Envisioning a Win-Win Strategy for Evacuation Routes on High-Injury Networks

Lead Author: Ashlee Takushi, RSP$_1$
Contributing Authors: Ian Barnes, PE and Chelsea Richer, AICP

Abstract

Evacuation analysis is at the crossroads of climate mitigation, sustainability, adaptation, resilience, and multimodal safety.

In California, Senate Bill 99, Assembly Bill 747, and Senate Bill 1409 were all adopted in the last five years to identify evacuation routes and locations to prepare agencies for wildfires. Wildfires have significantly impacted many communities throughout the state, especially in the last two decades. Broadly, more communities nationwide are required to consider evacuation needs due to the increasing frequency and severity of many natural disasters, and as climate change continues to affect global surface temperatures. These communities are also making Vision Zero commitments and following national, state, and local initiatives to embrace the Safe System Approach and prioritize multimodal safety needs. In many communities, key evacuation routes have also been identified as the High-Injury Network (HIN), leading to a "collision course" of evacuation and safety goals if the potential tensions are not proactively identified and creatively addressed.

A Safe System Toolbox—a suite of tools that can reduce evacuation time estimates—considers the demand and supply side tools that meet evacuation needs and priorities, while maintaining the daily multimodal safety needs of a community. These win-win strategies will often be "flexible capacity" tools that draw on technology and flexible shoulder or lane use. It will be essential to identify and plan for these early on in safety, complete streets, and evacuation efforts so that they are the default approach, and conflicting measures that may derail implementation of a safety project are not proposed on key evacuation routes.

Introduction

Three emerging trends are presenting new tensions that arise with the need for making trade-off decisions: an increasing focus on systemic safety for all users, an increasing focus on the need for intentional and proactive evacuation planning, and an increasing focus on reducing transportation-related greenhouse gas emissions (GHGs). Within the last five years, some topics that have come to the forefront of the practice include the following:

- A commitment at the federal and state level by adopting the Safe System Approach to address degraded multimodal safety in the post-COVID 19 pandemic environment (such as the FHWA's *Safe System Roadway Design Hierarchy* [2024])
- Multiple major wildfire evacuation events, especially throughout California, where severely congested conditions combined with fast-moving fires resulted in lives lost
- Emerging legislation (such as California's AB 747) and several California Environmental Quality Act lawsuits that have established requirements for agencies in high hazard risk zones to directly address evacuation needs through more analysis and planning
- Legislation and policies (such as California's SB 743 [2012], the FHWA's GHG Rule [2023], and the EPA's Multi-Pollutant Emissions Standards for Light and Medium Duty Vehicles [2024]) that established the need to monitor and reduce transportation-related GHGs either directly or through the reduction of vehicle miles traveled (VMT)

The Challenge

The goals and outcomes of these new paradigms could potentially conflict with one another. For example, widening roadways to improve evacuation capacity may lead to increased vehicle speeds under normal conditions, which worsens crash severity and may induce VMT and tailpipe emissions. However, the reallocation of right-of-way for complete streets/multimodal safety projects could worsen evacuation travel time in an emergency scenario. The transportation industry's typical methods of addressing these transportation goals individually—improve safety through multimodal projects; avoid inducing VMT; enable safe and efficient evacuations—must be considered together to strive to meet public needs under both normal conditions and evacuation circumstances.

Recent federal safety guidance (*Safe System Roadway Design Hierarchy* [2024]) focuses on removing potential roadway conflicts, separating vulnerable road users from traveling vehicles, and prioritizing countermeasures based on a hierarchy. Tier 1 calls for physical separation, and if that isn't feasible, identifying countermeasures from the successive tiers to enhance safety and create redundancy in the roadway network.

Many jurisdictions have or are in the process of completing Safety Action Plans, consistent with the federal Safe Streets and Roads for All Infrastructure Investment and Jobs Act funding (2021). These Safety Action Plans identify high-injury corridors or safety corridors that often align with major arterials within the jurisdiction. These arterials typically have high volumes, high speeds, and higher rates of fatalities and serious injuries. They also are likely to be identified as part of the evacuation route network due to the exact same characteristics—the ability to carry high volumes at high speeds. This paradigm shift in designing roadways to separate users in time and space and to reduce speeds during normal day-to-day operation has caused tension with the goal of having enough right of way to allow for high vehicle throughput in the event of an evacuation.

The good news is that more innovative combinations of existing and emerging strategies can be employed to incorporate the Safe System Approach, along with planning for evacuation needs and climate change concerns. For example, consider a typical street conversion project located along an evacuation route, where the jurisdiction's goal is to create a design that promotes walking and bicycling and addresses systemic safety risks on a high-injury corridor. How might the cross section of the corridor change to address these day-to-day safety concerns while still providing usable space during an evacuation?

Roadway Conversions: A Win-Win Idea

Existing roadways were typically built with vehicle throughput in mind, leaving bicyclists and pedestrians to share the sidewalk space or bicyclists to ride on street with minimal protection. Through the institutionalization of the Safe System Approach in jurisdictions nationwide, there is a push to revision the roadway space. The figures below go through the brief history of typical roadway design through the years and offers flexible roadway designs during an evacuation.

Figure 1: Existing Conditions

Four lane road with on-street parking

SOURCE: MADE WITH BEYOND TYPICALS

Roadways have historically been designed for vehicle throughput. This includes wide, 12-foot lanes and on-street parking, with narrow sidewalks and limited design for bicycle facilities.

Figure 2: The Classic Road Diet

Road diet with buffered bike lanes and on-street parking

SOURCE: MADE WITH BEYOND TYPICALS

As complete streets design became standard practice, jurisdictions started redesigning roadways following a "classic" road diet formula: four to three travel lanes, on-street buffered bike lanes, and a two-way left turn (TWLT) lane. This allowed for traffic calming measures along a corridor and an on-street facility for bicyclists.

Figure 3: The Win-Win Reconfiguration – Flexible Capacity, Day-to-Day Use

Road diet with TWLT, on-street parking, and separated bikeways

SOURCE: MADE WITH BEYOND TYPICALS

This "win-win" reconfiguration using flexible roadway design separates users in time and space and gives jurisdictions the flexibility to accommodate everyday traffic as well as additional vehicle throughput during an emergency evacuation event. This would require special attention to lane widths and materials to ensure emergency vehicles can use the multimodal space.

Figure 4: The Win-Win Reconfiguration – Flexible Capacity, Evacuation Conditions

Outbound-only lane conversion, prohibited on-street parking, conversion of separated bikeways and sidewalk to inbound emergency responder vehicles, room for staging vehicles, and separated bike lanes for multimodal evacuation use

SOURCE: MADE WITH BEYOND TYPICALS

The configuration in Figure 4 converts lanes to serve outbound evacuating vehicles, inbound emergency response, and fire response staging, as well as multimodal evacuation needs. During red flag days, jurisdictions could set a policy of prohibiting parking along evacuation routes, clearing additional space to be used specifically under evacuation conditions. This configuration requires both creative design and proactive implementation of intelligent transportation system (ITS) or communications technology to support variable message boards, signal timings, and overall dissemination of information on how to evacuate the area.

Some outstanding design details would need to be addressed to make this creative solution a reality:

- Facility widths and materials, especially for the sidewalk and separated bikeways would need to be designed to accommodate the size and weight of emergency response vehicles.
- The intersections of these corridors need to be designed to accommodate use of the separated bikeways by emergency response vehicles while achieving multimodal safety improvements.
- Safety countermeasures such as curb extensions may not be possible to retain flexible use of the parking lane.
- At a midblock crossing, a mountable pedestrian refuge island may need to be designed so the lane could be used as a through lane during an evacuation.
- To complement roadways changes, ITS can be included to reinforce flexible use (for example, variable message signage on different lane configurations, battery backup for traffic signals).

Trails: Untapped Opportunity for Enhancing Resiliency

It is also important to understand a gap remains in the design and use of trails as resilient infrastructure, and trails would typically be applicable in a suburban or rural setting. FHWA recently published two reports, *Trails and Resilience: Review of the Roles of Trails in Climate Resilience and Emergency Response* (March 2023) and *Trails as Resilient Infrastructure Guidebook* (December 2023). *Trails and Resilience* identifies the use of trails as critical infrastructure during evacuation events; however, there are still research gaps for trails in connection to climate resilience, emergency response, and public health emergencies. Additionally, the *Trails as Resilient Infrastructure Guidebook* highlights the need for jurisdictions to continually coordinate with state, regional, and local officials to integrate trails into emergency response plans, as well as trail maintenance and management, to tackle climate change through seasonal pattern changes.

Win-Win Transportation Systems Management & Operations (TSMO) Strategies

A Safe System-consistent evacuation approach must incorporate TSMO. A supply-increasing or supply-focused evacuation approach may retain or even add locations of high exposure to kinetic energy risk for vulnerable road users. To simultaneously reduce this risk while providing similar or greater flexible evacuation capacity, planners should look to TSMO to improve the reliability and safety of the existing transportation network.

TSMO strategies should be integrated across multiple agencies and departments and should proactively identify actions to be taken as early as possible when officials identify an emergency evacuation is needed. Management of capacity supply and demand should prioritize the safety of roadway users under both day-to-day and evacuation conditions and follow a similar Safe Systems Approach.

Strategies to manage demand align the number of evacuation trips in space and time to the available capacity. Successful strategies begin by evaluating the existing transportation network capacity to meet evacuation needs and allow for the phased roll-out of evacuation plans based on agency staff and managers realistic capabilities to facilitate those emergency and evacuation plans. These strategies include:

- Development of "right-sized" evacuation zones that provide the early evacuation targeted evacuation orders to not overwhelm roadway capacity early.
- Establishment of a "shelter-in-place" policy that works in conjunction with a phased evacuation, real-time communication, and granular evacuation zones that can be aggregated as capacity is added in the direction of the evacuation.
- Policies and systems to encourage and enable residents to share vehicles, provide rides to neighbors that may not own private vehicles, reduce the number of evacuating vehicles, and ensure all seats in evacuating vehicles are filled.
- Provide aggregated designated parking areas outside hazard zones for to additional household vehicles in advance of an evacuation, avoiding extra vehicles on the road while enabling the public to protect their property and day-to-day modes of transportation they rely on.
- Coordinate with emergency responders to provide complete access to all locations in a jurisdiction, including gated communities and critical infrastructure that may be adjacent to jurisdiction boundaries.
- Development of integrated transit evacuation plans for "Access & Functional Needs" populations as well as other vulnerable populations (such as those without sufficient access to or ability to operate a vehicle).
- Install travel time detectors (such as Bluetooth detection systems) to enable the management of evacuation travel speeds and on major evacuation routes to guide the public to the routes that best match the demand to the available capacity.

Strategies that manage the supply of capacity should identify priorities for agency staff and managers to roll out that add capacity as quickly as realistically possible given limitations and demands on agency staff under emergency conditions. Plans should focus on adding capacity near hazard areas, moving to downstream capacity, and then ultimately to multiple and alternative routes. These strategies can also proactively install ITS infrastructure that enables operators to manage capacity supply daily but can also

be used to manage supply during evacuation scenarios. Strategies to manage and operate the supply of capacity include:

- Proactively plan and implement flexible infrastructure that facilitates the management of public spaces, vehicle lanes, active modes lanes (cycle tracks, bike lanes, sidewalks, etc.) that can be repurposed during emergencies to provide essential services or additional capacity for evacuation routes.
- Provide priority transit evacuation routes that enable transit agencies to implement integrated transit evacuation plans.
- Provide multi-agency agreements to facilitate revisions to control of traffic signal phasing and timing by multiple partner agencies (such as local governments, counties, and state DOT's) during emergencies to better facilitate revisions on multiple corridors.
- Install improved and redundant communication lines (such as fiber optic interconnect) and connections to multiple control centers that facilitate traffic control signal timing to be remotely adjusted under emergency conditions to allow for green times to be maximized in the direction of the evacuation.
- Implement infrastructure to provide guidance to the public, such as changeable message and variable lane signs, directing them to major evacuation routes, alerting them to revised traffic patterns, and allowing for the repurposing of lanes.
- Install smart vehicle detection such as fishbowl and pan-tilt-zoom cameras along major evacuation routes to help identify vehicle breakdowns, crashes, and identify routes for emergency responders and expedite response.
- Implement improved evacuation warning systems (zonal evacuation alerts, wildfire warning sirens, NOAA hazard radios, etc.).
- Prepare emergency traffic control plans for key intersections along major evacuation routes where flaggers and traffic control devices will be needed to facilitate traffic revisions.
- Install battery back-up and alternative power systems at key intersections along major evacuation routes to ensure traffic signal and ITS equipment continue to operate under evacuation conditions.
- Coordinate with utilities to underground key electric and communication lines to prevent downed wires on main evacuation routes.
- Identify parallel and redundant critical transportation infrastructure to facilitate emergency response in the opposite direction of evacuations.
- Identify and prioritize key aging and vulnerable traffic signals for upgrade or replacement, connection to signal communication networks, and provide redundant connections to traffic control centers.

Planning for a Win-Win Paradigm

To align evacuation needs with the Safe System, an integrated planning approach is a critical step. Integrated planning approaches consider multiple agencies and departments, establish lines of communication, identifies the shared responsibilities of managers across the system, and relies on strategies from multiple plans and strategies including emergency response and evacuation plans, TSMO strategies and implementation plans, ITS plans and strategies, transportation master plans, comprehensive plan transportation elements, Vision/Target Zero plans, and Safe Systems Plans. The safety planning process should consider the flexible design solutions for High-Injury Network segments that are also part

of the evacuation network, and existing and emerging evacuation planning efforts can focus first on prioritizing the "win-win" solutions that actively management the physical capacity while not over supplying capacity under non-evacuation conditions.

Federal, state, and local funding sources are available to harness these opportunities. Agencies should reference area planning documents and identify alignments with evacuation and safety plans for grant funding opportunities. Additional agencies can use development impact fees as a mitigation in-lieu fee to address developments that specifically add demand in high-hazard areas or add strain to key evacuation routes within a community.

Future Research Needs

Research is needed to understand design barriers to these solutions, especially in urban and suburban areas which have limited capacity for expansion of roadway networks. Some of the outstanding issues include the following:

- How trails and bikeClass I multi-use paths would be designed at intersections to allow for mountable access for emergency services.
- How bikeClass I multi-use paths in urban/suburban areas interact with driveways.
- How to design safety countermeasures such as bulbouts, pedestrian refuge islands, and roundabouts along High-Injury Networks while using parking lanes and two-way left-turn lanes as evacuation through lanes.
- How to determine whether bike paths or separated bikeways lanes are needed on both sides of the roadway, and if not, which side of the roadway gets the path.
- How to determine who gets priority on the path, if right-of-way constraints require only a single path (emergency services vs. bicyclists vs. pedestrians)

No single transportation planning and engineering solution can adequately and universally address all the various competing needs on our transportation system in a rapidly evolving environment. However, similar to the Safe System Approach where the roadway needs to have redundancies to prevent fatalities and serious injuries, there needs to be redundancy in the roadway system to create avenues of utilizing the roadway for day-to-day operations and being able to move people safely and efficiently during an evacuation event. As resiliency continues to be an emerging field, jurisdictions must commit to proactively plan for evacuation events and implementation of hardened infrastructure and roadway redesign for emergency preparedness.