Safe Trips to BART: An Action Plan for Safer Roadways

DECEMBER 2025

BART

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Appendices are separate files due to their size and are found at www.bart.gov/safetrips.

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Key Terms

The following list defines key terms that are referenced throughout this Plan.

- **Annual Average Daily Traffic (AADT)** – A calculation that sums all vehicle trips on a road segment in both directions for a year then divides that sum by 365 days.
- **Countermeasures** – Physical changes to the roadway that aim to reduce the severity of crashes or prevent them from happening in the first place. Also referred to as roadway safety measures in this document.
- **Crash parties, crash victims** – Transportation modes involved in a crash as reported by police, such as motorist-only, pedestrian-involved, bicyclist-involved, and motorcyclist-involved. Victims are the people associated with each party, such as motorist, passenger, pedestrian, bicyclist, and motorcyclist.
- **Disadvantaged communities** – Communities with disproportionate economic, health, and environmental burdens, among other concerns. This Plan relies on the Metropolitan Transportation Commission's Equity Priority Communities when referencing disadvantaged communities.
- **Focus Station Area Action Plan (FSAAP)** – Conceptual designs using roadway safety measures on a selection of public streets in a Station Study Area to demonstrate where to locate improvements and select appropriate tools for addressing safety concerns. Seven FSAAPs were done for this Plan.
- **High injury network (HIN)** – A tool that identifies concentrations of fatal and severe injury crashes on streets to help practitioners identify where to prioritize resources for the greatest impact.
- **Injury crashes/collisions** – Crashes in which at least one person was reported by police as having injuries in one of four categories: fatal, suspected serious, suspected minor, or possible injury.
- **Killed or serious/severe injury (KSI) crashes/collisions** – Crashes in which at least one person was reported as killed or suspected as seriously injured. KSI crashes are a subset of injury crashes.
- **Parallel network** – The road network that BART riders would likely use to get to and from their destinations if the BART system hypothetically didn't exist.
- **Partner agencies** – Agencies with whom BART collaborated in developing this Plan, including cities, counties, towns, Caltrans, MTC, and/or countywide transportation authorities.
- **Public streets, roads, and/or roadways** – Terms that are used interchangeably throughout this Plan to indicate non-BART roads that are owned and/or operated by cities, counties, towns, or Caltrans. Technically, "streets" only refer to local roads while "roads" and "roadways" refer to both freeways and local roads. For this plan, however, all these terms are used to generally refer to local roads unless otherwise indicated.
- **Roadway Safety Action Plan** – Comprehensive safety plan aimed at reducing and eliminating severe-injury and fatal crashes affecting all roadway users. More information about the requirements for developing a plan can be found at https://www.transportation.gov/grants/ss4a/comprehensive-safety-action-plans.
- **Safe Streets and Roads for All (SS4A) Grant Program** – A federal program that funds regional, local, and tribal initiatives through grants to prevent roadway deaths and severe injuries. More information about the program can be found at https://www.transportation.gov/grants/SS4A.
- **Safe System Approach** – An effective way to address and mitigate the risks inherent in the transportation system. It works by building and reinforcing multiple layers of protection to both prevent crashes from happening in the first

place and minimize the harm caused to those involved when crashes do occur. More information about this approach can be found at https://www.transportation.gov/safe-system-approach.

- **Station Access Typology** – A system used by BART to classify stations into one of five groups based on the context of the surrounding neighborhood and how riders get to the station. More details on each category can be found at BART's Station Access Policy webpage.
  - Urban: A high-ridership station with no BART-operated parking. Generally located in a downtown or neighborhood commercial district where more than 75% of riders walk, bike, or take transit to access the station and less than 5% drive alone.
  - Urban with Parking: Similar to an Urban station but has some BART-operated parking on-site and may be in more residential neighborhoods. 60-75% of riders walk, bike or take transit to the station while up to 25% drive alone.
  - Balanced Intermodal: May be located in either urban or suburban areas and has BART-operated parking in addition to a significant local transit hub on site. Riders who walk and those who drive alone/carpool to access BART have similar rates of 25% to 40%.
  - Intermodal-Auto Reliant: Generally located in suburban areas with a significant local transit hub and BART-operated parking on site. Combined drive alone/carpool/passenger drop-off rate for riders to access BART range from 55% to 80%.
  - Auto Dependent: Typically adjacent to freeways and/or at the terminus with significant BART-operated parking on site. Combined drive alone/carpool/passenger drop-off rates for riders to access BART are 67% or higher.
- **Station study area** – The areas around stations based on the average distances people travel to access BART, which range from 0.66 miles to 1.96 miles depending on the station access typology.
- **Vision Zero** – A strategy to eliminate all fatal and serious injury while increasing safe, healthy, equitable mobility for all. More information about Vision Zero can be found at https://visionzeronetwork.org/about/what-is-vision-zero/.
- **Vulnerable road users (VRU)** – People when they are bicycling, walking, or using another type of personal conveyance (e.g., assistive mobility device, e-scooter, skateboard, etc.) and traveling at slower speeds. Motorcyclists and motorized scooter drivers (e.g., Vespa scooters) are also more vulnerable when involved in a crash, but they are not included in the Federal Highway Administration's definition of a vulnerable road user. Note that sharing space with motorists who are operating faster, heavier vehicles is what makes people outside the vehicle vulnerable; vulnerability is not an intrinsic quality of people walking, bicycling, or using another personal conveyance.

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Executive Summary

Context

The San Francisco Bay Area Rapid Transit District (BART) developed this roadway safety action plan, the first of its kind, as an initial step towards reducing or eliminating traffic crashes, in which at least one person is killed or seriously injured, on streets that provide access to its stations. This effort was funded by the US Department of Transportation's Safe Streets and Roads for All grant program[1], which supports initiatives that incorporate the Safe System approach to prevent deaths and severe injuries due to traffic crashes.

The Safe System Approach, shown in Figure 1, is founded on the principles that humans make mistakes and that human bodies have limited ability to tolerate crash impacts. In a Safe System, those mistakes should never lead to death or severe injuries. This Plan was guided by the Safe System approach and built on local and regional initiatives to eliminate fatal and serious injuries on roadways. BART is one of the first transit operators in the nation to develop a roadway safety action plan. Collaboration with BART's partner agencies was paramount in this Plan's development as almost all reported killed and serious injury (KSI) crashes occurred off BART property on public streets operated by cities, counties, towns, and California's Department of Transportation (Caltrans).

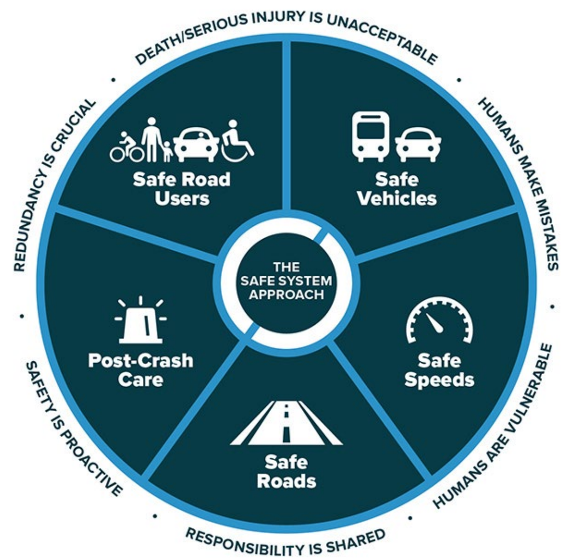


Figure 1. Safe System Approach

Source: FHWA

Addressing safety issues on public streets around BART stations is an important step towards improving the experience not only for BART riders but for all roadway users. Nonetheless, reducing or eliminating KSI crashes is an essential element of a high-quality transit experience and has the potential to boost ridership on BART. Improving roadway safety is particularly important for those who walk or bike because they are more likely to experience severe outcomes when involved in traffic crashes. Implementing roadway changes that prioritize their safety reduces KSI crashes for all road users.

About the Plan

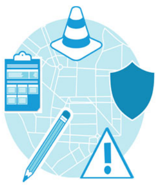
Safe Trips to BART: An Action Plan for Safer Roadways was developed with input based on 750 public comments and in collaboration with representatives from 11 BART departments or divisions and 38 partner agencies. It contains an examination of existing crash trends and their risk factors and provides a framework for selecting roadway safety measures to mitigate these risk factors for public streets providing access to BART.

As a heavy-rail transit operator, it may seem counter-intuitive for BART to lead a roadway safety action plan. BART has few roadways under its control and even fewer probable KSI crashes on its property (an estimated four crashes over seven years). This Plan, however, is a continuation of BART's efforts to improve first mile/last mile access to its stations by partnering with other public agencies. Its development enabled the unique opportunity to quantify and analyze traffic crashes on public streets through the lens of station access. This Plan can serve as a resource for cities, counties, towns, and Caltrans to seek funding for stand-alone roadway safety projects and/or include roadway safety elements in their capital improvement programs. The Plan's intended outcome is to motivate these agencies to advance initiatives that reduce or eliminate KSI

[1] More information about the SS4A Program can be found at https://www.transportation.gov/grants/SS4A.

crashes on public streets around BART stations because they are frequently located in areas where roadways are most in need of redesigning for safety.

Information gathered and analyzed for this Plan is summarized and organized by the following chapters:



Chapter 1:

Why a Roadway Safety Action Plan?

Purpose, vision, and background for the BART Safety Action Plan.

Chapter 2:

Public and Stakeholder Engagement

Findings about traffic safety concerns and best practices from engagement with members of the public, community-based organizations, elected officials, and partner agencies.

Chapter 3:

Safety Analysis

Analysis of crash, roadway, and demographic data to identify safety trends, crash patterns, and risk factors that impact traffic safety in BART Station Study Areas.

Chapter 4:

Roadway Safety Measures Toolbox

A resource for local partners to determine appropriate roadway safety improvements.

Chapter 5:

Developing the Focus Station Area Action Plans

Approach to selecting focus stations and developing conceptual recommendations for streets in their study areas using the Roadway Safety Measures Toolbox.

Chapter 6:

Future Actions

Summary of potential outcomes and implementation strategies.

Supporting documentation can be found in the appendices and on the project website at www.bart.gov/safetrips.

Key Findings

The safety analysis examined injury crash data on public streets over a five-year period (2019-2023) and on BART property over a seven-year period (2017 -2023). It identified trends, risk factors, and locations where the likelihood of KSI crashes was higher. While this Plan includes summaries of injury crashes on BART property and the regional roadway network roughly parallel to the BART system, most of the analysis focused on injury crashes on public streets (excluding freeways) in Station Study Areas.

The extent of each Station Study Area was based on the average distance riders travel to access BART, which ranges from 0.66 to 1.96 miles, depending on its Station Access typology (Urban, Urban with Parking, Balanced Intermodal, Intermodal-Auto Reliant, or Auto Dependent). Within each Station Study Area, crash data were used to establish the High Injury Network (HIN)[2], a set of roadways where higher concentrations of KSI crashes and/or their risk factors (like higher posted speed limits) were found. Four key themes emerged from the safety analysis of public streets in the Station Study Areas:

1. **Station Study Areas are uniquely important to the region for traffic safety.** Public streets providing access to BART have twice as many KSI crashes per mile than those further away in the five counties in which BART operates.

[2] Note that this plan's HIN does not replace or supersede HINs developed by other agencies.

Many stations are located adjacent to roadways that were built to accommodate suburbanization in the 1950s and 1960s, before the BART system was constructed. These roadways tend to have higher risk factors, as described next.

2. **Speed is a common thread relevant to nearly all other safety risk factors in Station Study Areas.** Streets with posted speed limits of 35 miles per hour (MPH) or higher accounted for 26% of public street miles but 47% of KSI crashes. Conversely, streets with posted speeds of 25 MPH accounted for 67% of public street miles but 41% of KSI crashes. These findings indicate a link between severe crashes and posted speeds and associated factors, such as the presence of arterial, multi-lane, or high-volume roadways.
3. **Bicyclists, pedestrians, and motorcyclists are disproportionately injured in Station Study Areas.** Collisions involving pedestrians, bicyclists, and motorcyclists accounted for 33% of all injury crashes, but 61% of KSI crashes. Moreover, bicyclists, pedestrians, and motorcyclists are almost ten times as likely to sustain a KSI injury as motorists or vehicle passengers (18% compared to 2%, respectively).
4. **Over three-quarters of KSI crashes occurred on just 18% of the Station Study Area roadways.** Most of these public roads are arterial streets, which are typically wider, faster, and busier than other types of non-freeway streets.

As a companion to the Station Study Area analysis, this Plan includes a white paper exploring the question: ***Does improving transit service levels serve as a systemic roadway safety measure?*** Most research has found that riding rail transit like BART is safer than traveling in a passenger vehicle.[3] **Appendix E: White Paper for System Safety Analysis** expanded the concept of rail safety by exploring whether and how transit can act as a roadway safety measure in the Bay Area. It found that the most effective roadway safety measures, like road diets, are more universally supported when robust transit service provides a good alternative to driving. Safer roadways would result if BART service improvements were implemented *in tandem* with its partner agencies reconfiguring streets parallel to the BART system to accommodate lower traffic volumes and speeds. However, a *direct* relationship between improved transit service and roadway safety is less clear.

Based on the safety analysis, BART developed a toolbox of Systemic Roadway Safety Measures, found in Chapter 4, which includes over 30 best practice tools that agency practitioners can utilize on their roadways to reduce or eliminate KSI crashes. The tools are organized by their effectiveness in addressing KSI crashes and reducing vehicle speeds based on the FHWA Safe System Roadway Design Hierarchy.[4]

Next Steps

This Plan is foundational for BART's partner agencies to prioritize efforts on their streets with high concentrations of KSI crashes, which tend to be found in Station Study Areas. BART will work with them to help include safety improvements around BART stations in their capital improvement programs and pursue funding for designing and implementing roadway safety projects on streets under their jurisdiction. The Systemic Roadway Safety Measures Toolbox can be used by cities, counties, towns, and Caltrans to determine which improvements could be implemented on Station Study Area HIN roadways under their jurisdiction for the greatest safety benefits not only to BART riders but all roadway users. If funding becomes available in the future, BART may revisit this analysis with local partners to assess how implemented roadway safety measures have impacted KSI crashes. In the meantime, members of the public could advocate for roadway safety projects on the Station Study Area HIN by using **Appendix H: Support Letter Template** to contact elected officials and/or staff at the agency (city, county, town, or Caltrans) that owns or operates the HIN roadway section of concern.

[3] One data point, for example, showed that riding rail transit is 18 times safer than traveling in a passenger vehicle. It was calculated using death rates per 100,000,000 passenger miles in the year 2022, which was 0.54 for passenger vehicles and 0.03 for railroad passenger trains from the National Safety Council's Injury Facts, found at https://injuryfacts.nsc.org/home-and-community/safety-topics/deaths-by-transportation-mode.
[4] More information about the FHWA's Safe System Roadway Design Hierarchy can be found at https://highways.dot.gov/safety/zero-deaths/safe-system-roadway-design-hierarchy.

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1. Why a Roadway Safety Action Plan?

Background

A good transit experience begins with a safe and comfortable journey to the station. However, public roadways that provide access to its stations have more instances per mile of killed and serious injury (KSI) traffic crashes than streets further away in the five counties that BART serves. This is not because the BART system causes behaviors that lead to an increase in KSI traffic crashes. Rather, BART was originally constructed as a commuter rail system, so its stations were intentionally located adjacent to existing roadways that have greater risk factors for safety: higher posted speed limits, multiple vehicle lanes, and classifications like "arterials" that prioritize automobility.

Safe Trips to BART: An Action Plan for Safer Roadways (also referred to as "BART's Safety Action Plan" or "Plan") is a pioneering, comprehensive plan aimed at proactively reducing or eliminating KSI crashes on public roadways surrounding BART stations. The terms "public street", "public road", and "public roadways" are used interchangeably throughout this Plan to indicate non-BART roads that are owned and/or operated by cities, counties, towns, or Caltrans. This Plan continues BART's practice of working with partner agencies to improve rider experience getting to and from its stations. Some of the more recent BART-led efforts include:

- Safe Routes to BART – A grant program to local agencies in Alameda, Contra Costa, and San Francisco counties for constructing walking and bicycle improvements on public streets that provide access to BART. This program is led by BART using funding from Measure RR, a bond passed in 2016. Over $20 million has been awarded to 13 projects.
- Berkeley-El Cerrito Corridor Access Plan – A study to improve strategies for getting to BART along the Richmond line once 2,000 homes are built on three BART rider parking lots of El Cerrito Plaza, North Berkeley, and Ashby stations. The study was funded by Caltrans and was instrumental in getting roughly a $24 million grant from the state's Transit and Intercity Rail Capital Program for El Cerrito Plaza access improvements that include a parking garage, an on-street parking management plan, biking and pedestrian improvements, and station signage and wayfinding upgrades.
- BART Walk and Bicycle Network Gap Study – A planning process from 2017 through 2020 to identify conceptual access improvements to make walking and biking to and from 17 BART stations safer and easier. Its focus was on near-term projects to support BART's Station Access Policy, which was adopted in 2016.

This Plan can be used in conjunction with previous and future BART efforts as well as those led by our partner agencies. They identify and promote safety and access improvements to roadways in and around BART station areas. The implementation of improvements depends on agency priorities, funding availability, and best practices for roadway changes that address the safety issues identified.

Current road safety policy and design have been moving towards Vision Zero[5] and the Safe System Approach[6], both recognized internationally as best practices to eliminate KSI crashes on roadways. The introduction of Vision Zero marked a global shift in roadway safety thinking. It sets an aspiration that mobility is possible without long-term injury or loss of life. The Safe System Approach recognizes that people make mistakes. The design and operation of our road networks should ensure those mistakes do not result in severe or fatal injuries. These road safety efforts may include data-driven approaches to prioritize resources; community engagement to gather feedback; collaboration between designers, enforcement, community organizations, and public agencies; and safety measures that focus on protecting the most vulnerable road users (VRU),

[5] Vision Zero Network. What is Vision Zero? https://visionzeronetwork.org/about/what-is-vision-zero/
[6] US Department of Transportation. What is a Safe System Approach? https://www.transportation.gov/NRSS/SafeSystem

pedestrians and bicyclists, since their implementation results in better safety outcomes for all, including those who travel in or on motorized vehicles.

Within the nine-county San Francisco Bay Area region, roadway collisions result in over 400 fatalities and 2,000 severe injuries each year[7]. Efforts at the regional level, such as the Metropolitan Transportation Commission's (MTC) Regional Safety/Vision Zero Policy, have inspired many local jurisdictions to adopt active transportation and roadway safety plans and make significant strides in enhancing traffic safety. Projects, plans, policies and programs led by BART and its local, regional, and state agency partners are foundational initiatives to improve traffic safety around BART stations and other areas. Efforts and existing plans from 39 agencies (including BART) are summarized in **Appendix C: Review of Existing Plans and Projects by Station Area and Agency** to understand safety-related work already being undertaken

Plan Vision and Purpose

Safe Trips to BART: An Action Plan for Safer Roadways establishes a vision in which riders can get to and from BART stations safely, comfortably, conveniently, and reliably, no matter how they travel. The goal of this Plan is to eliminate fatalities and severe injuries resulting from traffic crashes on public streets that provide access to BART stations. Designing roadways to prioritize the safety of vulnerable road users leads to better safety for everybody — transit users, drivers and their passengers, pedestrians, motorcyclists, wheelchair users, scooter riders and bicyclists alike.

The purpose of this Plan is to identify safety trends, understand risk factors, and provide a framework for selecting appropriate roadway safety measures for public streets surrounding BART stations. This Plan also aims to serve as a resource for local practitioners when identifying roadway improvements to include in their capital improvement programs and/or to apply for grant funding. As part of this effort, BART developed Focus Station Area Action Plans (FSAAPs) for seven stations to demonstrate how to apply this Plan at a local level (See **Appendix G: Focus Station Area Action Plans**). Any partner agency can reference this Plan to carry forward safety projects within the Station Study Areas. BART's Safety Action Plan helps partners agency staff to identify where to focus their efforts and what measures could be implemented for the greatest impact.

The Plan was developed over the course of two years, as detailed in Figure 2.

City of Fremont's Safe System Approach

Protected Intersection on Walnut Avenue
Source: SF Streetsblog

Fremont achieved 45% reduction in major crashes in five years following implementation of their 2016 Vision Zero Action Plan. The City uses the Safe Systems Approach, which aims to eliminate fatal and severe injury roadway crashes holistically through safe roads, safe speeds, safe vehicles, safe road users, and post-crash care.

These safety improvements include more protected intersections and bikeways, citywide streetlight upgrades, traffic calming, and traffic signal upgrades to prioritize pedestrians, coordinate traffic flow and enable emergency response preemptions.

Fremont's fatality rate in 2023 was 2.6 (fatalities per 100,000 people), compared to 6.3 in the Bay Area, 11.2 in California, and 12.7 nationwide. The City was awarded the "Safety Achievement Award" in 2021 by the Institute of Transportation Engineers.

[7] Metropolitan Transportation Commission Resolution No. 4400: Regional Safety / Vision Zero Policy https://mtc.ca.gov/sites/default/files/10a%2020-0788%20-%20ResoNo%204400%20Regional%20Safety%20VZ%20Policy.pdf

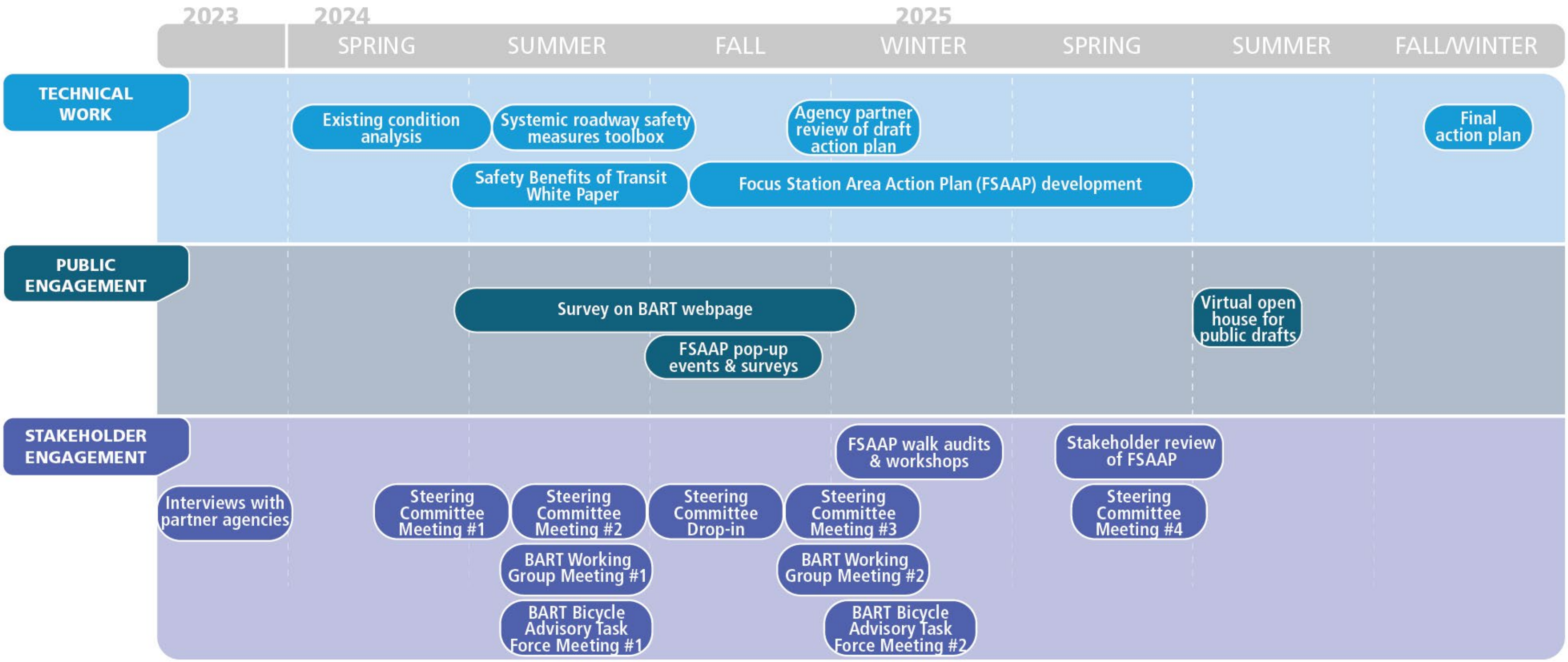

Figure 2. BART Safety Action Plan Timeline

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2. Outreach and Engagement

This Plan was developed in consultation with BART riders, BART staff, and partner agency representatives, as summarized below. For more details, refer to **Appendix A: Outreach Milestone Reports**.

Stakeholder Engagement

Agency Partners

BART led individual meetings with staff representing nearly 40 partner agencies at the outset of this planning process. This included staff from District 4 of California's Department of Transportation (Caltrans), the Metropolitan Transportation Commission (MTC), countywide authorities, and local jurisdictions who control roadways within a half mile of each non-airport BART station. The purpose was to raise awareness about the project, learn about planned and ongoing safety efforts at the local level, and gauge local agency interest and capacity to collaborate. Local partners identified projects, plans, programs, and studies for BART to review to understand existing local efforts. These stakeholders participated throughout the Plan's development. A subset of them collaborated, as appropriate, with BART on site selection for and development of the Focus Station Area Action Plans (FSAAP).

Steering Committee

The Steering Committee included representatives from MTC, Caltrans, and the following five countywide authorities: Alameda County Transportation Commission (Alameda CTC), Contra Costa Transportation Authority (CCTA), San Francisco County Transportation Authority (SFCTA), City/County Association of Governments of San Mateo County (C/CAG), and Santa Clara Valley Transportation Authority (VTA). The purpose of the Steering Committee was to guide the development of this Plan by reviewing key deliverables and sharing resources related to local roadway safety. Members provided guidance on the development of the high injury network (HIN) for the Station Study Areas, the selection of focus station areas for each county, and this Plan's agency draft. The committee also served to strengthen relationships between BART and partner agencies to collaboratively address roadway safety on public streets around BART stations. The Steering Committee met four times during the planning process.

BART Working Group

The BART Working Group included representatives from various BART departments and divisions: System Capacity, Police, Customer Access, Sustainability, Performance & Budget, Communications, Office of District Architect, and Property Development. The purpose of the working group was to build internal support for the project, provide requested data and resources, and ensure the recommendations and strategies in this Plan align with BART's best practices. There were two group meetings during the planning process, but individuals from this group were also consulted on a one-on-one basis, as needed, to provide expert guidance and data.

Public Outreach & Engagement

Engaging BART riders and other members of the public was essential for identifying their traffic safety concerns to inform development of the Plan. The project team engaged the public as follows:

- A general, free-form survey about traffic safety getting to and from BART which was found at the *Safe Trips to BART* webpage (www.bart.gov/safetrips) from its launch on July 15, 2024 through January 6, 2025.
- Pop-up events and intercept surveys (in-person and online) November through December 2024 at focus stations: Balboa Park (San Francisco County), Coliseum (Alameda County), Colma (San Mateo County), Concord (Contra Costa

County), Hayward (Alameda County), Milpitas (Santa Clara County), and Richmond (Contra Costa County). More information about how these stations were chosen is contained in Chapter 5: Developing the Focus Station Area Action Plans.

- Project updates at the BART Bicycle Advisory Task Force meetings on December 2, 2024, and August 4, 2025.
- Virtual open house and survey for the draft Plan and draft FSAAPs between June 25 through August 6, 2025.

General, Free-Form Survey Summary

The general, free-form survey was available on the project website for roughly 6 months. It asked respondents to share their stories about roadway safety and what safe trips to BART means to them. It received a total of 51 responses. Key themes that emerged from this survey included safety concerns related to speeding cars, inadequate bicyclist and pedestrian facilities near BART stations, proximity to highways and wide arterials, as shown in word cloud in Figure 3.

Figure 3. Free-form Survey Summary Word Cloud

Focus Station Area Survey Summary

The focus station survey was distributed at pop-up events at each of the seven focus stations between November 21 and December 12, 2024. Each event occurred between 4:30-6:30 PM to capture input from the highest number of exiting riders. The survey was administered in multiple languages using electronic tablets, QR codes, and on paper to gather feedback from riders about their roadway safety experiences and concerns as they travel to and from BART. The survey was available online through December 19, 2024, and received 503 responses. Key themes that emerged from this survey included concerns about speeding, reckless driving, lack of pedestrian and bicycle infrastructure, street lighting, and more protection when crossing streets. A more detailed summary of concerns is contained in Chapter 5: Developing the Focus Station Area Action Plans.

Photo of public outreach event held November 2024 at Richmond BART Station

Draft Plan and FSAAPs Survey Summary

An online open house to share the draft Plan and FSAAPs along with online surveys to solicit community feedback were launched on June 25, 2025. The goals of this open house were to present the project to communities in the Station Study Areas, solicit input on the Plan and FSAAPs, and encourage riders and community members to advocate to local jurisdictions and Caltrans for safer roadways. The survey was available online through August 6 and received over 150 responses. Respondents overwhelmingly agreed that the High-Injury Network (HIN) accurately represented their real-life experience of which streets felt unsafe. Similarly, 85% of respondents thought the proposed roadway safety measures would make them feel safer and 86% felt the Plan should be put into use. Based on community feedback, the final plan has been updated.

Notably, a template for a support letter has been added as Appendix H, which community members can use to advocate for the street safety improvements recommended in this plan.

For the FSAAPs, the following were identified as top priorities among the recommended projects, as indicated by their votes (percent of total responses and the raw number of votes). However, these results are anecdotal rather than representative of BART rider opinions due to the low number of respondents for any given station (20 on average).

- Balboa Park FSAAP: Ocean Avenue from I-280 to Cayuga Avenue (44%, 8)
- Coliseum FSAAP: 66th Avenue from San Leandro Street to International Boulevard (36%, 5)
- Colma FSAAP: Albert M Teglia Boulevard at Colma BART to El Camino Real & A Street (33%, 3)
- Concord FSAAP: Clayton Road from Park St to The Alameda; Sunset St and East St (33%, 2) & Salvio Street from East Street to Parkside Drive (33%, 2)
- Hayward FSAAP: D Street & Grand Street (23%, 3)
- Milpitas FSAAP: Great Mall Parkway & Main Street (38%, 5)
- Richmond FSAAP: MacDonald Avenue from 15th Street to 23rd Street (63%, 5)

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3. Safety Analysis

This chapter summarizes roadway safety conditions for streets in close proximity to the BART system. Injury crash data were reviewed for public, non-BART streets covering a five-year period between 2019 and 2023.[8] These data were analyzed to develop a high injury network (HIN) that identified concentrations of killed and severe injury (KSI) crashes on public, non-freeway streets that provide access to BART stations. These data were additionally analyzed for the regional public roadway network that runs roughly parallel to the entire BART system as part of the white paper. KSI traffic crashes on BART property were also reviewed and summarized for the seven-year period between 2017 and 2023. Findings from these analyses informed the selection of systemwide roadway safety measures detailed in **Chapter 4**.

Key Findings of Station Study Area Safety

Between 2019 and 2023, over 4,000 traffic injury crashes occurred annually on public (non-BART) streets in Station Study Areas. Of these crashes, 10% resulted in someone being killed or severely injured.

Per passenger mile, BART and other forms of public transit are vastly safer than nearly all other forms of ground transportation.* Yet these statistics show that traffic safety still affects BART riders at the beginning and end of their journeys.

**Source: American Public Transportation Association. "The Hidden Traffic Safety Solution: Public Transportation." (PDF) Sep 2016.*

Most of this chapter focuses on the Station Study Area HIN to identify high-priority locations for safety improvements on public, non-BART streets in Station Study Areas. It is organized into the following sections:

- **Methodology** is an overview of the approach to 1) defining Station Study Areas, and 2) developing the HIN for the BART system.
- **Station Study Area Findings** summarize crash frequency, sociodemographic information of crash victims, and roadway infrastructure conditions related to injury and KSI crashes for all non-airport BART stations.
- **High Injury Network (HIN) Findings** summarize KSI crash frequency and roadway infrastructure conditions that may influence crash severity.
- The **Relationship between Transit and the Safe System Approach** presents findings from a white paper that explores the concept of "transit as a roadway safety measure" from a regional perspective.
- **Roadway Safety on BART Station Property** summarizes injury traffic crashes on BART owned or operated roads.

[8] The impact of the pandemic on the 2019-2023 data was studied in **Appendix E White Paper for Systemic Safety Analysis**.

Defining Station Study Areas

The areas surrounding BART stations where riders typically walk, bike, or drive on public streets to get to and from BART are considered Station Study Areas. They were defined using BART's Station Access Typology.[9] Every non-airport station in BART's system is characterized as one of five station access types based on its ridership and access mode shares (percent of customers who walk, bike, take transit, carpool, drive alone and park, or get dropped off); surrounding land uses and transportation network; station footprints, and parking, among other factors. The average median distance that riders travel for each Station Access Type was calculated from BART's Station Profile Study[10] and applied to the street network using the open-source tool, OpenTripPlanner.[11] Figure 4 captures the Access Typology and Study Areas for all 48 stations but more detail can be found in **Appendix B: Existing Resources and Conditions Report** and at the project webpage, www.bart.gov/safetrips.

Table 1 shows all five Station Access Types and the average median rider travel distances used to define Station Study Areas. The Intermodal–Auto Reliant distance was also used for Auto Dependent stations because the latter's calculated distance was too far to be meaningful.

Table 1. Distances Used to Define Station Study Areas

BART's Station Access Type	Auto Mode Share	Average Travel Distance (miles)
Urban	Least	0.66
Urban with parking	↓	0.81
Balanced intermodal	↓	1.16
Intermodal – Auto reliant	↓	1.96
Auto dependent	Most	1.96

Analysis of injury crash data on public streets in Station Study Areas excluded those on mainline freeways but did include freeway ramps and interchanges. This was because injury crash data on mainline freeways does not indicate if the crash victims were just passing through an area or intending to exit the freeway to travel within a Station Study Area.

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[9] Information about BART's Station Access Typologies can be found at https://www.bart.gov/about/planning/station-access/policy.
[10] The BART Station Profile Study (2015) can be found at https://www.bart.gov/about/reports/profile.
[11] More information about OpenTripPlanner can be found at https://www.opentripplanner.org/.

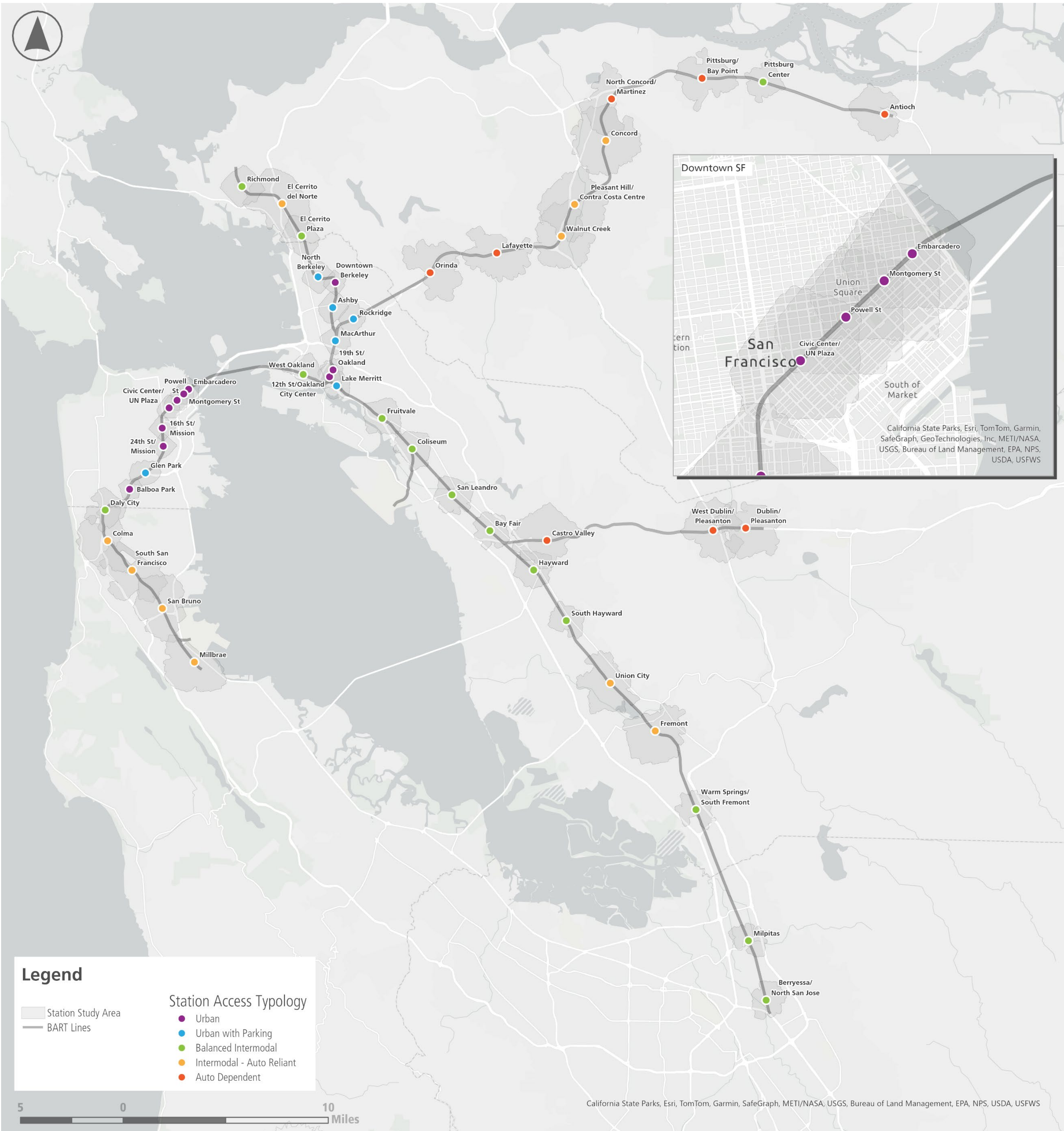

Figure 4. BART's Station Access Typology and Station Study Area Map

Further detail found in **Appendix B: Existing Resources and Conditions Report, Appendix D: High Injury Network Map by Station,** and at the project webpage, www.bart.gov/safetrips

Developing the High Injury Network (HIN)

An HIN is a common tool used to identify and prioritize parts of a street network where KSI crashes are most frequent. Ideally, streets on an HIN should ideally be prioritized for safety improvements over streets not on an HIN.

The HIN developed for this Plan prioritized areas where the greatest concentrations of KSI crashes happened within each Station Study Area, in line with the Federal Highway Administration's Safe System Approach. The primary input in developing the Station Study Area HIN was five-years of police crash report data for the years 2019 through 2023 from University of California (UC) Berkeley's Transportation Injury Mapping System (TIMS). TIMS data were obtained from California's Statewide Integrated Traffic Records System (SWITRS) and geocoded by UC Berkeley's Safe Transportation Research and Education Center (SafeTREC). The HIN was developed using data for a subregion of five counties, but the safety analysis focuses only on the HIN within the station study area. A map of the Station Study Areas and the HIN for this analysis is shown in Figure 5. **Appendix B: Existing Resources and Conditions Report** contains a full description of the Station Study Area's HIN methodology and analysis while **Appendix D: High Injury Network Map by Station** contains zoomed in views of each Station Study Area.

While an HIN analysis is considered a primarily reactive approach because it uses past crash data to determine where roadway safety improvements should occur, the analysis also included identification of risk factors, aligned with the Safe System approach, to more proactively identify corridors that need to be improved. These roadway risk factors include crossings at midblock locations and unsignalized intersections, which will be analyzed as part of the risk factors section.

The HIN is not the only place where crashes occur. KSI crashes at unsignalized intersections and midblock crossings tended to occur across the transportation network and were less likely to be captured by a method that measured linear clustering like the Station Study Area HIN. This means that midblock and unsignalized intersection injury crashes could be overlooked and remain unaddressed if roadway safety measures are exclusively concentrated on the Station Study Area HIN. Systemically targeting unsignalized intersection and midblock locations beyond the Station Study Area HIN that exhibit other risk factors may help address KSI crashes on public streets that are not on the Station Study Area HIN. Furthermore, these locations could be prioritized for roadway safety improvements if the risk factors are co-located with uses that generate higher levels of activity, such housing complexes, transit stops, schools, medical centers, and/or grocery and convenience stores. or risk factors that are overrepresented on the Station Study Area HIN (e.g., higher speeds, multi-lane roads).

This Plan's HIN will likely differ from HINs developed by other local and regional partner agencies. It was developed using injury crash data across five Bay Area counties with Station Study Areas as its focus. The Station Study Area HIN does not aim to replace but rather complement other HINs by providing additional evidence to support investment in priority corridors.

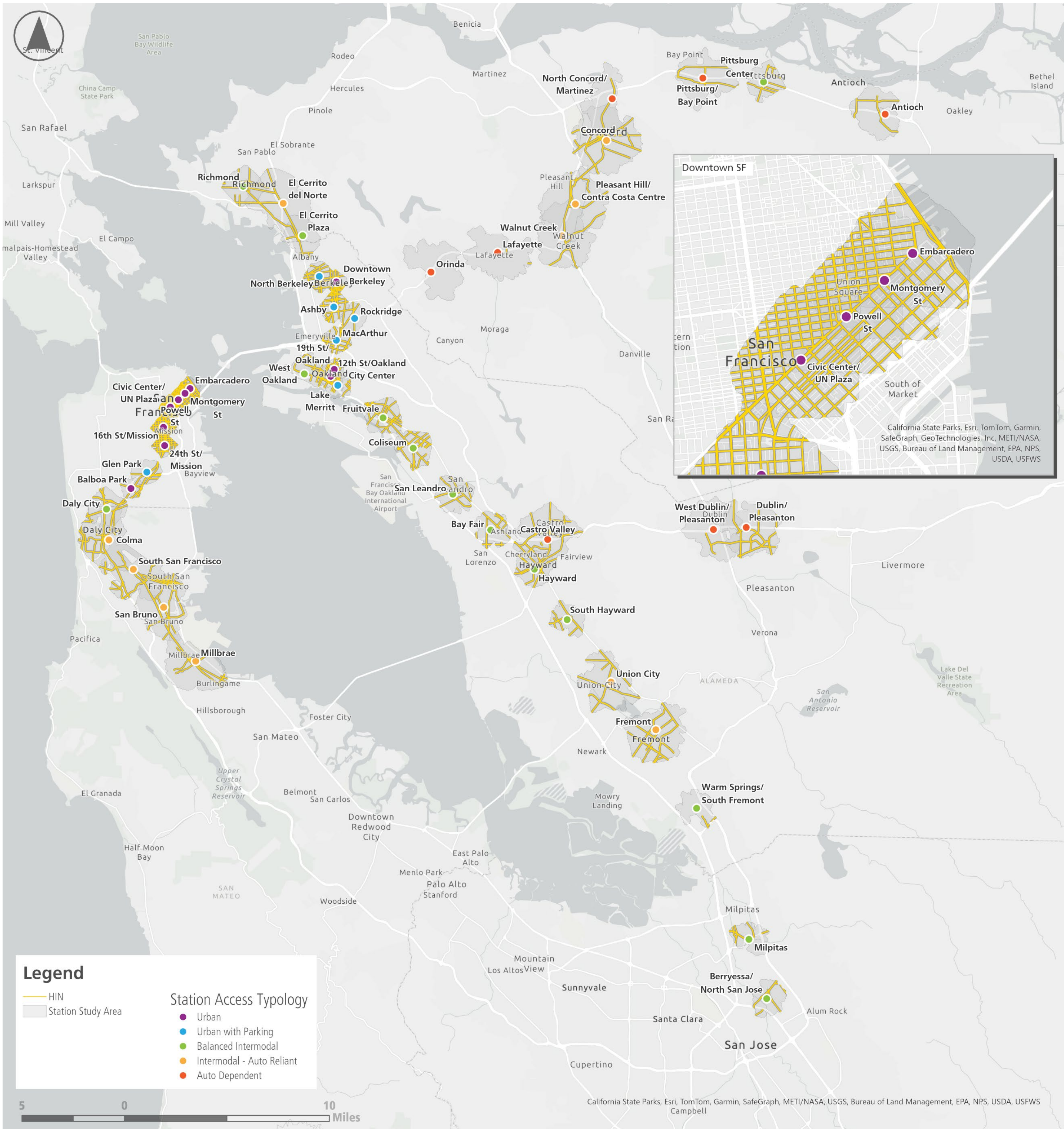

Figure 5. BART Station Study Area High Injury Network

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Appendix D: High Injury Network Map by Station and the project webpage, www.bart.gov/safetrips, contain views of each Station Study Area

Station Study Area Findings

Figure 6 summarizes some key disparities for KSI crashes on public, non-freeway roadways in the five counties in which BART operates. Streets closer to BART stations, meaning those found in Station Study Areas, had:

- Twice as many KSI crashes per 100 miles than those further away (67 compared to 33).
- A higher percentage of KSI crashes than its share of roadway miles. Namely, 24% (1,873) of the 7,800 total KSI crashes even though they compromise only 14% (2,801) of the approximate 20,700 total roadway miles.

BART-served Counties	BART Station Study Areas: In	BART Station Study Areas: Out
Public roadway miles (excludes freeways)	14% (2,801)	86% (17,928)
KSI crashes	24% (1,873)	76% (5,929)
KSI crashes per 100 miles of roadway	67	33

Figure 6. Killed and Severe Injury (KSI) Crashes on Public Streets in BART-served Counties

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

People who walk, bike, motorcycle, scooter, take transit or travel in a car are exposed to this risk whether they are going to BART or not. The disparity between public roadway miles and KSI crashes in Station Study Areas is **not attributable** to BART station activity. Rather, many stations are located adjacent to roadways that were built to accommodate suburbanization in the 1950s and 1960s before the BART system was constructed. These roadways tend to have higher risk factors, such as higher posted speed limits, which are discussed in more detail under the Roadway Risk Factors within Station Study Areas section in this chapter.

The Station Study Areas represent high-priority opportunity areas to improve safety on public streets, reduce fatalities and severe injuries, and promote safety for BART passengers and all other road users. The following section summarizes the injury crash data findings in the following topic areas: injury severity by mode of travel and by Station Access Type, demographics of crash victims, and roadway risk factors.

Injury Severity by Mode of Travel[12]

When completing a crash report, police determine the level of injury for victim as one of four categories: fatal, suspected serious, suspected minor, or possible injury. During the five-year study period for the five counties that BART serves, there were 21,408 reported crashes that resulted in injury of any level (minor to fatal) to at least one person involved on public streets in Station Study Areas. Of those injury crashes, 1,873 crashes resulted in someone being killed or severely injured (KSI) – equivalent to nearly one KSI crash every day. While crashes involving pedestrians, bicyclists, and motorcyclists accounted for 33% of all injury crashes, they were involved in 61% of KSI crashes, as illustrated in Figure 7.

[12] The injury severity sections analyze data at the crash level (unit of analysis is a crash). Each crash is classified based on the most vulnerable road user present. In the majority of cases, the most vulnerable road user is also the most severely injured road user.

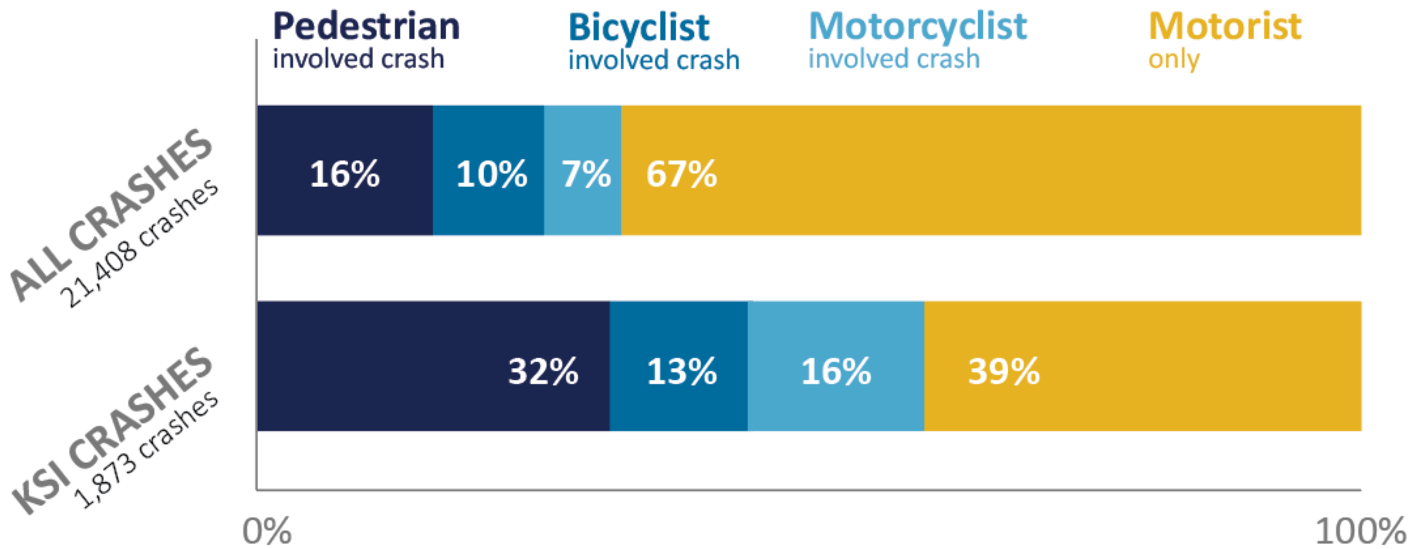

Figure 7. Percentage of Injury Crashes on Public Streets by Mode of Travel

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Injury Severity by Station Access Type

Crash severity on public streets by mode of travel was reviewed by Station Access Type of the Station Study Areas to better understand potential injury collision trends and relationships. Interestingly, the percentage of KSI crashes compared to all injury crashes for bicyclist-involved and motorist-only collisions remained consistent across all five Station Types (Urban, Urban with Parking, Balanced Intermodal, Intermodal-Auto Reliant, and Auto Dependent). However, the percentage of KSI crashes compared to all injury crashes for pedestrian-involved and motorcyclist-involved collisions consistently increased as Station Study Areas became more auto-oriented. They experienced nearly double the likelihood of being involved in KSI crashes in Auto Dependent Station Study Areas as Urban Station Study Areas, as shown in Figure 8.

Crash patterns on public streets for all Station Study Areas can be viewed on the interactive map found at the project website, www.bart.gov/safetrips. Users can select data summaries of interest, such as the modes involved, crash severity.

Figure 8. Percentage of Crashes Resulting in a KSI Outcome by Mode Involved and Station Access Type

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Characteristics of Parties Injured in KSI Crashes[13]

Organizations such as Smart Growth America advocate for a "people-focused approach" to traffic safety. The risk for any road user being involved in a KSI collision, no matter their travel mode, is greatly reduced by implementing roadway improvements that protect those who are most exposed and vulnerable to danger.[14] Those who bear disproportionate risk of injury or death include road users traveling outside of vehicles, such as pedestrians, bicyclists, scooter riders, and motorcyclists.

Characteristics of parties injured in KSI crashes were compared based on local data in the following sections to identify possible disparities across characteristics and communities. Analysis used a metric that reflected the proportion of victims to a group's population in BART's five-county region. Values greater than one suggest that a certain segment of the population is overrepresented on a per capita basis while values less than one indicate underrepresentation on the same basis.

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[13] While the majority of this study analyzes data at the crash level, this demographic section analyzes data at the victim level in order to compare victim statistics with the general population.

[14] Smart Growth America. (2024). Dangerous by Design 2024. https://smartgrowthamerica.org/dangerous-by-design/

Age

Teenagers (15-19 years old), young adults (20-29 years old), and older adults (aged 55+) experienced overrepresentation in KSI pedestrian and bicyclist crashes, as shown in Figure 9. Older adults were more vulnerable to fatal or severe injuries in a pedestrian crash: 25% of older adults involved in a pedestrian crash experienced a fatal or severe injury.

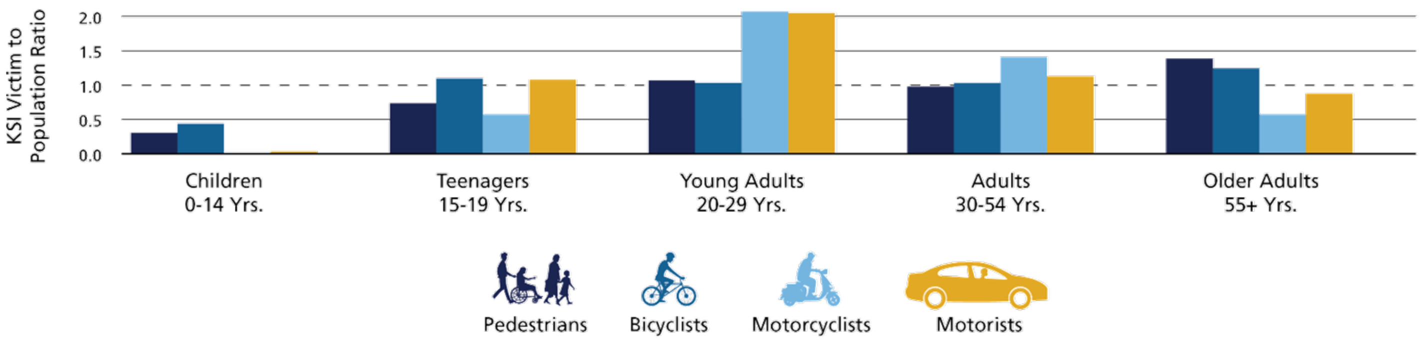


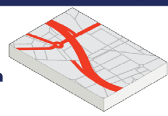
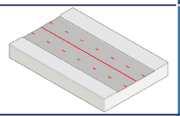
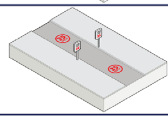
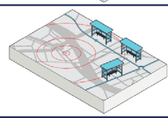
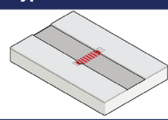
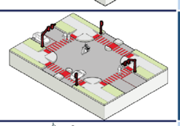
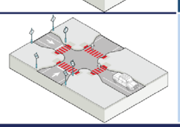
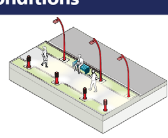
Figure 9. KSI Crash Victim Age as a Proportion of Regional Population, by Mode

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Roadway Risk Factors in Station Study Areas

A roadway risk factor is any element that increases the likelihood of a collision. For this study, roadway risk factors were broadly categorized into four levels of association, as shown in Table 2: Very strong, strong, moderate, and low. The percentages included in the table reflect the percentage of KSI crashes for all modes within each Station Access Type. Some risk factors are not as applicable to certain station types. For example, there are a limited number of roadways with posted speed limits of 35 miles per hour (MPH) or more in Urban Station Study Areas. The table also shows how risk factors affected injury severity by Station Access Type, with darker colors indicating a stronger association with injury severity.

Table 2. Roadway Risk Factors by Station Access Type for All Modes of Travel

Risk Factor		Station Access Type				
		Urban	Urban with Parking	Balanced Intermodal	Intermodal Auto-Reliant	Auto Dependent
Modifiable Roadway Design & Operational Factors						
Arterial Classification		88%	82%	68%	68%	62%
4+ Lanes		46%	57%	49%	52%	50%
35+ mph Speed Limit		15%	22%	52%	70%	74%
Proximity to Bus Stops		35%	10%	5%	2%	0%
Crash Location Type Factors						
Midblock Crossing		17%	14%	18%	28%	28%
Signalized Intersection		64%	41%	23%	28%	11%
Unsignalized Intersection		20%	44%	59%	44%	60%
Lighting Conditions						
Darkness		41%	46%	51%	43%	46%

Very Strong Association (≥50%) | Strong Association (25-49%) | Moderate Association (15-24%) | Low Association (<15%)

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Two findings emerged from this analysis:

- The classification of a roadway as an arterial tends to be strongly associated with risk factors regardless of Station Access Type. "Arterial" is the most auto-oriented designation for local streets, as it denotes roadways that serve longer trips.
- Some roadway risk factors vary across Station Access Type. For example, signalized intersections have their strongest association with KSI crashes in Urban Station Study Areas (64%) but their weakest association with them in Balanced Intermodal and Auto Dependent Station Study Areas (23% and 11%, respectively). This finding may be due to the presence of more signalized intersections in Urban Station Study Areas and longer distances between signalized intersections in more auto-oriented Station Study Areas, which tend to prioritize vehicle access and accommodate higher vehicle speeds.

Roadway Classification

Many agencies in California classify their roadways using a hierarchy that reflects vehicle volumes and speeds. Freeways indicate very high vehicle volumes and speeds, but roadways in this classification were not analyzed for Station Study Areas. Arterials (principal and minor) indicate high volume and/or high-speed roadways, collectors (principal and minor) indicate medium volume and/or medium speed roadways, and local streets indicate low volume and/or low speed roadways.

Local streets account for 55% of the road network mileage within Station Study Areas, yet they only account for 7% of all crashes. This reflects a low concentration of injury crashes (0.9) and KSI crashes (0.1) per mile. Conversely, principal arterials had the largest share of injury crashes (47%) and KSI crashes (46%) while representing less than 13% of roadway network mileage. These findings are summarized in Figure 10 and are consistent with national research about the overrepresentation of pedestrian fatality hotspots on arterials.[15]

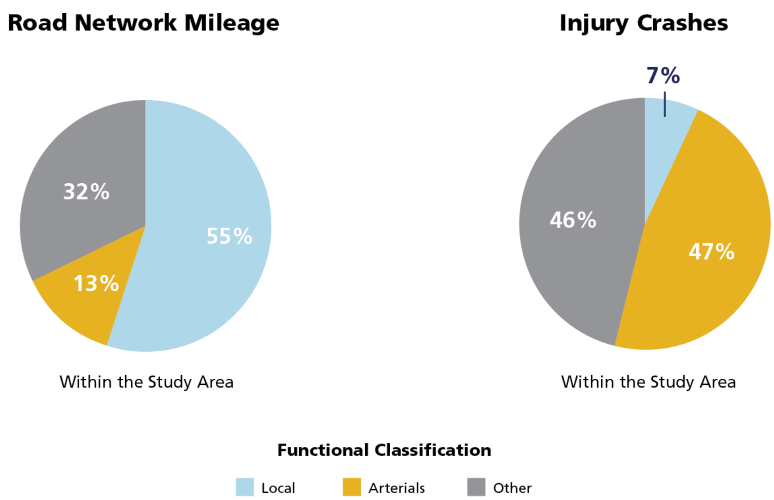


Figure 10. Road Network Mileage and Injury Crashes within Station Study Area by Roadway Classification

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

The proportion of KSI crashes did not vary substantially between the different roadway functional classifications across the different Station Access Types. The consistent trend was that principal arterials accounted for the largest share of all injury crashes and KSI crashes for all Station Access Types

Number of Lanes

Injury crashes and KSI crashes were concentrated on two- and four-lane public roadways in all Station Study Areas regardless of Station Access Type, parties involved or mode of travel. The proportion of KSI crashes on two-lane compared to four-lane public roadways was nearly identical. However, differences appeared as the number of lanes increased. On five-lane public roads, the proportions of KSI crashes involving pedestrians, bicyclists, and motorcyclists were notably higher. On six-lane public roads, the proportion of KSI crashes involving pedestrians was also notably higher.

Posted Speed Limit

Most of the public road network (67%) within Station Study Areas had posted speed limits of 25 MPH. While the highest frequency of injury crashes (39%) and KSI crashes (41%) occurred on these 25 MPH roadways, they also had the lowest concentration of injury crashes and KSI crashes on a per-mile basis. The fastest streets, with a posted speed limit of 45+ mph,

[15] Schneider, R. J., Sanders, R., Proulx, F., & Moayyed, H. (2021). United States fatal pedestrian crash hot spot locations and characteristics. Journal of Transport and Land Use, 14(1), 1–23. https://doi.org/10.5198/jtlu.2021.1825

had the second-highest share of crashes (24%) and KSI crashes (23%) while representing only 11% of the network mileage, making them more dangerous on a per-mile basis. Figure 11 summarizes these findings.

The patterns within different Station Study Area types further reinforced the importance of higher speeds. In Urban and Urban with Parking Station Study Areas, most crashes occur on 25-MPH streets because very few streets in these Station Study Areas have faster speed limits. Balanced intermodal, intermodal auto-reliant, and auto-dependent Station Study Areas had a much wider range of speed limits present on the network. While the fastest streets had the most severe outcomes, even expanding this lens to include moderate and higher speed streets in these Station Study Areas, with posted speed limits of 35 MPH or more, showed a strong association with KSI crashes. Auto-oriented areas containing public roadways with higher posted speed limits experienced more crashes (all injury crashes and KSI crashes). This finding is consistent with higher risks near more auto-oriented stations, which have a larger proportion of public roadways with higher posted speed limits and less orientation towards walking and biking.

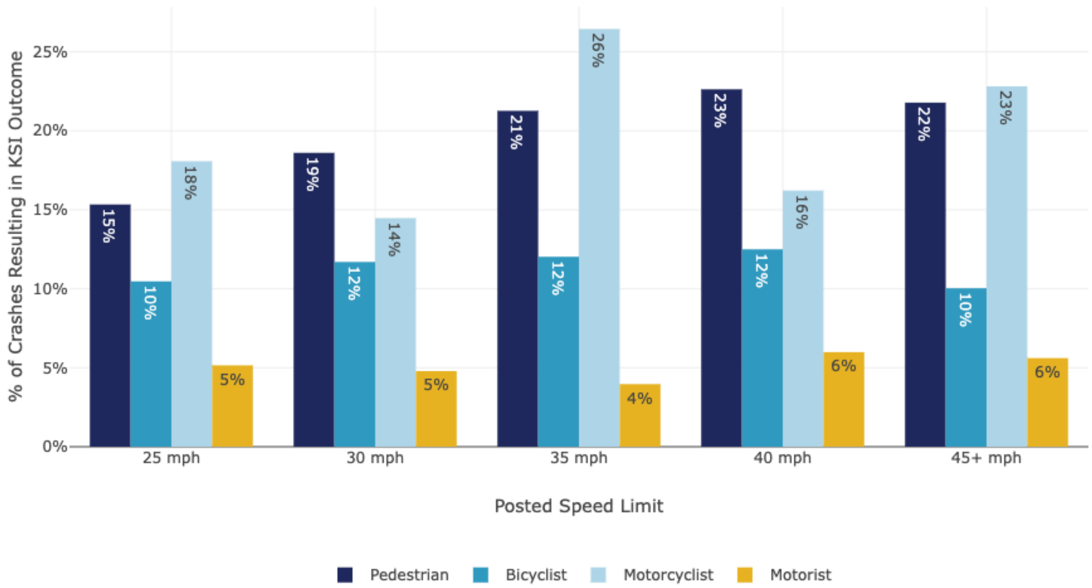


Figure 11. Percent of Injury Crashes Resulting in KSI Outcome by Posted Speed Limit

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Proximity to Bus Stops

About one-third of all KSI crashes in Urban Station Study Areas happened on public streets within 250 feet of a bus stop (ranging from 29% to 37% by mode involved). This association likely reflects higher levels of activity around bus stops, particularly pedestrian activity. The association decreased with increased auto orientation, most likely due to less bus and pedestrian activity in general.

Crash Location Type

Crash location type refers to whether crashes occur at signalized, unsignalized, or midblock crossings. In Urban Station Study Areas (and Urban Parking for pedestrians), most pedestrian-involved crashes happen at signalized intersections. With increasing auto orientation, the predominant location type shifts to unsignalized intersections. This reflects the underlying fabric of the built environment in more auto-oriented areas, where the distance between signalized intersections is longer.

More auto-oriented Station Study Areas (Auto dependent and Intermodal -Auto Dependent) commonly have more unsignalized intersections and unmarked crosswalks.[16]

In BART Station Study Areas, injury crashes at midblock locations on public roads are less common than intersection crashes. However, Intermodal-Auto Reliant and Auto Dependent Station Study Areas had the highest percentages of injury crashes within each station study area occur at mid-block locations on public streets no matter the mode involved. This is likely attributable to the same factors as the increasing prevalence of unsignalized intersection crashes at the auto-oriented end of the typology. Longer blocks and greater distances between signalized intersections lead to higher speeds and fewer pedestrian crossing opportunities. There were no strong location type patterns for bicyclist-involved crashes.

Lighting Conditions

Injury crashes on public roads were more common during the daytime than in dark or low-light conditions, which likely reflected the number of travelers on public roads throughout the day. However, all modes experienced a higher proportion of crashes resulting in a fatality or serious injury during darkness. One in four of all crashes under low light conditions resulted in at least one person getting killed or severely injured. Pedestrians and motorcyclists were particularly vulnerable under dark conditions. 13% of all pedestrian-involved crashes under daylight conditions were KSI whereas 25% were KSI under low light conditions. Similarly, 19% of all motorcyclist-involved crashes were KSI under daylight conditions whereas 24% were KSI under low light conditions.

Vehicle Volumes

Surprisingly, vehicle volume did not appear to be a strong risk factor based on data analyzed. Posted speed limits and roadway design tended to influence behavior more than vehicle volumes. The association between vehicle volumes and KSI crashes was weak compared with other variables and was subsequently not included in Table 2.

On low-volume public roads with less than 7,500 annual average daily traffic (AADT), pedestrian- and bicyclist-involved KSI crashes on public streets were about 50% to 300% more likely in Auto-Dependent Station Study Areas than in Urban and Urban with Parking Station Study Areas. In contrast, pedestrian- and bicyclist-involved collisions on high volume public roadways with more than 25,000 AADT were more likely to be KSI crashes on public roads in Urban Station Study areas (about 22%) compared to Auto-Dependent Study Areas (about 13%[17]).

That said, Urban Station Study Areas had fewer KSI crashes on public streets with lower vehicle volumes, while more auto-oriented Station Study Areas showed the opposite. This finding may indicate that overall multimodal activity and/or roadway design in Urban Station Study Areas have a traffic calming influence. Lower vehicle volumes on public roads in more auto-oriented Station Study Areas may have wider roads, wider lanes, and less multimodal activity.

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[16] Dipanjan Mukherjee, Sudeshna Mitra. (2019). A comparative study of safe and unsafe signalized intersections from the viewpoint of pedestrian behavior and perception, Accident Analysis & Prevention. https://doi.org/10.1016/j.aap.2019.06.010

[17] Note this was a small sample size.

High Injury Network (HIN) Findings

This Plan's HIN was developed to summarize where the greatest concentrations of KSI crashes happened within each Station Study Area using five years of police crash report data (2019 through 2023). Practitioners at Caltrans, cities, counties and towns can use the Station Study Area HIN to identify where to prioritize their limited resources on roadways under their jurisdiction for the greatest impact. Almost all local agencies have adopted policies that prioritize transit access, particularly by walking and biking. As mentioned previously, this Plan's HIN will likely differ from HINs developed by other local and regional partner agencies due to different datasets, geographic scale, and methodologies. As a reminder, this analysis was focused on non-airport stations and included no freeway mainline roads. **Appendix C: Existing Resources and Conditions Report** contains a full description of the Station Study Area HIN methodology and analysis.

Figure 12 summarizes the Station Study Area HIN in terms of its concentrations of KSI crashes compared to those not on the HIN. It finds that:

- Over three-quarters of KSI crashes occurred on just 18% of the public non-freeway roadway miles (508 of the total 2,801 miles) found in Station Study Areas. Focused investments on the Plan's HIN would be one of the most effective ways to address traffic safety while also improving multimodal access to BART stations.

- There are almost 13 times as many KSI crashes per 100 miles in the HIN than those out of the HIN (279 compared to 20).

Additionally, Arterial roadways (both principal and minor), which are typically wider, faster, and busier roads, comprise nearly 85% of the HIN, and yet these streets comprise only 15% of non-HIN streets.

More information about the HIN methodology and results can be found in **Appendix B. Existing Resources and Conditions Report**.

BART Station Study Areas	High Injury Network	
	In	Out
Public roadway miles (excludes freeways)	18% (508)	82% (2,293)
KSI crashes	76% (1,416)	24% (457)
KSI crashes per 100 miles of roadway	279	20

Figure 12. KSI Crashes on Public Streets in BART Station Study Areas

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Risk Factors for Public Streets in the HIN

An analysis of HIN characteristics and associated injury crashes on public streets aligned with many of the risk factors described in Table 2. Street classifications, posted speed limits, and the number of travel lanes were all observed risk factors for KSI crashes on the Station Study Area HIN. Of all the pedestrian-involved KSI crashes within the Station Study Areas, 83% of them occurred on public streets in the HIN. Arterial street classification, higher posted speed limits, and multi-lane public streets were all overrepresented on the HIN relative to their percent of all roadway miles in Station Study Areas, as shown in Figure 13.

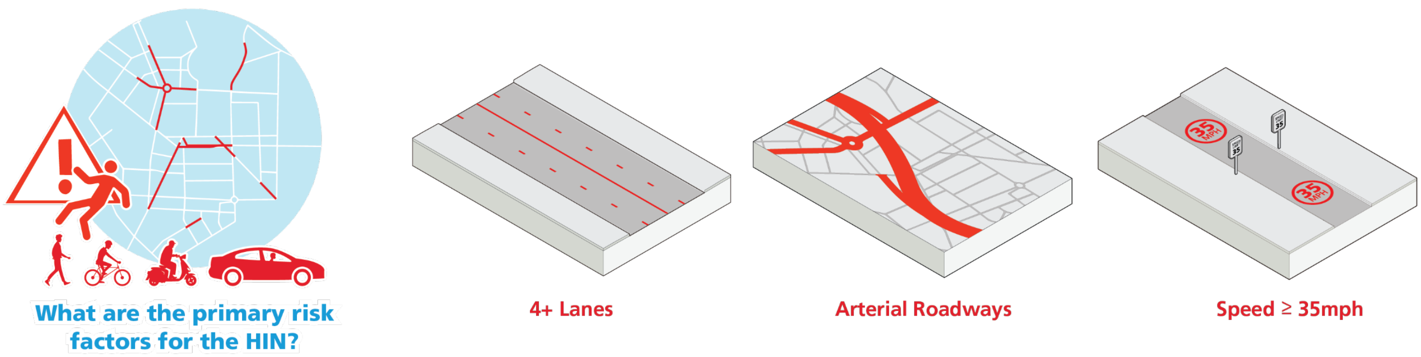

Figure 13. HIN Risk Factors

Disadvantaged Communities and the HIN

Communities with disproportionate economic, health, and environmental burdens are generally considered disadvantaged. Federal, state, regional, and local governments each have their own programs to identify these communities. For example, the Environmental Protection Agency has used the Climate and Economic Justice Screening Tool, but the tool's upkeep and availability through the federal government's website have been terminated as of January 22, 2025. The San Francisco Bay Area's Metropolitan Transportation Commission (MTC) uses Equity Priority Communities (EPC) to identify census tracts that have high concentrations of underserved populations. This Plan relied on MTC's EPC when analyzing crash data in disadvantaged communities.

Public street miles in EPCs were overrepresented in the Station Study Area HIN, as shown in Figure 14. 27% of all public road miles in Station Study Areas fell within EPCs, but 48% of their HIN mileage fell within EPCs. These findings are consistent with national research[18] that demonstrates a need to prioritize investment in communities that have experienced systemic underinvestment in public infrastructure.

Further analysis by Station Access Type revealed that injury crashes and KSI crashes were more common in EPCs than non-EPC areas for Urban and Balanced Intermodal Station Study Areas. However, it also revealed that public street networks in these two Station Access Types had significantly more overall mileage in EPCs compared to the other Station Access Types of Urban with Parking, Intermodal-Auto Reliant, and Auto Dependent Station Study Areas. As a result, EPC data did not provide additional insights for KSI crashes in Station Study Areas by Station Access Type.

[18] USDOT FHWA. Exploring Risk Factors to Disparities in Pedestrian and Bicyclist Fatalities and Serious Injuries. 2024 Dec. https://highways.dot.gov/sites/fhwa.dot.gov/files/FHWA-HRT-25-035.pdf

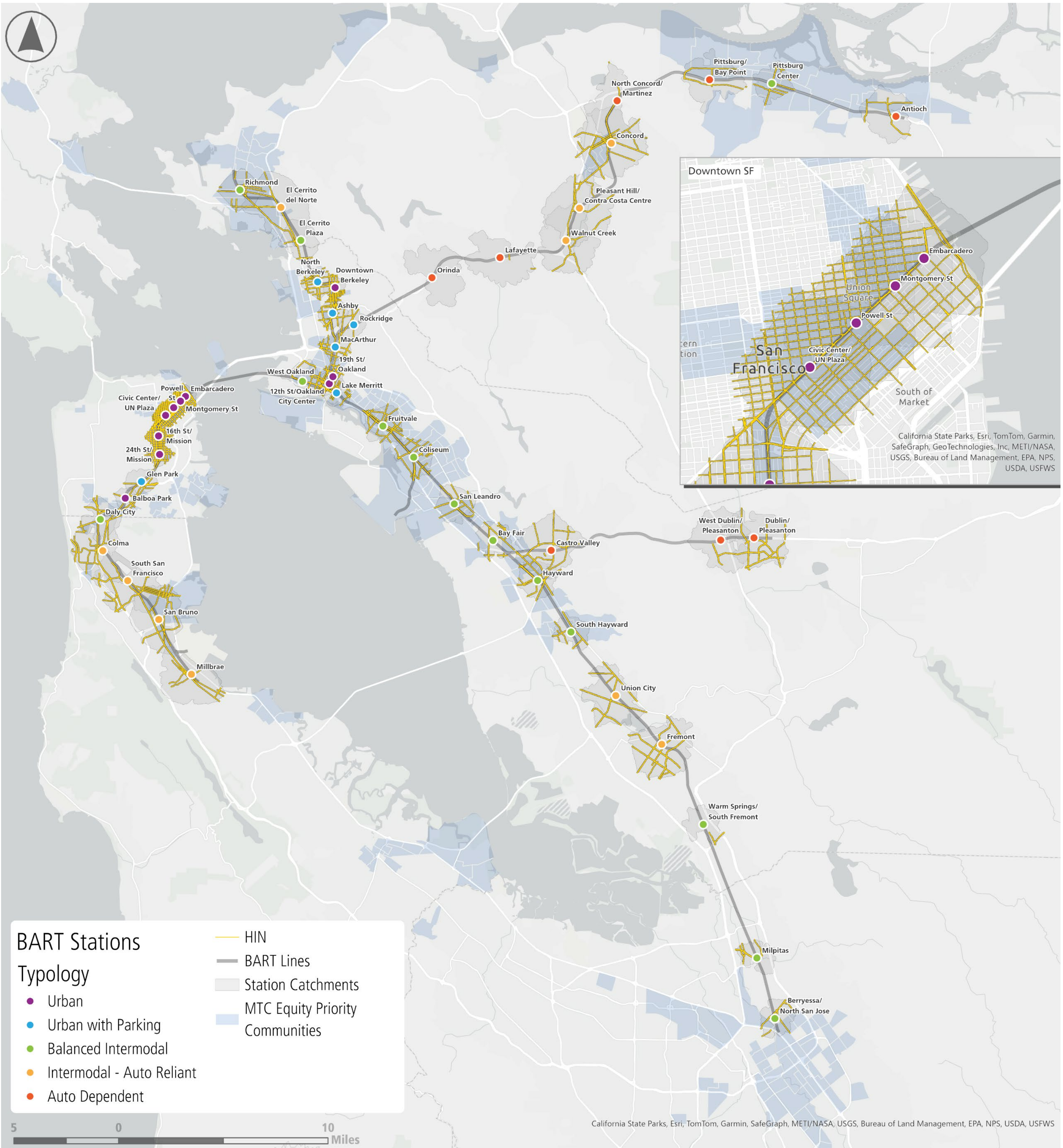

Figure 14. Proximity of Equity Priority Communities to BART Station Study Areas and the High Injury Network

Based on data from UC Berkeley SafeTREC TIMS data for January 1, 2019, through December 31, 2023

Further detail found in **Appendix D: High Injury Network Map by County** and at the project webpage, **www.bart.gov/safetrips**.

Limitations of Findings

The roadway safety analysis performed for this Plan had the following limitations:

- A lack of pedestrian and bicyclist exposure data meant that it was not possible to normalize crashes by their volumes. This may be most notable in areas where people feel unsafe and therefore actively avoid walking or bicycling, which therefore reduces their exposure to any risk. For this reason, the absence of KSI crashes in a particular Station Study Area does not necessarily mean that it's safer than another Station Study Area that has more reported KSI crashes. An understanding of both exposure and the presence of systemic risk factors is important to more accurately gauge real risk.
- Reported crash data is the best source currently available for understanding traffic safety conditions on public roads. However, underreporting of crashes, particularly those in disadvantaged communities and/or those involving pedestrians or cyclists, is relatively common.[19,20] Even so, the disproportionate burden of crashes in disadvantaged communities and/or those involving pedestrians or bicyclists was clear in the analysis.
- Only injury crashes were analyzed. Property damage only crashes in which nobody was reported as injured or killed were excluded from the analysis. This data limitation and methodological decision was consistent with the Plan's goal to reduce and ultimately eliminate KSI crashes in Station Study Areas. However, it meant that severity percentages in this analysis were higher than they would have been if non-injury crashes were included. Excluding non-injury crashes may have also resulted in an underestimation of the disparity between motorist and non-motorist crash severity, as motorist-only crashes more frequently result in no injuries than ones in which pedestrians, bicyclists, or motorcyclists are involved.
- The Plan's HIN was more effective at capturing some types of KSI crashes than others. Signalized intersection crashes were largely concentrated on the Station Study Area HIN, but risky areas for midblock crashes and unsignalized arterial intersection crashes may not have been as well represented.
- Some of the crash report variables are susceptible to inaccurate or imprecise coding, and some of the underlying roadway data may be outdated. Nonetheless, pooling crash data across years and across geographies, as was done in this analysis, helped mitigate data accuracy issues. Meaningful patterns were still evident even in less precise and less consistent data.
- This study focused on a review of past injury crash data on public roads, which was a primarily reactive approach. The methods used in this study were consistent with the Safe System Approach and had some proactive features, such as the exploration of common risk factors and the spatial pattern-based methodology underlying Station Study Area HIN. However, a logical next step toward a Safe System might include a more robust proactive analysis, such as risk factor screening.

19 S. Sciortino, M. Vassar, M. Radetsky, and M. M. Knudson, "San Francisco pedestrian injury surveillance: Mapping, under-reporting, and injury severity in police and hospital records," Accident Analysis & Prevention, vol. 37, no. 6, pp. 1102–1113, Nov. 2005, doi: 10.1016/j.aap.2005.06.010.
20 S. Soltani et al., "What is counted counts: An innovative linkage of police, hospital, and spatial data for transportation injury prevention," Journal of Safety Research, vol. 83, pp. 35–44, Dec. 2022, doi: 10.1016/j.jsr.2022.08.002.

Roadway Safety on BART Station Property

BART property around stations mainly consists of access roads, parking facilities, and multimodal facilities (such as bus and passenger pick-up/drop-off zones). While these areas are designed for low vehicle speeds, crashes occur occasionally. However, injury crashes are rare and do not exhibit the same patterns associated with road risk factors found in the Station Study Areas and in the HIN. Nonetheless, incidents on BART property that might be categorized as KSI crashes were summarized.

Crashes on BART property are reported by BART's Police Department but are generally not included in California's Statewide Integrated Traffic Records System (SWITRS) or UC Berkeley's Transportation Injury Mapping System (TIMS). Nonetheless, crashes over a seven-year period, a longer timeframe than the rest of this Plan due to the paucity of reported crash data from 2019 onwards, were summarized.

There were eight reported injury crashes on BART station property for 2017 through 2023 of which half were included as possible KSI crashes in Table 3. The common pattern for reported KSI crashes on BART property was that motorists were consistently involved and unharmed while vulnerable road users – pedestrians and a bicyclist – experienced injuries or fatality.

Table 3. Possible KSI Crashes on BART Station Property

Date/ Time	Station	Location	Parties Involved	Injury Level
June 30, 2018, at 10:56 PM	West Oakland	Passenger loading zone in front of station faregates	Motorist-Pedestrian	Pedestrian severe injury
October 23, 2018, at 9:17 AM	Pleasant Hill/ Contra Costa Centre	Parking garage exit at Coggins Street and Jones Road	Motorist-Bicycle	Bicyclist severe injury
October 25, 2018, at 8:50 AM	San Bruno	Parking garage, 4th level	Motorist-Pedestrian	Pedestrian fatality
March 1, 2019, at 5:10 PM	Dublin/ Pleasanton	Eastern end of parking lot off Owens Road	Motorist-Pedestrian	Pedestrian severe injury

Source: BART Police Department for the period from January 1, 2017, to December 31, 2023

BART transportation operations staff who spend their working days at BART stations are in unique positions to observe behaviors as riders and/or their drivers operate on BART property. Their anecdotal input about traffic safety patterns on BART roadways was distilled as follows:

- Driver speeds tend to be faster at stations that are located near high-speed roadways like freeways.
- The time pressure for passengers to catch trains can result in speeding or impatient drivers conflicting with other drivers, walkers, bikers and rollers who are also in a rush.
- Drivers operate their vehicles erratically when they seem unfamiliar with navigating BART station areas.

Based on data, public input, and observations, this Plan includes some roadway safety measures that could be considered for roadways on BART's property.

The Relationship between Transit and the Safe System Approach

As a companion to the Station Study Area analysis, a White Paper for System Safety Analysis was developed for this Plan exploring the question: **Does improving transit service levels improve roadway safety systemwide?** Many sources have found that riding rail transit like BART is safer than traveling in a passenger vehicle.[21] This project expanded the concept of rail safety by exploring whether and how rail transit can act as a roadway safety measure in a region. Analysis for this White Paper used twelve years of injury crash data on public roads from 2012 through 2023 as was used for the Station Study Area for most of its analysis. However, the geographic scope was expanded to include freeways and BART airport stations. See **Appendix E: White Paper for System Safety Analysis** for more details.

The concept of "transit as a roadway safety measure" was explored — new territory that had not yet been comprehensively studied by BART - through three streams of analyses:

1. Crash patterns on the roadway network parallel to the BART system, or roads that drivers would take to get to the same destinations if BART did not exist. See Figure 15 for the map of the parallel network.

2. BART operational changes and events: Crash patterns when the BART system was non-operational during BART worker strikes in 2013 and when new stations were opened (the Oakland Airport Connector in 2014, the eBART connections to Pittsburg Center and Antioch stations in 2018, the Warm Springs extension in 2017, and the Silicon Valley Phase I extension in 2020). This analysis explored whether the parallel roadway network adjacent to the various expanded routes had different crash patterns than the core part of the system that existed prior to 2013.

3. Scenarios for drivers shifting to BART: Travel patterns under potential BART ridership increase scenarios that might unlock new opportunities for promoting roadway safety design changes. This analysis specifically explored how many streets with four or

Right-sizing Roadways Saves Lives and Limbs

Example candidates: Non-freeway streets with 4 or more vehicle-through lanes and an average of 20,000 vehicles or less per day

Qualifying roadways parallel to BART: 307 linear miles

Action: Remove at least one vehicle through lane and reallocate for another use*

Result: Avoids 127 life-changing crashes each year on roadways parallel to BART, saving $370 million annually

How BART can help: Agencies can right-size even more streets to save more lives and limbs if they assume that a small percent of motorists will switch to transit

Source: Strong Towns

* Other uses could be adding bikeways, widening sidewalks, installing sidewalk planting strips, restriping for two-way left-turn lane, installing raised medians, etc.

[21] One data point, for example, showed that riding rail transit is 18 times safer than traveling in a passenger vehicle. It was calculated using death rates per 100,000,000 passenger miles in the year 2022, which was 0.54 for passenger vehicles and 0.03 for railroad passenger trains from the National Safety Council's Injury Facts, found at https://injuryfacts.nsc.org/home-and-community/safety-topics/deaths-by-transportation-mode.

more lanes and moderate to high vehicle volumes might become eligible for road diets with increased mode shift from driving to BART.

Summary of Findings

Analysis for the White Paper found that public streets parallel to the BART system are less safe than the rest of the regional road network because they are typically wider regional roads designed to carry peak-hour traffic volumes at high speeds. These types of roadways become more dangerous during uncongested conditions in terms of crash severity when the lack of traffic encourages vehicles to travel at even greater speeds. While freeways were included as part of the parallel network analysis, their safety interventions require a different set of tools that are not contained in this Plan.

The analysis identified 307 linear miles of non-freeway roadways parallel to the BART system that are candidates for right-sizing because they have four or more vehicle through lanes (bi-directional or one way) and carry 20,000 or fewer vehicles per day. These streets would become safer if they were reconfigured for two or three vehicle lanes which would not only avoid an average of 127 KSI crashes annually but would improve safety without increasing motorist delays. This reconfiguration would create space to install or improve infrastructure for walking and biking in addition to improving roadway safety for all users.

The analysis also found that transit service improvements could encourage existing drivers to use BART for their trips and thus reduce demand for driving. This reduction in driving may, in turn, unlock more opportunities to reconfigure parallel non-freeway roadways to accommodate lower traffic volumes and speeds, which would then make those public streets safer for all road users. Reallocating roadways could be implemented in tandem with transit service improvements on parallel corridors to provide a reliable alternative to driving. Scenarios studied showed that various increases in BART ridership from former motorists unlocked up to 20 more miles of roadways for reallocation and would avoid up to 28 more KSI crashes annually.

The most effective roadway safety improvements would be more universally supported when robust transit service provides a good alternative to driving. Thus, while a direct relationship between improved transit service and roadway safety is unclear, transit service improvements would be a critical and necessary measure for enabling the implementation of roadway configurations that prioritize safety and provide meaningful mobility options.

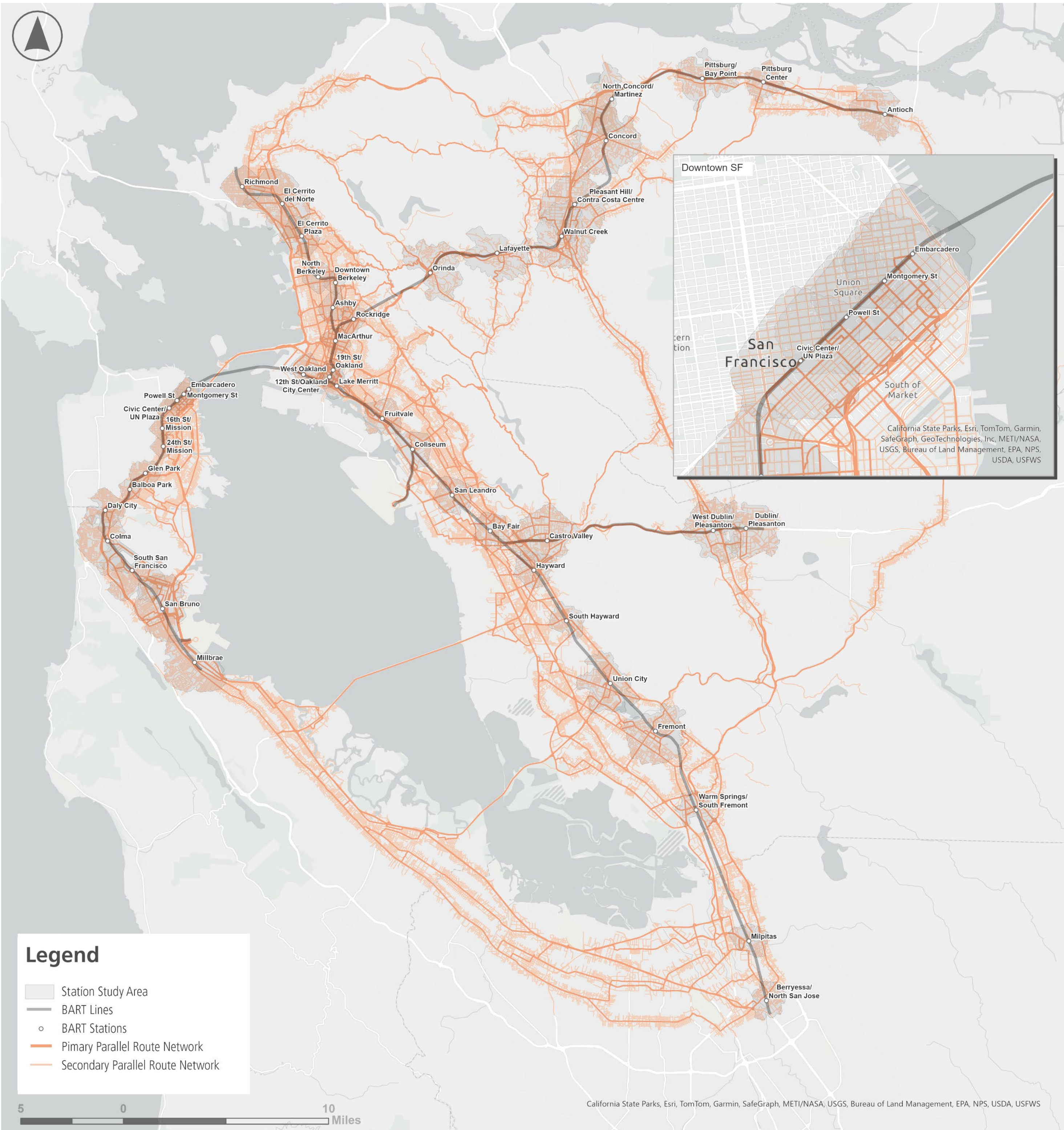

Figure 15. Map of the Parallel Route Network Serving Vehicle Trips as an Alternative to the BART System

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4. Systemic Roadway Safety Measures Toolbox

This chapter identifies roadway safety measures, engineering tools that counteract the risk factors found on roadways on and off the High Injury Network (HIN) for the Station Study Areas. The toolbox of roadway safety measures, shown in Table 4, was developed based on a review of best practices and the Federal Highway Administration's (FHWA) Safe System Approach. Multiple guides and toolboxes at the federal, state, and local levels present roadway safety measures aligned with industry best practices. Moreover, BART Facilities Standards include criteria for passenger station sites that consider safety as one of many priorities for access, in addition to requiring conformance of traffic control devices with state regulations. The purpose of this toolbox is not to recreate this inventory, but to synthesize the existing body of research into a resource that supports policies adopted by BART and its partner agencies to prioritize access to transit. This toolbox focuses on engineering interventions, which can complement safety education, promotion, and enforcement campaigns.

The toolbox draws roadway safety measures primarily from the National Cooperative Highway Research Program (NCHRP) Report 926, *Guidance to Improve Pedestrian & Bicyclist Safety at Intersections*. The toolbox is supplemented with general traffic signal and signage roadway safety measures included in the Caltrans Pedestrian Safety Countermeasure Toolbox, and Proven Safety Roadway Countermeasures lists from the FHWA and Caltrans. In keeping with the FHWA's movement toward a Safe System Approach, the FHWA Safe System Roadway Design Hierarchy was used to inform the organization and evaluation of the countermeasure toolbox, as shown in Figure 16. The four tiers of the hierarchy are described below.

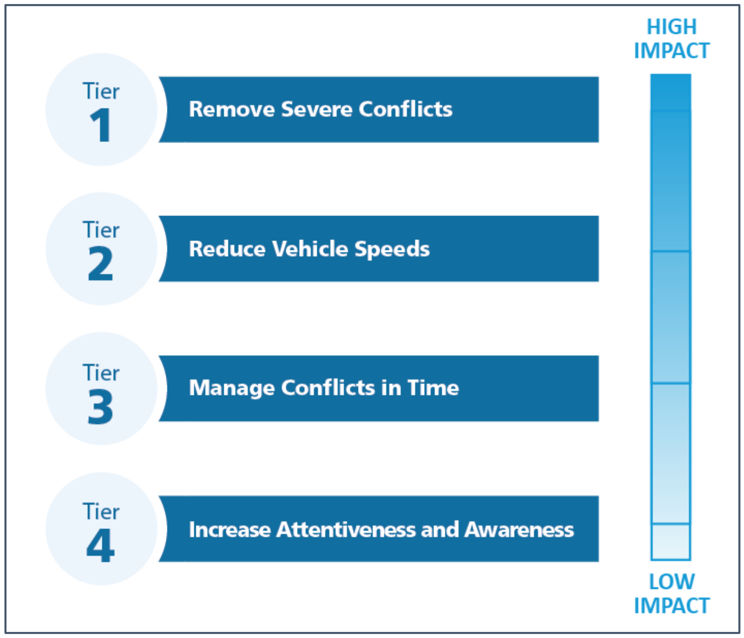


Figure 16. Roadway Safety Measures Tiers, Adapted from FHWA Safe System Roadway Design Hierarchy
Source: FHWA 2024 and Ederer et al., 2023

Tier 1 - **Remove Severe Conflicts**: Eliminate high risk conditions by providing physical separation between users moving at different speeds or in different directions to minimize conflicts and reduce crash risk. This separation is typically accomplished with countermeasures that address intersection and roadway design.

Tier 2 - Reduce Vehicle Speeds: Implement speed management strategies to limit crash severity and likelihood. Speed management countermeasures include elements of self-enforcing roadways (i.e., roadways that communicate the appropriate speed and user behavior through land use and design) and traffic calming to slow vehicles or enforce appropriate vehicle speeds.

Tier 3 - Manage Conflicts in Time: Use traffic signals or hybrid beacons to reduce crash likelihood by separating roadway users and eliminating potential conflicts.

Tier 4 - Increase Attentiveness and Awareness: Alert roadway users to potential conflicts and reinforce the concept of shared responsibility. Typical Tier 4 countermeasures reinforce key elements of the roadway and remind users to stay aware and comply with the rules of the road.

The roadway safety measures were then evaluated based on a modified benefit-to-cost ratio, implementation feasibility, and equity considerations. More details are documented in **Appendix F: Roadway Safety Measures Toolbox Methodology**. The following toolbox includes description of each roadway safety measure along with an explanation of why it is effective, in what contexts it is most applicable, and a few considerations that may impact suitability. Note that all the measures identified require proper maintenance to ensure effectiveness in reducing conflicts.

Tier 1: Remove Severe Conflicts

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Bikeways  *Source:NACTO*	• Dedicated space allocated for bicycle travel with optional (but generally preferred) physical protection: including Class I, Class II, and Class IV	• Provides dedicated space for bicyclists and separates motorist and bicyclist flows. • Safety benefits increase with increased buffer zones and vertical separation.	• Corridors that are part of a planned bicycle network • Corridors that are being considered for a roadway reallocation project • Locations with high bicyclist volumes • Locations with documented bicyclist safety issues	**Safety Considerations** • Connectivity of facilities is critical for safety, as is continuity of facility type. • Where appropriate facilities cannot be accommodated or conflicts occur such as at intersections, deliberate design of mixing zones should reflect the priorities of road user vulnerability, pedestrians, then bicyclists, then vehicles. • Vehicle speed and volume along a corridor should be considered when selecting a bike facility. Class II bike lanes should be protected by a buffer or physical barrier wherever possible. • When speeds are above 35 mph, a separated cycle track (Class IV) or shared use path (Class I) is recommended (FHWA, 2019). • Increased width of the lane or buffer space from traffic increases bike visibility, improves rider comfort, and provides room for user error. • Physical obstacles such as posts, curbs, fences, and landscaping provide increased prominence of bikeways and a deterrent to vehicle lane intrusion. These can also be a tripping hazard for pedestrians or limit curb access for paratransit users and need to be designed prioritizing vulnerable users. • Separation material selection can influence biker safety and comfort: concrete separation will provide more safety and comfort than paint or plastic separation. However, concrete barriers are more expensive and difficult to build. **Community Considerations** • New bike infrastructure can be perceived as a precursor to gentrification and displacement. While this may not be the case in every project, this belief stems from historical circumstances. • Any potential new bike infrastructure, especially in EPCs, requires meaningful community engagement and building trusted relationships to identify where community needs align with bike infrastructure. • Bikeway projects may be a result of other market pressures in the area and anti-displacement policies should be considered holistically as part of a new project even if it is not associated with housing. • New bikeways may result in the removal of on-street parking spaces, loading zones, ADA spaces, etc. and should be thoroughly evaluated and replaced. • New bikeways should also be implemented within an overall planned bicycle network to ensure connectivity across the city.

Tier 1: Remove Severe Conflicts

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Accessible Sidewalks  *Source:pedbikeimages/Dan Burden*	• Sidewalks that meet the standards associated Americans with Disabilities Act (ADA) and the Architectural Barriers Act (ABA). Public Right-of-Way Accessibility Guidelines (PROWAG) provides additional information for accessible sidewalk facilities.	• Enable all sidewalk users to move along a street in a space vertically separated from vehicle traffic. • Accessible sidewalks provide safe options and a baseline level of access for all users. • A lack of connected accessible sidewalks forces vulnerable road users to take longer routes or increase their exposure to motor vehicles. • Uneven or broken pavement creates a physical risk for pedestrians.	• Streets with sidewalk gaps or existing sidewalks that do not meet accessibility standards • All sidewalks should be accessible. • Existing sidewalks with uneven, steep grades, or obstacles blocking the minimum clear width, or without curb ramps.	**Community Considerations** • Some communities may have larger populations of people who struggle to navigate non-ADA sidewalks, such as parents with strollers or people with mobility devices. • Wider sidewalks can be part of placemaking strategies which have not typically been available in historically-marginalized communities. Similar care should be taken to bike facilities around market pressures as part of a holistic placemaking effort.
Bus Boarding Islands with Bicycle Lane  *Source:City of Chicago*	• Bus boarding islands enable bus traffic to be separated from bike traffic at the stop.	• Reduce conflicts by physically separating bike lanes and curb activity from buses. • Bus boarding islands may reduce pedestrian crossing distance.	• Streets with bike lanes • High-volume bus routes	**Safety Considerations** • Potential conflicts between pedestrians and bicyclists in mixing zone. **Community Considerations** • Bus boarding islands should be accessible and navigable for all users without compromising rider experience.
Close Slip Lane  *Source:NextSTL*	• Slip lanes enable vehicles to make right turns separate from other intersection movements. • Closing slip lanes to vehicle traffic reducing vehicle speeds and improves pedestrian safety. • The closure can be executed with quick-build materials or by changing the curb line.	• Closing slip lanes reduces the turn radii, which encourages vehicles to make slower turns and requires them to stop when the light is red. • Closing lanes reduces pedestrian crossing widths and simplifies crossing maneuvers, reducing their exposure to vehicle conflicts. • Closing slip lanes improves sightlines between vehicles, pedestrians, and bicycles.	• Intersections with slip lanes • Streets with heavy right-turn volumes • Streets with bike lanes	**Safety Considerations** • Driver frustration may lead to erratic behavior.

Tier 1: Remove Severe Conflicts

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Crossing Barriers  *Source:NCHRP*	• Continuous barrier that channelizes pedestrians away from an unsafe crossing	• Designed to deter pedestrians from crossing at locations with an elevated risk of being struck by a vehicle.	• Locations with a history of risky pedestrian crossing behavior or crashes which cannot be resolved by other intersection design treatments • This can also be applicable where designated crossings feel unsafe or inconvenient	**Safety Considerations** • Barrier does not resolve crossing demand and can create more risky behavior. This is a last resort roadway safety measure that is not recommended in most cases. • Safe crossings should be provided nearby. • Installation should include wayfinding to alternative crossing locations. • Evaluate whether improved, relocated, and/or new designated crossings are needed. **Community Considerations** • Increases opportunities for enforcement, despite California's decriminalization of "jaywalking". • Barriers should be aesthetically pleasing and compatible with the surrounding architecture of street design
Crossing Islands  *Source:NCHRP*	• Refuge areas at least 6-8 feet wide for pedestrians and bicyclists between vehicle travel lanes of opposing directions at intersections and midblock locations	• Crossing islands reduce crossing distances and allow pedestrians and bicyclists to focus on crossing one direction of traffic at a time.	• Midblock or intersection crossing locations • All roads with two or more lanes of through traffic in each direction and speeds over 25 mph • Uncontrolled crossings where traffic gaps are insufficient • Where space allows	**Safety Considerations** • Especially important across corridors with medium-high vehicle speeds and volumes • Landscaping should not obstruct visibility between pedestrians and approaching motorists. • Must be fully accessible with ramps or cut throughs and detectable warnings. Must provide sufficient space for people using wheelchairs and mobility devices. Audible or actuated crossing buttons need to be accessible. • Midblock locations should include an active warning beacon. • Bullnose refuges can pose a tripping hazard. • In some designs, a median may act like a crossing island, but medians are distinct from crossing islands. • Daylighting is also recommended to improve visibility at intersections, particularly at unmarked crossings and refuge islands.
Grade-Separated Crossings  *Source:NCHRP*	• Overpasses and underpasses that provide crossings where no at-grade crossing is possible or connect off-road paths and trails across facilities such as freeways, high-speed, high-volume arterials, and rail tracks.	• The complete separation of pedestrians and bicyclists from vehicular traffic reduces the risk of crash at this point, provided the facility is accessible and clearly visible.	• Where at-grade crossing treatments are not possible or potentially unsafe, such as crossings of free-flow, high-speed highway ramps or railroads • Locations with high vehicle volumes, high-speed highways, railroad tracks, or natural barriers	**Safety Considerations** • All grade-separated crossings must comply with ADA standards. • This treatment should be regarded as a spot treatment in cases where there is no other option. • These should not be used in place of an at-grade crossing. • High-quality pedestrian-scale lighting should be considered to provide visibility in underpasses. Lighting should comply with local jurisdiction guidance. **Community Considerations** • If placed in a residential area, the scale of the structure and potential construction and operational impact on surrounding houses should be considered. This may include lighting, crime, shading, and refuse.

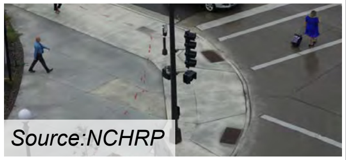
Tier 1: Remove Severe Conflicts

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Protected Intersections  *Source:NCHRP*	• Include a corner protection island, a forward queuing area, and recessed bicycle and pedestrian crossings	• They are designed to slow turning motorist speeds to induce yielding and to improve the sight line between motorists and bicyclists, reducing conflicts between turning motorists and through moving bicyclists.	• Urban areas • Signalized intersections with sufficient space to accommodate the design • High volumes of bicyclists and motorists, or medium to high volumes of bicyclists, motorists, and pedestrians	**Safety Considerations** • Mountable truck aprons can reduce turning speeds for passenger vehicles while accommodating the off-tracking of larger vehicles where a larger corner radius is necessary. • Protected intersections may require more space along the intersection approach than standard intersections; intersection right-of-way and roadside dimensions are typically more important factors than total roadway width. • It is important to establish design and control vehicle types/sizes prior to establishing geometry of protected intersection. • For constrained intersections, consider a bike box to provide bikes with prominence in front of other traffic, especially if a left turn is required. • Raised curbs can be a tripping hazard. **Community Considerations** • The introduction of an intersection treatment can be seen as a prelude to gentrification and displacement, similar to bike lanes.
Roundabouts  *Source: FHWA*	• Circular intersections that are designed to improve safety by removing left turns and requiring traffic to circulate around a central island.	• This reduces angle and higher-speed collisions, allows more efficient traffic operations, and reduces operation costs associated with signalized intersections.	• Suburban areas with sufficient land and available space • Intersections of local, collector, or arterial roadways; freeway interchanges • Intersections with high left-turning vehicle volumes • Installed in place of traffic signals to reduce vehicle speeds	**Safety Considerations** • Roundabouts prioritize vehicles over more vulnerable road users such as pedestrians and bicyclists. Pedestrians have less direct routes and cross longer distances to get across an intersection. • Areas with high pedestrian volumes should consider signal controls and larger crosswalk widths. • It is important to slow the entry and exit points of the roundabout to 15-18 mph through horizontal defelction, vertical deflection, or both. • Bicyclist facilities around the permiter of the roundabout should be designed to mitigate risk of bicycle collisions. **Community Considerations** • Roundabouts require a large footprint, and in some cases, require buildings to be destroyed in more dense areas to create more space.
Realign Intersection  *Source:Bowman*	• Realign intersection to 90 degrees	• Intersections that meet at perpendicular angles provide sufficient visibility and allow for tighter turning radii that encourage slower turning speeds. • Intersections that meet at right angles also allow for the most direct crossings for pedestrians.	• Intersections that meet at a 75 degree angle or less	**Safety Considerations** • Driver frustration may lead to erratic behavior.

Tier 2: Reduced Vehicle Speeds

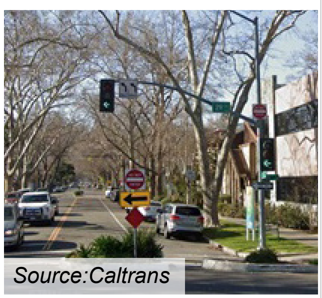
Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Appropriate Speed Limits[a]  Source:NACTO	• Speed limits that reflect the likelihood of conflicts along a corridor.	• Reduction of fatal and severe crashes is achieved through setting speed limits that enable vehicles to identify a potential conflict and slow down or stop before reaching the conflict point.	• All street types in all contexts. • Setting and enforcing speed limits requires regular speed survey data collection. • Speed limit reductions outside of these surveys require changes to policy or legislation.	**Safety Considerations** • Where speed limits are set by the 85th percentile speed, physical interventions within this tier can be installed to reduce speeds along a corridor. • In jurisdictions where setting speed limits are more flexible, identify critical corridors and institute new speed limits with clear messaging. AB43 allows local jurisdictions to reduce speed limits by 5mph and set limits of 20-25 mph in business districts. • Prioritize slow speed zones in areas with vulnerable users are likely to be: e.g., schools, elder care, medical facilities.
Continuous Raised Medians  Source:NCHRP	• Raised median separating opposing directions of traffic at intersections and midblock locations.	• Continuous raised medians can be used as an access management strategy to eliminate motorist left turns or at intersections to reduce speeds of vehicles turning left.	• Midblock crossing locations • Locations where left-turning motorists pose safety concerns	**Safety Considerations** • Landscaping should not obstruct visibility between pedestrians and approaching motorists. • Continuous raised medians may take up space that could otherwise be used for wider sidewalks, bicycle lanes, or on-street parking. • Where pedestrians or bicyclists are expected, medians should be transitioned into crossing islands at intersections and in appropriate midblock locations. In these cases, the medians should be 6-8 feet wide and include ADA access to the highest degree possible. • Midblock locations should also consider an active warning beacon.
Coordinated Signal Timing  Source:NACTO	• A signal timing strategy to help manage traffic movement through a corridor.	• Coordinated signal timing can be used to encourage slower speeds by timing a set of signals to allow vehicles moving at a certain speed to pass through a corridor without stopping. This concept is sometimes called a "green wave."	• Corridors with densely spaced intersections (1/4 mile or less) (NACTO, 2013)	**Safety Considerations** • Progression speeds should be set at or below the target speed, which should be in line with the appropriate speed limit for the context.
Curb Extensions  Source:NCHRP	• Also known as bulb-outs, curb extensions decrease the width of the roadway with a physical extension of the curb line.	• Curb extensions increase visibility, reduce crossing distances, and slow turning traffic.	• Locations with permanent on-street parking	**Safety Considerations** • Curb extensions should not extend into travel lanes, bicycle lanes, or shoulders (Blackburn, Zeeger, & Brookshire, 2017). • Lower-cost alternatives such as bollards, temporary curbs, planters, or striping can be used to emulate concrete curb extensions. • Turning needs of larger vehicles should be considered in the design. • Curb extensions may support active bike signal actuation buttons that don't require the bicyclist to dismount.

a. BART station area speed limits are generally 15 MPH.

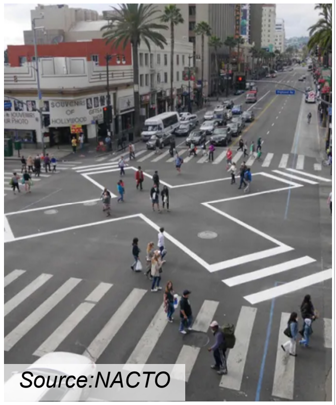
Tier 2: Reduced Vehicle Speeds				
Roadway Safety Measure	**Description**	**Why it works?**	**Applicable Context**	**Key Considerations**
Curb Radius Reduction[b]  Source:NCHRP	• A curb radius reduction reclaims space that had been part of the travelled way to protect pedestrians and bicyclists.	• Reducing curb radii can reduce turning speeds by forcing sharper turns.	• Urban areas • Areas with low truck, but, or other large vehicle volumes	**Safety Considerations** • Curb radius should be chosen to accommodate the most frequent large design vehicle as opposed to the occasional large vehicle size. • A mountable truck apron may be used to accommodate larger vehicles.
Hardened Centerline  Source:NCHRP	• Strip of raised centerline that may be accompanied by bollards that reduces the turning radius for left turns	• Hardened centerlines can be used as an access management strategy to eliminate motorist left turns or at intersections to reduce speeds of vehicles turning left.	• Intersection or midblock crossing locations • Locations where left-turning motorists pose safety concerns	**Safety Considerations** • Hardened centerlines can use temporary curbing with flexible delineators. • The hardened centerline should extend past the crosswalk to most effectively slow left-turning vehicles, but vertical elements should not be within the crosswalk. • Midblock locations should also consider an active warning beacon.
Raised Crossing  Source:NCHRP	• A vertical traffic control measure • Designed with ramps on each vehicle approach to elevate the entire crosswalk (raised crossing) or intersection (raised intersections) to the level of the sidewalk.	• Can reduce vehicle speeds, reduce the need for curb ramps, and improve pedestrian and bicyclist crossing safety by improving motorists yielding • Increases visibility between modes	• School zones • Locations where motorists are failing to yield at pedestrian crossings • Slip lanes • Roundabout crossings • Shared-use path crossings	**Safety Considerations** • Do not use for crossings on steep curves or roadways with steep grades where visibility is limited. • Consider storm water drainage in the design of the raised crosswalk • Noise may increase, particularly if trucks regularly use the route • Markings and signs should promote nighttime visibility of raised devices for bicyclists and motorists • Consider directional detectable tiles in addition to required truncated domes to assist with low vision and blind users. • Can face objections from emergency services
Roadway Reallocation/ Re-channelization  Source:FHWA	• Reduction of the number and width of lanes, reducing travel speed; the space can then be used to implement additional pedestrian and bicyclist safety treatments such bike lanes and median crossing islands.	• The number of lanes on a roadway determines how far pedestrians must cross at an intersection and how many conflict points might exist. • Often completed to improve access management, increase bicycle and pedestrian access, and enhance roadway safety.	• Priority bicycle and pedestrian routes • Urban and rural areas • Multilane roads	**Feasibility may be influenced by:** • Traffic volumes and mix • Left-turn movements • Crash types and frequency • Geometric data such as roadway widths, sight distance, and the number of driveways

b. For curbs under BART property, BART Facility Standards has a section on minimum radii for curb returns.

Tier 2: Reduced Vehicle Speeds

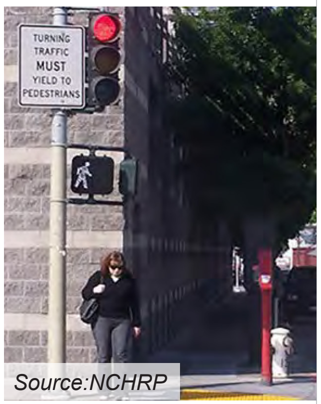
Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Speed Safety Cameras (SSCs)  *Source:NPR*	• Speed measurement devices to detect vehicles that are exceeding the speed limit • Also called photo radar or automated speed enforcement (ASE)	• Can decrease injurious crashes and increase road safety by encouraging slower speeds. • Compliance can be high 99% for spot cameras. (Victorian Government, 2024) • License plate readers can be used to track average speed to encourage compliance on a corridor rather than at a single point.	• Signalized intersections experiencing high vehicle speeds, high speed crashes, multimodal crashes. • Note that use of cameras may be limited by law, and may require advocacy and policy changes to implement.	**Safety Considerations** • Automated enforcement should only be used as a supplement to traditional engineering and education roadway safety measures, never as a replacement for these measures. **Community Considerations** • Creating an enforcement program within a jurisdiction may necessitate the establishment of a new traffic unit or the hiring of personnel to oversee the program. • In order to build public trust, SSC programs should be transparent about the use of revenue from citations. Revenue generated from SSCs in some jurisdictions has been put back into safety programs, rather than to finance unrelated expenses for the city or county (FHWA, 2023).
Speed Humps and Tables  *Source:Caltrans*	• Midblock traffic calming measures that reduce speeds by introducing vertical deflection within the vehicle's path of travel.	• Speed humps and tables reduce vehicle speeds along a corridor. • When paired with a crosswalk, speed tables can improve pedestrian visibility and reduce conflict severity.	• Streets with low traffic volumes, high speeds, and limited or no truck traffic.	**Safety Considerations** • Placement should not interfere with bicycle traffic and can be designed to allow for bike cut-through. • Coordination with emergency services will be necessary to ensure compliance with their requirements. **Community Considerations** • Speed humps can generate unwanted noise when introduced on a residential street with moderate traffic volumes.
Traffic Diverters/Modal Filters  *Source:Caltrans*	• Physical barriers that limit vehicle traffic along certain streets	• Physically limits cut-through traffic, reducing speeds and conflict exposure. • May reduce effective crossing distance.	• Streets with low traffic volumes and medium-high bicycle volumes	**Safety Considerations** • Placement should not interfere with bicycle traffic. **Community Considerations** • Placement should not interfere with local or emergency access.

Tier 3: Manage Conflicts in Time[c]

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
All-Walk Phase  *Source:NACTO*	• Exclusive pedestrian phase at signalized intersections that allows pedestrians to cross in any direction • Also known as a Barnes Dance or Scramble phase.	• All-walk phases are low-cost treatments that can increase pedestrian safety by separating pedestrians and vehicles in time.	• Densely populated urban areas, often in downtown areas • Signalized intersection with high instances of turning-vehicle--pedestrian conflicts • High pedestrian volumes and either low-to-moderate vehicle volumes or high turning-vehicle volumes	**Safety Considerations** • Sidewalk spaces must be sufficient to handle a queue of pedestrians waiting to cross. • May improve the efficiency of intersections in areas of high pedestrian activity and low vehicle volumes • These signal phases need to be combined with standard crossing phases, or the wait times may become an impediment to pedestrian mobility. • Hatched or continental crossing striping in the center of the intersection is recommended to indicate a difference in pedestrian crossing conditions. **Community Considerations** • Nonvisual guidance should be provided for pedestrians with low or no vision. • This treatment may increase delays for all users, including pedestrians and transit vehicles. It can also lead to red-light violations by impatient drivers or pedestrians, creating unsafe conditions. All-walk phases should be limited to select locations with careful coordination of signal phasing along the corridor.
Bicycle Signals  *Source:NACTO*	• A traffic signal intended to control bicycle movements • Bicycle signals are needed to orchestrate a leading or protected phase for bicycle movements.	• Initial findings show that bicycle signals may reduce vehicle-bicycle conflicts (Thompson, Monsere, Figliozzi, Koonce, & Obery, 2013).	• Signalized intersections with high bicycle volumes and high turning-vehicle volumes • Locations where a high-volume bicycle route crosses a major signalized intersection • Intersections with contraflow bike lanes or separated bike lanes • Intersections where a bicycle facility transitions from off-street to on-street • Complex intersections that may be difficult for users to navigate	**Safety Considerations** • Signals should be installed with actuation and appropriate detection for bicyclists. • Separated or exclusive bicycle signal phases can increase delay for all users, which may decrease compliance. • FHWA requires an agency to request permission to apply a leading bicycle phase. • This can be costly to implement as a red right arrow phase is needed, requiring a new signal head. • If this is not consistently applied throughout the city it can be confusing to all users how to act with these signals – vehicles expect to be able to right turn on red, and bikes may expect to be able to travel with through traffic when the bike lantern is red.
Extend Pedestrian Crossing Time  *Source:FHWA*	• Increasing the length of the pedestrian walk phase based on a slower assumed speed of travel (3.0mph instead of 3.5mph)	• This roadway safety measure allows more time for pedestrians to cross the street safely.	• Multilane facilities with long crossing distances • Signalized intersections with high pedestrian volumes or high volumes of pedestrians that require more time to move across the intersection	**Community Considerations** • Demographic and land use data may support decisions about where this roadway safety measure might be most needed, such as locations where vulnerable users are concentrated: e.g., elder care, schools, and medical facilities.

c. Note that BART does not operate any traffic signals. These measures would be more applicable to local jurisdictions.

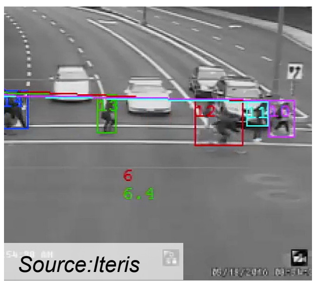
Tier 3: Manage Conflicts in Time

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Leading Pedestrian Interval (LPI)  *Source:NCHRP*	• Provides pedestrians head starts when crossing at a signalized intersection • LPIs can be easily programmed into existing signals to give pedestrians the WALK signal a minimum of 3 to 7 seconds before motorists are allowed to proceed through the intersection.	• This extra time provides pedestrians with an opportunity to establish their presence in the crosswalk before motorists start turning. • Provides additional crossing time for those who need it • Increases the percentage of motorists who yield the right-of-way to pedestrians • Can minimize conflicts at intersections • Allows for more vehicles to clear the intersection before the next phase	• Signalized intersections • Medium to high turning-vehicle volumes and pedestrian volumes • Special cases: locations with particularly high elderly populations, high crash histories, or at school crosswalks • High incidence of failure to yield crashes or citations	**Safety Considerations** • If an intersection has particularly high pedestrian traffic, consider lengthening the LPI or adding an exclusive pedestrian phase instead of an LPI, or installing a curb extension. • LPI should be accompanied by an audible noise to inform visually-impaired pedestrians that it is safe to cross. • Consider combining with a no-right-turn-on-red restriction.
No Turn on Red  *Source:NCHRP*	• A sign posted at the signalized intersection for each approach where the turn restriction is desired	• The purpose of this treatment is to eliminate conflicts between turning vehicles and pedestrians and/or bicyclists during a concurrent walk/bike phase.	• Signalized intersections • High volumes of right-turning vehicles and high volumes of bicyclists and/or pedestrians	**Safety Considerations** • Signs should be clearly visible to right-turning motorists stopped in the curb lane at the crosswalk. • A common concern that comes up when restricting right turns on red is that this can lead to higher right-turn-on-green conflicts when there are concurrent signals. The use of an LPI can usually address this issue. • This can be combined with a red light camera to enforce compliance. **Community Considerations** • May increase opportunities for enforcement.
Passive Bicycle Signal Detection  *Source:NCHRP*	• The signal system automatically detects the presence of a cyclist to actuate a signal for the cyclist's phase. • Loop detectors, video and microwave detection	• Can deter unsafe cycling behaviors, such as disregarding red signal indications	• Signalized intersections that require users to be detected to actuate a signal for one or more movement • Intersections with bicycle signals and/or bicycle-specific phasing • Bike lanes approaching intersections with bicycle signals • Left-turn lanes with left-turn signals where bicyclists also turn left	**Safety Considerations** • Detection should be located in the most conspicuous and convenient location. • Signal timing should be adjusted to account for the unique operating characteristics of bicycles. • Redundancy in placement will assist with potential failures in the loop system. If the detection system stops working, bike users may need to take very risky maneuvers to turn on busy roads. • Signage and striping should be clearly provided to instruct bike riders on where to stand to trigger the signal.

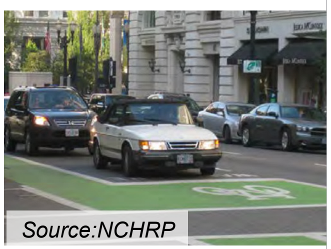
Tier 3: Manage Conflicts in Time

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Pedestrian Countdown Signals  *Source:NCHRP*	• Indications designed to begin counting down at the beginning of the clearance interval, letting the pedestrian how much time is left in the crossing phase.	• Pedestrian signals and countdown signals provide positive guidance to pedestrians regarding the permitted signal interval to cross a street and prohibit pedestrian crossings when conflicting traffic may impact pedestrian safety.	• Any time a new pedestrian signal is installed • Crossings with exclusive pedestrian phases • Signalized intersections spanning wide streets • Crossings with medium-to-high volumes of pedestrians	**Safety Considerations** • This is an MUTCD requirement for all newly installed traffic signals where pedestrian signals are installed. **Community Considerations** • This should be supplemental nonvisual guidance for pedestrians with sensory restriction. • Push-buttons should be within reach and operable from a flat surface for pedestrians in wheelchairs or with low or no vision.
Pedestrian Hybrid Beacons (PHBs)  *Source:NCHRP*	• Signals installed at unsignalized major street crossing locations to help pedestrians cross the street safely • Also called HAWKs	• Systemic safety improvement at uncontrolled locations with safety concerns or high frequency of pedestrian crashes • Reduces long pedestrian delay due to few available gaps in traffic. • May be effective at reducing multiple threat crashes	• Urban or suburban multilane roadways • Higher speed roads (particularly at or above 35 mph) • Locations with high volumes of pedestrians and vehicles (AADT > 9,000); if higher volumes, 30 mph locations may be appropriate	**Safety Considerations** • PHBs may be appropriate where traffic signals are unwarranted. • Some cities use PHBs along heavily used bicycle routes to help bicyclists cross major streets. • This does not resolve the underlying safety issue. **Community Considerations** • Education and outreach may be needed on the proper use of PHBs since many users are unfamiliar with these treatments.
Pedestrian Phase Recall  *Source:Greater Washington*	• Places a continuous call for pedestrian service, without the need for pedestrian actuation, and results in pedestrian phases getting realized every cycle including that phase's walk and flashing don't walk (FDW) intervals.	• Reduces pedestrian delay at intersections compared to actuation, which in turn improves pedestrian safety as reducing pedestrian delay tends to improve pedestrian compliance (Pline, 2001).	• Any time a new pedestrian signal is installed • Signalized intersections spanning wide streets • Crossings with medium-to-high volumes of pedestrians	**Safety Considerations** • Pedestrian recall may increase vehicular delay particularly at intersections with low to moderate pedestrian volumes (i.e., where there is no pedestrian actuation every cycle). • Where pedestrian phase recall is not feasible, consider automatic pedestrian detection to call the pedestrian phase.
Protected Phases  *Source:NCHRP*	• Providing an exclusive turn phase at a signalized intersection	• Protected phases at intersections provide a way to separate vehicular traffic from pedestrian and/or bicyclist movements, particularly for left turns when concurrent phasing would result in a conflict between modes.	• Urban areas, particularly in downtown locations • Intersections with high volumes of pedestrians or bicyclists and turning vehicles	**Safety Considerations** • Signal timing decisions should consider the needs of pedestrians, bicyclists, trucks, buses, and other motor vehicles. • Signal timing decisions should consider the volume of turning motorists. • Where protected turns are not consistently installed on a corridor or in a city it can result in confusion for users anticipating signal phases.

Tier 3: Manage Conflicts in Time

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Reduce Cycle Lengths  *Source:NACTO*	• Reduction in the length of a signal cycle: the time from when one WALK or green bike interval ends until the next WALK or green bike interval ends, with all conflicting phases served in between • Cycle length may be fixed or variable.	• Reducing the length of a signal cycle results in lower pedestrian and bicycle delay, and has the potential to make roads safer for walking and cycling by reducing speeding opportunities (Furth, Halawani, Li, Hu, & Cesme, 2018).	• Urban areas, particularly in downtown locations • Intersections with high volumes of pedestrians or bicyclists and turning vehicles • Intersections with low to medium vehicle volumes	**Safety Considerations** • Choice of signal cycle length generally involves a tradeoff of capacity, delay, and progression. • Consider re-evaluating overall signal timing at intersection (and corridor) to improve overall efficiency for all modes. A more efficient intersection can also lead to fewer safety issues such as red-light running or speeding.
Adaptive Pedestrian and Bicycle Detection  *Source:Iteris*	• Adaptive pedestrian and bicycle detection can be used to extend the bike or pedestrian phase if one is detected in the intersection after their phase has ended.	• Adaptive pedestrian and bicycle detection can reduce conflicts in time by ensuring the intersection is clear of bicyclists and pedestrians before cross-traffic enters.	• Intersections with long crossing distances and multilane approaches	**Safety Considerations** • This requires additional sensors at each leg of intersection. • Sensors can be unreliable, and faulty sensors may go unnoticed for longer periods of time. Backup options are recommended. **Community Considerations** • Alternative feedback methods should still be provided for those who rely on them. • Communication of the system should be inclusive of people with different disabilities.

Tier 4: Increase Attentiveness and Awareness

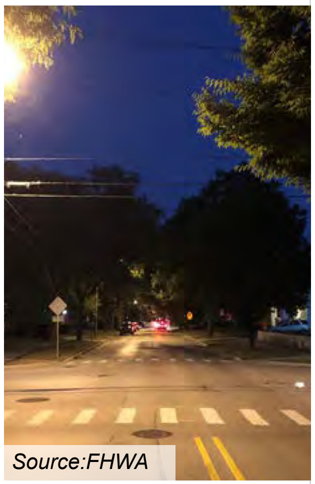
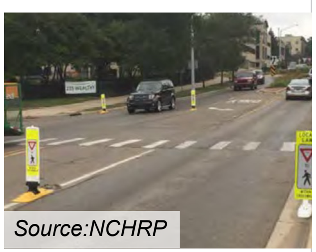
Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Active Warning Beacons  *Source:NCHRP*	• User-actuated flashing lights that supplement warning signs at unsignalized crossings • Lower-cost alternative to rapid flashing beacons or pedestrian hybrid beacons	• Active warning beacons alert drivers that people are crossing the road and encourage motorist yielding.	• Unsignalized crossings • High pedestrian and/or bicycle volumes • Crossings where driver yielding is low	**Safety Considerations** • This is appropriate when combined with other speed reduction roadway safety measures or locations with high pedestrian and/or bicycle volumes. • This is best suited for spot treatments; too many installations may reduce compliance. • This does not resolve the underlying safety issue.
Advance Stop/Yield Lines  *Source:NCHRP*	• Pavement markings placed 20 to 50 feet in advance of an uncontrolled and unsignalized pedestrian or bicycle crossing	• Advance stop/yield signs improve the visibility of crossing pedestrians and bicyclists to motorists by increasing the distance between where motorists have stopped or yielded and the crossing.	• Uncontrolled multilane crossings (at least two lanes in each direction)	**Safety Considerations** • This has potential as systemic safety improvement at all uncontrolled crossings of roadways with at least four lanes and posted speeds of at least 30 mph. • Compliance is low, and the requirement to stop is poorly understood.
Bike Boxes  *Source:NCHRP*	• Marked boxes at intersections where bicyclists can wait at an intersection	• Bike boxes can improve safety by increasing the visibility and predictability of bicyclists and encourage motorist yielding at the onset of a green signal.	• Signalized intersections with medium to high volumes of bicyclists and motor vehicles • Intersections where large vehicles are common • Intersections with high volumes of queuing bicyclists • Intersections with high volumes of turning vehicles and bicyclists going straight	**Safety Considerations** • Boxes may be disregarded by motorists if not commonly used by bicyclists (PBOT, 2010). • Should be accompanied with motorist right-on-red restrictions or dedicated turn pockets. • The distinction between waiting areas and turning boxes is poorly understood by the community. • These markings can encourage bikes to block the crosswalk.
Bicycle Lane Extension Through Intersection  *Source:NCHRP*	• Bicycle lane pavement markings that extend through intersections	• These markings provide bicyclists with a clear, highly visible path through an intersection and alert motorists to the presence of bicycle through-traffic, encouraging turning motorists to yield.	• Locations with bicycle lanes or separated bike lanes where it is desired to delineate the bicycle crossing • Locations where right- or left-turning vehicles cross through moving bicyclists • Wide or complex intersections where the bicyclist path is unclear	**Safety Considerations** • Maintaining markings must be a high priority to prolong effectiveness; the long-term maintenance cost should be considered prior to installation. • These markings can encourage bikes to block the crosswalk.

Tier 4: Increase Attentiveness and Awareness

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
High-Visibility Crosswalk Markings[d]  *Source:NCHRP*	• Continental or ladder-style crosswalk markings placed at intersections or midblock crossings	• High-visibility crosswalk markings improve pedestrian visibility to approaching motorists and can establish legal midblock crossings.	• All controlled intersections • Uncontrolled intersections that meet the requirements listed in MUTCD Section 3B.18	**Safety Considerations** • When vehicle speeds are over 30 mph, there is more than one lane in one direction, or AADT is above 9,000, there should be additional treatments present (Zegeer et al., 2017). • Midblock locations should also include warning signs and additional treatments that encourage motorist yielding. • To enhance pedestrian visibility, consider adding advanced stop lines/bars to let vehicles know to stop before a crosswalk at a signalized or stop-controlled intersection.
In-Street Pedestrian Crossing Signs  *Source:NCHRP*	• Stop or Yield to Pedestrian signs in the roadway at the centerline of an uncontrolled crosswalk • Spot treatment	• Associated with increased driver yielding and slight reductions in vehicle travel speeds when placed at marked crosswalks • Slight delay to vehicles • May increase safety and reduce delay for non-motorized modes	• Uncontrolled crossings of multilane roadways	**Safety Considerations** • The signs should be placed on a center line, on a lane line, or on a median island at the crosswalk. • Signs can be placed up to 50 feet away from a crossing. • The signs cannot be post mounted on another traffic control sign.
Mixing Zone Treatments  *Source:NCHRP*	• Locations within intersections where bicyclists approach an intersection in a bicycle lane or separated bicycle lane that terminates in a shared motor vehicle turn lane	• The provision of a constrained merging location encourages motorists to yield to bicyclists, reduce motor vehicle speed within the shared turn lane, and reduce the risk of hook crashes.	• Signalized intersections • Roadways with constrained right-of-way • Along bike routes or intersections with medium to high volumes of bicyclists • Roadways that can drop on-street parking near the intersection • Intersections with high volumes of turning vehicles and insufficient space for a bike lane • Along bike routes where there is a dedicated turn lane on the side of the street with the cycle track, but a bike signal is not appropriate	**Safety Considerations** • When vehicle speeds are over 30 mph, there is more than one lane in one direction, or AADT is above 9,000, there should be additional treatments present (Zegeer et al., 2017). • Midblock locations should also include warning signs and additional treatments that encourage motorist yielding.

d. BART Facilities Standards require high-visibility crosswalks on BART property.

Tier 4: Increase Attentiveness and Awareness

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Lighting[e]  *Source:FHWA*	• Illumination at crosswalks and along the roadway • Note that lighting is considered a fundamental roadway design element that should be included in all roadway projects, and particularly those aiming to improve safety.	• Can help increase visibility for pedestrians and bicyclists, particularly at approaches to crossings	• Bus stops, signalized and unsignalized intersections, and midblock locations • Special cases: at and near intersections in commercial or retail areas, near schools, parks, and recreation centers	**Safety Considerations** • Use uniform lighting levels. • Pedestrian-scale lighting can increase the prominence of pedestrians on-street, and typically improves pedestrian amenity and feelings of safety. • FHWA recommends luminaires be placed prior to the crosswalk in the direction of travel to provide adequate vertical illumination. **Community Considerations** • Lighting may be disruptive to people experiencing homelessness/housing insecurity. Care should be taken to choose an appropriate lighting intensity and color to mitigate these impacts.
Gateway Treatments  *Source:NCHRP*	• Stop or Yield to Pedestrian signs (MUTCD R1-6 or R1-6a) placed on-street on each side of the travel lane ahead of an uncontrolled crosswalk	• This treatment requires motorists to drive between the signs, resulting in a vehicle speed reduction between 4-10 mph (Van Houten & Hochmuth, 2017).	• Uncontrolled crossings on roads with speed limits of 30 mph or less • Uncontrolled crossings on roads with speed limits of 35 mph with average annual daily traffic levels below 12,000 (Van Houten & Hochmuth, 2017)	**Safety Considerations** • Signs should be placed on both sides of all travel lanes and may be located on a center line, median or crossing island, lane line, within a gutter, or near the curb, but they should not be placed within the crosswalk (Van Houten & Hochmuth, 2017). • The narrower the gap, the more effective the gateway treatment.

e. For lighting on BART property, BART Facility Standards has lighting standards specified in the electrical engineering section.

Tier 4: Increase Attentiveness and Awareness

Roadway Safety Measure	Description	Why it works?	Applicable Context	Key Considerations
Parking Restrictions at Crossing Locations/ Daylighting  Source:NCHRP	• Removing parking space(s) on an intersection approach • No Parking sign (MUTCD R7 series)	• Can improve the visibility between pedestrians and bicyclists with approaching motorists	• Approaches to intersections where parked vehicles block sightlines • Approaches to intersections with high volumes of pedestrians • Intersections with high frequencies of pedestrian-vehicle conflicts • Note that California passed AB 413 in 2025 to prohibit stopping or parking a vehicle within 20 feet of a crosswalk.	**Safety Considerations** • In some cases, it may be necessary to provide physical roadway barriers to prevent motorists from parking near crosswalks, such as temporary curbing, planters, flexible delineators, or curb extensions. • These restrictions are not typically enforced and should be physically reinforced with curb extensions. **Community Considerations** • It is important to communicate with nearby property owners and businesses who might be impacted by parking space removal. • This increases opportunities for enforcement. Consider means-tested fine structures.
Rectangular Rapid Flashing Beacons (RRFBs)  Source:NCHRP	• Placed on both sides of an uncontrolled crosswalk, below a pedestrian crossing sign, and above an arrow pointing at the crosswalk • RRFBs differ from standard flashing beacons by using a rapid flash frequency, brighter light intensity, and ability to aim the LED lighting. • Can be passively or pedestrian actuated	• Feature an irregular, eye-catching flash pattern to call attention to the presence of pedestrians • Shown to significantly increase motorist yielding behavior at uncontrolled crosswalks, with motorist yield rates ranging from 34 percent to over 90 percent	• Roadways with low-to-medium vehicle volumes • Roadways with posted speeds less than 40 mph	**Safety Considerations** • RRFBs are good for two-lane streets, but less suited for multilane roadways. • If multiple RRFBs are needed in close proximity, consider redesigning the roadway to address systemic safety challenges. • This does not resolve the underlying safety issue. **Community Considerations** • Education and outreach may be needed on the proper use of PHBs since many users are unfamiliar with these treatments.
Two-Stage Bicycle Turn Queue Boxes  Source:NCHRP	• Designates an area outside of vehicle conflicts for bicyclists to wait for traffic to clear before proceeding in a different direction of travel • May be used for left or right turns	• Reduce conflicts between motorists and turning bicyclists • Useful at locations where bicyclists would have to merge across multiple lanes of traffic, would have to wait in a shared travel lane with motorists to turn, or at locations with separated bike lanes or side paths where it is not possible for bicyclists to merge into motor vehicle lanes in advance of the intersection.	• Multilane intersections where bicyclists frequently turn left from a facility on the right side of the roadway • Cycle tracks or bike lanes with multiple adjacent motor vehicle travel lanes with high traffic speeds and/or traffic volumes • Special case: intersections where bicyclists must cross streetcar or light rail tracks to make a left turn	**Safety Considerations** • Consider a physical refuge (e.g., curb extension or jug-handle) for queuing bicyclists. • Consider a leading bike interval (LBI). • The queue box can also be used to help bicyclist make a right turn from a left-side bicycle lane or cycle track.

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5. Developing the Focus Station Area Action Plans

This Plan's Safety Analysis (Chapter 3) and Systemic Roadway Safety Measures Toolbox (Chapter 4) were used to develop Focus Station Area Action Plans (FSAAPs), conceptual public roadway safety improvement designs that demonstrate how partner agencies could use this Plan to identify locations and tools. This chapter describes the process of selecting the Focus Station Areas and developing the FSAAPs. It is important to understand that the FSAAPs do not provide recommendations for every road and intersection on the HIN in the Station Study Area. Rather, they represent a model of using this Plan to identify and develop safety improvement plans. The FSAAP for each station are presented in **Appendix G** and include high-level conceptual designs of roadway safety measures, analysis of safety benefits, estimated costs, and impacts to roadway users.

Selecting Focus Station Areas

Several criteria were used to determine the selected stations, including collision history, geographic diversity, and local jurisdictions' needs and capacity. At least one station from each of the five counties was selected, and one additional station was selected for the two counties with the highest number of BART stations: Alameda and Contra Costa.

BART worked with its Steering Committee members to review the KSI crash data and identify Station Study Area candidates. Staff at local agencies and Caltrans with roadways on the HIN in Station Study Areas were queried about their interest in participating in the FSAAP process and their capacity for developing and implementing FSAAP recommendations. As a result, seven Station Study Areas were selected for FSAAPs as follows:

- **Balboa Park** (City and County of San Francisco)
- **Coliseum** (Alameda County)
- **Colma** (San Mateo County)
- **Concord** (Contra Costa County)
- **Hayward** (Alameda County)
- **Milpitas** (Santa Clara County)
- **Richmond** (Contra Costa County)

FSAAP Development

Stakeholder Involvement

BART worked with local, countywide, and state agency staff to participate in the pop-up events for rider outreach, conduct walk audits, identify safety improvement recommendations, and align recommendations with existing local plans and Vision Zero toolkits. BART collaborated with participating agency staff to develop FSAAPs, each of which focused on addressing safety issues at key locations that were visited during the walk audits.

Rider Input

BART riders shared their input about traffic safety during in-station pop-up events and through an online survey in November and December 2024. This input informed which roads and intersections on the Station Study Area HIN should be prioritized for the FSAAP development. Table 5 summarizes common safety concerns by respondents.

Table 5. Summary of Input from Focus Station Area Survey

BART Station & Pop-Up Event Date	*Survey Takeaways*
Balboa Park **December 10, 2024**	Respondents were primarily concerned with pedestrian safety, especially at intersections on Ocean Avenue, Geneva Avenue, and San Jose Avenue. Concerns included intersections and freeway on/off ramps where motorists often speed, disregard traffic signals, and do not yield to pedestrians. Some respondents also expressed concern with the lack of prominent crosswalk signals and safe pedestrian crossing opportunities around City College, light rail tracks, and the BART station.
Coliseum **December 5, 2024**	Respondents were concerned with speeding and reckless driving on San Leandro Street and Snell Street and cited the need for improved street lighting around the station. Suggestions to improve safety around the station included implementing improved pedestrian crosswalks on San Leandro Street and more robust bicycle and pedestrian facilities on Hegenberger Road.
Colma **December 11, 2024**	Respondents were concerned with speeding on D Street and insufficient street lighting. They suggested implementing more stop signs to slow cars for crossing pedestrians.
Concord **December 3, 2024**	Respondents were concerned about vehicles parking in bike lanes along Grant Street creating traffic crowding and safety issues. Other concerns included inadequate street lighting and lack of pedestrian crosswalks around the station (including to One Concord Center); reckless driving along Grant Street, Clayton Road, and Oakland Avenue, in addition to insufficient bike facilities on Clayton Road.
Hayward **December 4, 2024**	Respondents were concerned with speeding and reckless driving, especially where there is a lack of safe bike and pedestrian facilities (e.g., B Street, Western Blvd near Cherryland Elementary School, Winton Avenue over the train tracks and over I-880). Bike, pedestrian, and driver safety concerns were also reported at the intersections along D Street, Mission Boulevard, B Street, Grand St, and Foothill Boulevard due to reckless driving behavior. There were also concerns about safety on Montgomery Avenue.
Milpitas **December 12, 2024**	Respondents expressed the need for more protected bike lanes and were concerned that Montague Expressway and Great Mall Parkway were too wide for safe pedestrian crossings. There were also speeding and reckless driving concerns on Montague Expressway and Milpitas Boulevard.
Richmond **November 21, 2024**	Respondents were concerned with poor lighting and reckless driving at nearby intersections, 23rd Street, and the MacDonald Avenue underpass, which makes pedestrians and cyclists feel unsafe.

Determining the Walk Audit Route

Walk audit routes were determined in collaboration with partner agency staff. Inputs included choosing public roads and intersections that were contained in the Station Study Area HIN, those that were identified by public or agency staff, and/or locations where there were no improvements planned. Based on this information, the project team developed a recommended walking route that guided each walk audit. In some cases, other streets were also considered for improvements based on observations during the site visit and recommendations from agency staff and representatives from citizen groups who joined the walk audit. Only a selection of streets on the HIN were feasible to visit due to time constraints.

Photo of Hayward FSAAP Walk Audit

Selecting Roadway Safety Measures

A design session to brainstorm recommended improvements followed every walk audit and all participants provided input to ensure a collaborative process. The identified roadway safety measures were summarized in the FSAAP, which were distributed to partner agencies to ensure alignment. Partner agency concurrence was crucial as they would be the ones taking the lead to design, fund, and construct the recommended improvements on roadways under their jurisdiction. It's important to note that only a selection of streets on the HIN were feasible to include in the FSAAP due to time and budget constraints.

The FSAAP for each station is presented in **Appendix G: Focus Station Area Action Plans**.

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6. Future Actions

Safe Trips to BART: An Action Plan for Safer Roadways aims to achieve the following outcomes:

- Make getting to and from BART as safe as riding BART itself.
- Identify the Station Study Area HIN and a toolkit of potential roadway safety measures that partner agencies can use to pursue funding and implement on roadways under their respective jurisdictions.
- Enable the pursuit of funding from federal, state, and local safety grant sources, such as Safe Streets and Roadways for All, by agencies with roadways found in the Station Study Area HIN to improve access to transit.
- Demonstrate that funding transit service improvements and providing more mobility options are necessary to reduce demand for driving and enable implementation of the most effective roadway safety measures.
- Foster collaboration between BART, local jurisdictions, Caltrans, and other agencies to design, fund, and implement recommendations identified in the seven Focus Station Area Action Plans.
- Empower members of the public to advocate for roadway safety projects on the Station Study Area HIN by providing **Appendix H: Support Letter Template** they could use to contact elected officials and/or staff at the agency (city, county, town, or Caltrans) that owns or operates the HIN roadway section of concern.

This Plan is foundational for BART and its local and regional partners to pursue funding for designing and implementing roadway safety projects and improving BART transit service levels. The following is an implementation strategy:

1. BART will support partner agencies as they apply for eligible funding sources to implement safety improvements on this Plan's HIN roadways under their jurisdiction. Sources could include grants offered by federal, state, regional, or local agencies, such as:
    - Federal Highway Administration (FHWA)
    - United States Department of Transportation (USDOT) and Environmental Protection Agency (USEPA)
    - California Air Resources Board (CARB)
    - California Department of Transportation (Caltrans)
    - California Office of Traffic Safety (OTS)
    - California Strategic Growth Council (SGC)
    - California Transportation Commission (CTC)
    - Metropolitan Transportation Commission (MTC)
    - Countywide Transportation Authorities
2. If funding becomes available in the future, BART may revisit this analysis with local partners to assess how implemented roadway safety measures have impacted KSI crashes.
3. BART plans to continue investing in transit service levels and transit facility safety improvements to provide reliable transit options for existing riders and encourage more drivers to shift to BART. Fewer drivers on the road may also create opportunities to redesign streets to reduce driver speeds, reduce severe conflicts, and create additional space for vulnerable roadway users.

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- Midori Tabata and Priyanka Altman, Walk Oakland Bike Oakland
- Erika Viveros and Brandon Evans, Richmond Main Street Initiative
- Ronnie Mills and John Gioia, Contra Costa County Board of Supervisor John Gioia representing District 1

Appendices

Appendices are separate files due to their size and are found at www.bart.gov/safetrips.

- Appendix A. Outreach Milestone Reports
- Appendix B. Existing Resources and Conditions Report
- Appendix C. Review of Existing Plans and Projects by Station Area and Agency
- Appendix D. High Injury Network Map by Station
- Appendix E. White Paper for System Safety Analysis
- Appendix F. Roadway Safety Measures Toolbox Methodology
- Appendix G. Focus Station Area Action Plans
- Appendix H. Support Letter Template