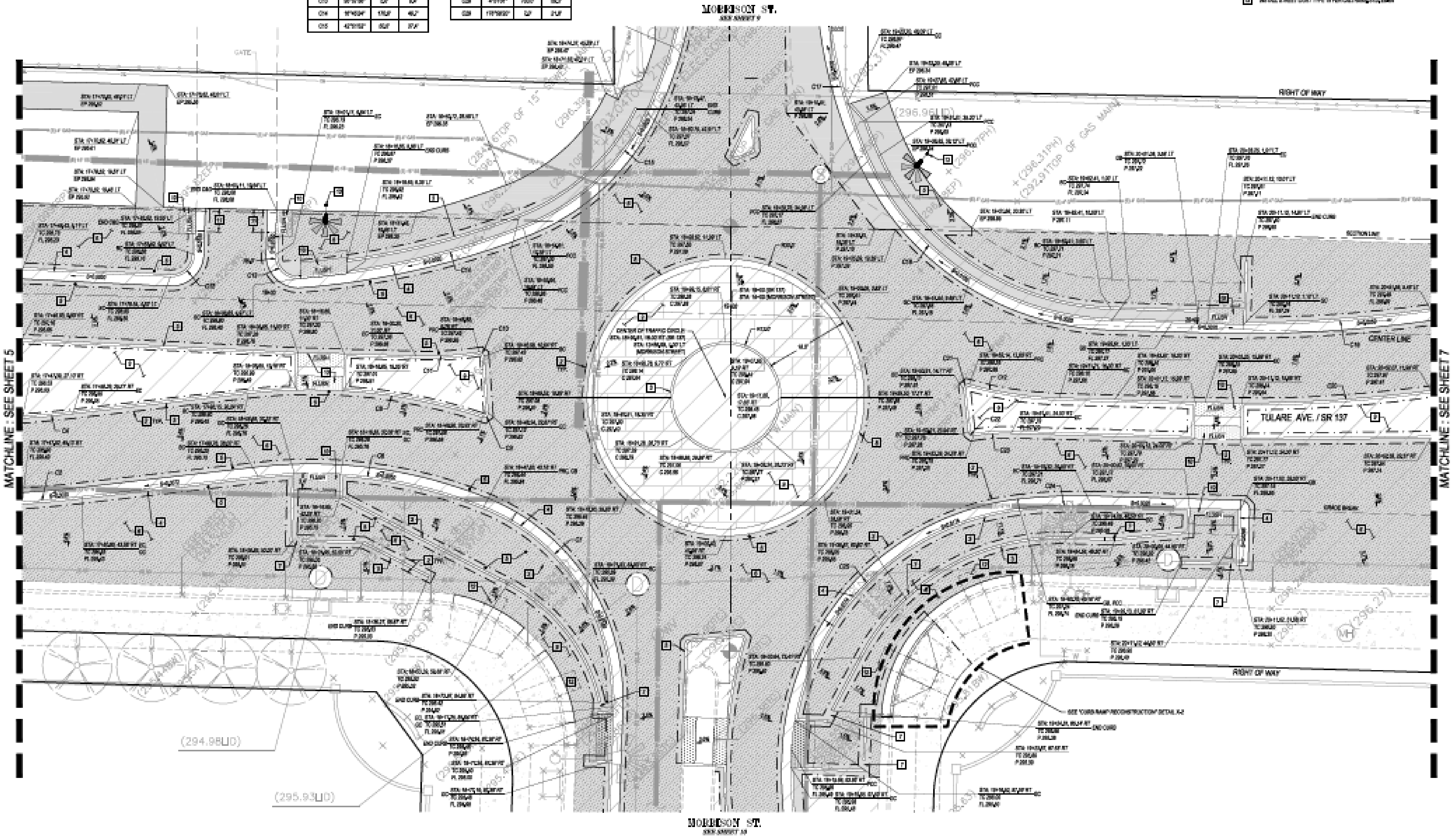
SR-137 at Morrison Street

- Need to accommodate STAA trucks
- Route 137 AADT is 15,000
- 2035 Concept and UTC are 4-lane conventional highways
- Caltrans contributed $1.25 million Minor A
- Developer funded the project plans and $350k construction costs
- City of Tulare administered the construction contract

SR-137 at Morrison Street

C13	[illegible]	[illegible]	[illegible]
C14	19°45'24"	175.8'	40.7'
C15	42°31'52"	[illegible]	37.4'

C28	[illegible]	[illegible]	[illegible]
C29	[illegible]	[illegible]	21.8'




NOW SELLING
The Orchards
& The Acres
at Copper Heights
Across Street
Tulare Ave.
Woodside
WoodsideHomes.com

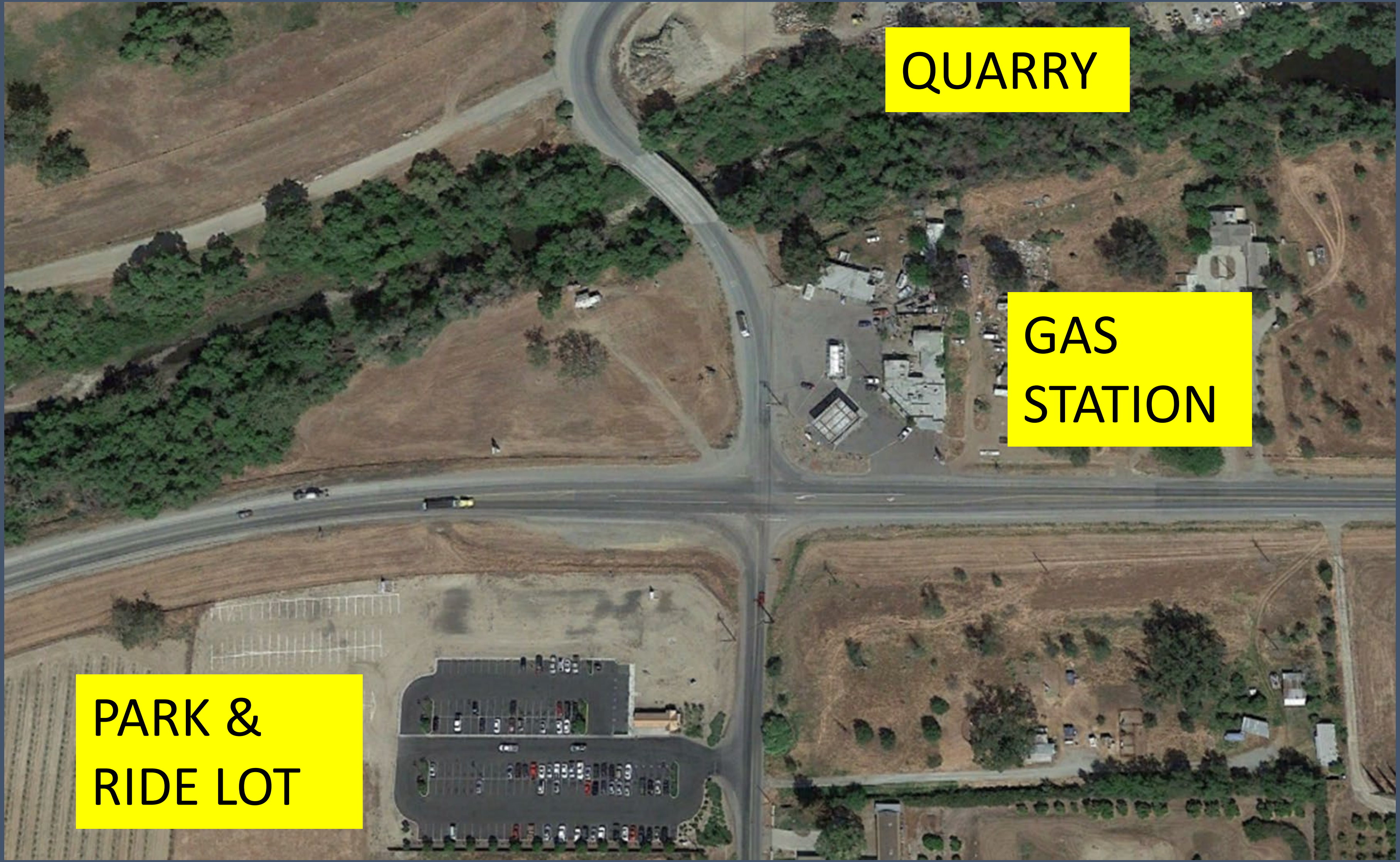
Public Outreach

- The planning and project delivery processes incorporate public outreach
- Additional public outreach beyond the planning and project deliver activities may be needed
- Education may need to be provided to local officials or the public for novel or unfamiliar forms of intersections

Identify Public Concerns

- Identify community concerns, such as
  - Safety or congestion
  - Restricted access to adjacent properties
  - Speeding
  - Parking impacts
  - Pedestrian and bicycle facilities
  - Truck access
  - Controversial proposed intersection configurations

SR-190 and Reservation Rd in Tulare Co



SR-190 and Reservation Road

Source: Porterville Recorder

THE PORTERVILLE Recorder

Highway 190 roundabout lacked input

May 14, 2015

However, we and many others have concerns. First, motorists will be traveling along at 55 to 65 mph and have to slow to 15 mph to negotiate the roundabout. Very dangerous.

SR-190 and Reservation Road

SR-168 and Auberry Road in Prather

Stratford Public Meeting

- Community is asking for left-turn channelization or a roundabout on SR-41
- 170 attendees, heated discussion at times

Public Outreach Tips

- Environmental Division has guidance for public participation (Standard Environmental Reference)
- Consult District Community Engagement Coordinator
- Use workshop format, separate from City Council or Board of Supervisor meeting
- Consider giving a presentation addressing the pertinent issues, including need and potential concerns
- Show relevant videos that can address concerns
- Allow questions and answers

Public Outreach Tips

- Listen with empathy
- Consider having law enforcement present at public meetings
- Consider a roundabout rodeo for first roundabout in area
- Meet individually with concerned public officials

Case Studies / Exercise

VA DOT's National Safety Award Winning *Instant* Roundabout *(2017)*

Location: Edgewater & Poland Road in South Riding, VA

RESULTS of Performance Evaluation:

- **Broadside crash pattern:**
  89% of Injury Crashes Reduced
- **Recurrent peak hour congestion:**
  eliminated immediately

The temporary design served for 4 years before it was replaced by a permanent roundabout (next slide)

Source: FHWA INNOVATOR, Issue 66, 2018 – "Getting a Jump Start on Safer Intersections
https://www.fhwa.dot.gov/innovation/innovator/issue66/issue66.cfm

VA DOT's National Safety Award Winning *Instant* Roundabout *(2017)*

Location: Edgewater & Poland Road in South Riding, VA

Interim **Roundabout installed in 6 days**

Permanent **Roundabout constructed in 2019**

VA DOT's National Safety Award Winning *Instant* Roundabout *(2017)*

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VA DOT's National Safety Award Winning *Instant* Roundabout *(2017)*
Location: Edgewater & Poland Road in South Riding, VA

The results were dramatic: Overall crashes decreased 30 percent and injury crashes dropped 89 percent, about what would be expected of a permanent roundabout. A 3-minute-long traffic queue during rush hours also disappeared. The project won a 2017 National Roadway Safety Award from the Roadway Safety Foundation and Federal Highway Administration.

VA DOT's National Safety Award Winning *Instant* Roundabout *(2017)*

Location: Edgewater & Poland Road in South Riding, VA

Winning Community Support

The project was not without challenges, though. "The hardest part was getting the community to accept the roundabout idea," said VDOT District Traffic Engineer Ivan Horodyskyj.

While engineers designed the project, the agency's public liaison team reached out to the area's county officials and homeowners associations to explain the benefits of roundabouts. Homeowners expressed concerns about the appearance of a roundabout made of plastic parts and its effect on property values.

"We said this is temporary, we expect it will provide immediate relief on crashes, and we'll revisit it after the construction is over," said Horodyskyj. The homeowners associations eventually agreed to the project and, after residents saw crashes diminish, asked VDOT to make the roundabout permanent.

Another challenge is that the plastic components occasionally break or become dislodged and must be repaired, particularly after snowplows come through. "That's one thing we would do differently in the future," said Horodyskyj. "We would look for more durable components."

CASE STUDY: City of Cleveland
MINI-ROUNDABOUT CORRIDOR

PRE-Project Conditions

Purpose & Need: TRAFFIC CALMING / SAFETY

West Franklin Boulevard

- **2-lane arterial thru economically depressed**
- **residential neighborhood**
- **Posted Speed = 35 mph**
- 1.8 miles (project limits)
- **Nine (9) traffic signals**
- ADT: 4,300
- **History of pedestrian fatal & injury crashes**

West Franklin Boulevard on the near West-side

West Franklin Blvd MINI-ROUNDABOUT CORRIDOR Project

City of Cleveland, Ohio

POST-Project Intersection Control

Project Budget & Timeline

Construction Cost: $3,435,000

Funding Sources:

$2,355,000 – STBG
$330,000 – TA
$750,000 – City Road and Bridge Bonds

Conceptual Planning 2018 → Design 2021 → Construction (Phase 1) 2022 → Construction (Phase 2) 2023

West Franklin Blvd MINI-ROUNDABOUT CORRIDOR Project

Observations and Evaluation: Traffic Calming and Safety Findings

Pre-Project

Location	Direction	85th Percentile Speed (mph)
8205 Franklin Blvd.	Eastbound	32
	Westbound	36
6016 Franklin Blvd.	Eastbound	34
	Westbound	34
4610 Franklin Blvd.	Eastbound	34
	Westbound	32
3600 Franklin Blvd.	Eastbound	34
	Westbound	34
Corridor Average		**34**

Table 4: Measured Speeds, 2016 Speed Study

Post-Project

- Speeds slowed: 50^{th} percentile ~22.5 mph; 85^{th} percentile ~27
- Speed limit signage changed to 25 mph
- Crash records: too soon to say, but only 1 recorded roundabout-involved crash (PDO)

CITY OF CLEVELAND
Mayor Justin M. Bibb

West Franklin Blvd Mini-Roundabout Project

November 21, 2024

Construction Cost: $3,435,000

City of Cleveland
Franklin Blvd Mini-Roundabout Corridor
***Low-Cost* Traffic Calming & Safety Project**

City of Cleveland
Franklin Blvd Mini-Roundabout Corridor
***Low-Cost* Traffic Calming & Safety Project**

Project **COST: $3.4 Million (7 Minis +)**

RESULTS:

<> Lower Vehicle Speeds ...
... 85% Speed of 27 MPH

<> **Speed Limit** Changed from 35 to **25 MPH**

<> 1 minor crash since project completion


Franklin
W 74th St

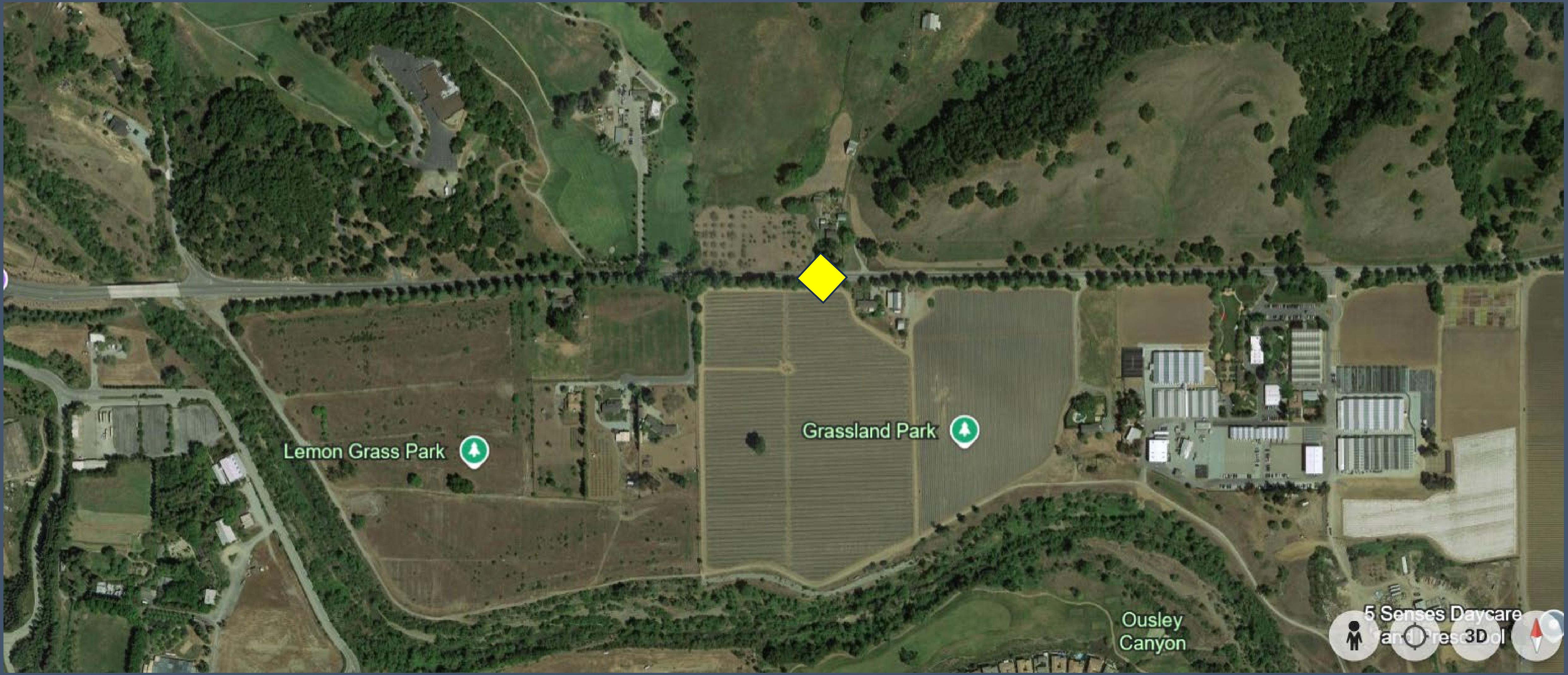
Example: RCUT at Interchange (cars only)

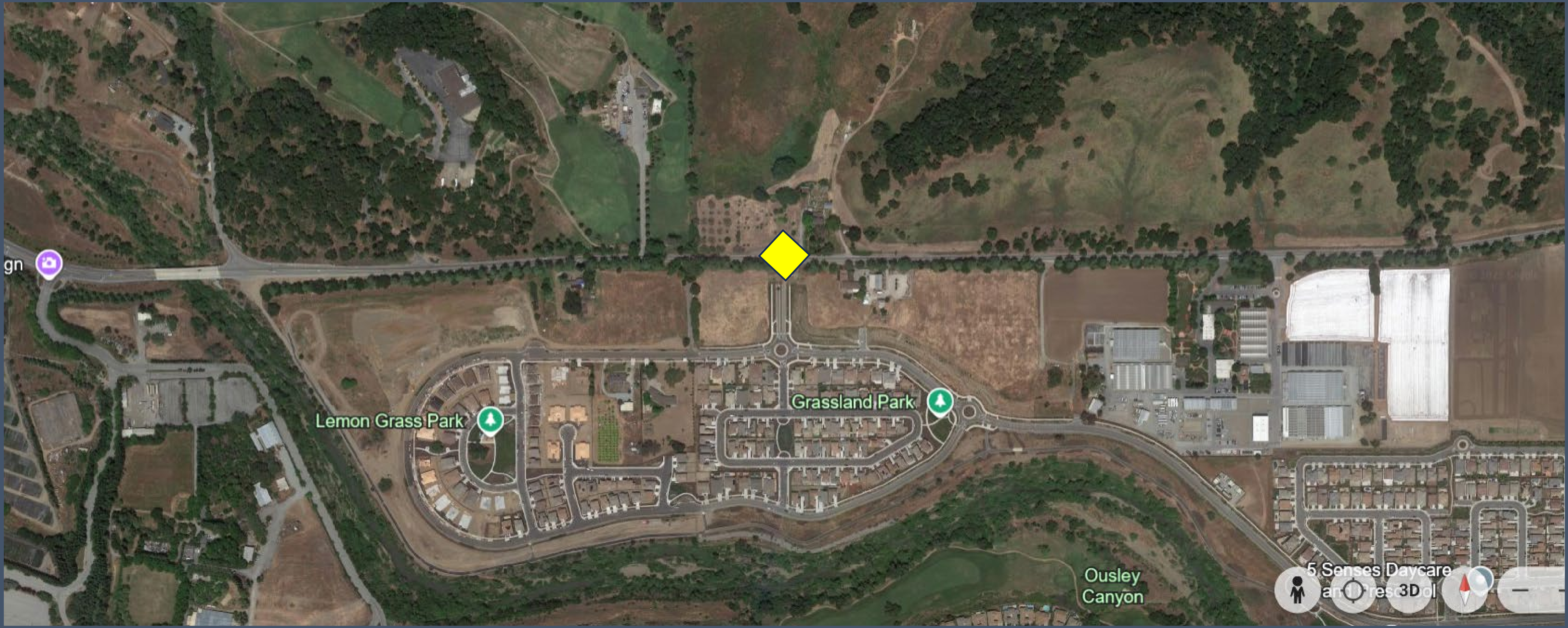
Provides most drivers with a bypass of existing "hook" entrance to SB I-80

Example: RCUT at Interchange

Drivers of passenger cars can access both SB entrance ramps.

- Travel distance is similar.
- Travel time is usually less for diagonal entrance ramp


Lemon Grass Park
Grassland Park
Ousley
Canyon
5 Senses Daycare
3D



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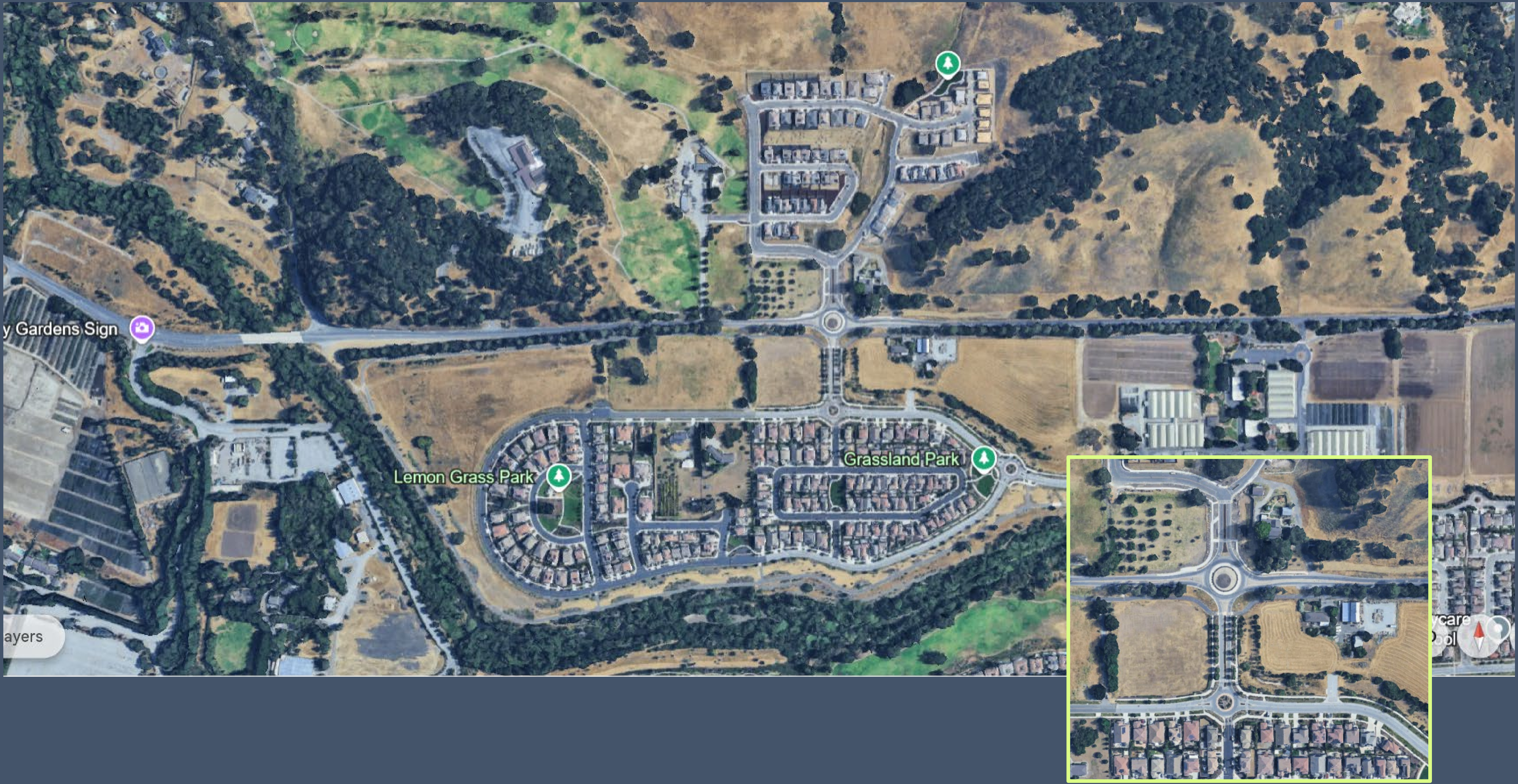
y Gardens Sign
Lemon Grass Park
Grassland Park
ayers

Questions and Answers

john.liu@dot.ca.gov

jerry.champa@dot.ca.gov

District ISOAP Coordinators

District/HQ	Coordinator
1 – Eureka	Paul Hailey
2 – Redding	Jesse Solorio
3 – Marysville	Scott Waksdal
4 – Oakland	Whitney Lawrence
5 – San Luis Obispo	Bing Yu
6 – Fresno	Caleb Wu
7 – Los Angeles	Wilfred Domingo
8 – San Bernardino	Siva Sivakkolunthar
9 – Bishop	Lianne Talbot
10 – Stockton	Jaime Quesada
11 – San Diego	Safwat Ibrahim
12 – Orange County	Mohsen Zadeh
HQ Traffic Operations	Zifeng "Lilian" Wu

Additional Resources

- **ISOAP website:** www.dot.ca.gov/programs/traffic-operations/isoap
- **ISOAP Technical Assistance Program (TAP)**
  - Program Coordinator Zifeng “Lilian” Wu, Traffic Operations
  - District ISOAP Coordinators
  - John Liu, District 6 Maintenance and Operations