Amherst Multimodal Master Plan

Utilizing Systematic Safety Principles to Develop a Town-wide Multimodal Network

Amherst Bicycle & Pedestrian Advisory Committee

Multimodal Master Plan
Version 9.2.1

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Amherst Bicycle & Pedestrian Advisory Committee
Amherst, New Hampshire

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1 A Town-Wide Multimodal Network

1.1 The Amherst Bicycle and Pedestrian Advisory Committee

The Amherst Bicycle and Pedestrian Advisory Committee was formed by the Amherst Board of Selectmen *to facilitate a town-wide network for the enhancement and encouragement of safe, multi-use transportation for connectivity, recreation, and health through the development of strategic and actionable plans*. After working for over a year to engage with Amherst residents, collect relevant data, interface with several other committees in town, and research multimodal best-practices, the committee has produced this document as a recommended vision for the development of a safe, multimodal network in our community.

1.2 Purpose

The Amherst Multimodal Master Plan has been developed to promote safe access to the town's transportation network for all users, by enshrining systematic safety principles into the design of our on-road and off-road (trail) system.

The adoption of this document demonstrates the town's commitment to a sustainable, connected, and accessible transportation network.

1.3 Plan Outreach & Engagement

The Committee engaged in extensive outreach efforts such as advertising the survey in the Amherst Middle School & Souhegan High School newsletters, during the Healthy Living Program for seniors at the Hampshire Dome, Town Voting Day, Halloween, 4th of July Parade, and other Town-sponsored events. In addition, two public listening sessions to receive input for the Plan were held, attracting over 130 attendees.

1.4 Background Resources

When creating the Trail, Pedestrian, and Bicycle Master Plan, several resources were consulted to provide context regarding local issues surrounding multimodality.

- Town of Amherst's Master Plan (Community Preservation Assoc. 2010)
- Transportation and Community and Systems Preservation Study (NRPC 2006)
- Clark-Wilkins Elementary & Amherst Middle Schools Safe Route to School Travel Plan (NRPC 2013)
- Regional Plan: 2015-2040 Metropolitan Transportation Plan (NRPC 2014)
- Middle Street Traffic Study (NRPC 2014)
- Amherst Village Strategic Plan (NRPC 2015)
- Advisory Bicycle Lane Design Guide (Williams 2018)
- Multimodal Roadways for Amherst (Buchanan 2018)

Bicycle-pedestrian safety and connectivity are highlighted as priorities in Amherst's 2010 Master Plan. The Master Plan calls for "a town-wide pedestrian and bicycle trail system that connects open spaces with schools, recreation areas, shopping, and residential areas" (AMP, 58). The Village Strategic Plan concludes that better connectivity between schools, parks, and the village center is desired. This report recommends "a pedestrian/bicycle route from Souhegan High School and

Amherst Middle School to the Village District" (VSP, 17). The 2013 Clark-Wilkins & Amherst Middle School Safe Routes to School Travel Plan reaches similar conclusions by emphasizing the need for a safe and connected network for multimodal travel.

The findings of the 2013 Plan were focused on providing better access to Amherst schools through the construction of new sidewalks and repairing existing sidewalks. The author states that the goal of improving sidewalk connections is "to increase the number of students who use non-motorized transportation to get to and from school; to ensure the safety of students on their way to and from school; [and] to improve children's fitness and health" (SRTS, 4). According the Safe Routes to School report, "the highest priority infrastructure project is to develop a path from the Amherst Middle School to the east side of Boston Post Road and a sidewalk along the east side of Boston Post Road from just north of Cross Road south to Homestead Road" (SRTS, 34).

The 2015 Village Strategic Plan recommends expanding the pedestrian amenities in the Historic District. The Plan calls for a trail network branching out from the Village center to connect with existing trails, as well as constructing sidewalks to provide safe passage along a popular walking route. Locally known as the village loop, the proposed route includes segments of Manchester Road, Mack Hill Road, Jones Road, New Boston Road, and Boston Post Road. These reports were consulted when developing the Trail, Pedestrian, and Bicycle Master Plan. The overwhelming similarities between the 2010, 2013, and 2015 plans help substantiate the findings reached by collecting data, soliciting survey responses, and input received at the public sessions.

1.5 Data Collection & Review

During plan development, several sources of data provided valuable information that helped inform project recommendations. In 2017, all town-owned sidewalks, crosswalks, and curb ramps were mapped and evaluated through the town's participation in the Statewide Asset Data Exchange System (SADES). In 2018, staff examined selected town-owned roads noting lane width, sight distance, condition, and existence of a shoulder. All data was catalogued in GIS (geographic information system) format so it can be used for asset management and planning purposes.

The Bicycle and Pedestrian Advisory Committee conducted a bicycle-pedestrian transportation survey to understand perspectives toward alternative transportation. The survey was posted online and paper copies could be found at many community gathering locations including the Amherst Town Hall, Town Library, Amherst Middle School, Souhegan High School and Moulton's Market. The Committee used the survey to collect contact information from residents interested in participating in the planning process. Over 530 survey responses were received, providing insight into the preferences and opinions of pedestrians and bicyclists using Amherst trails and roads.

Survey respondents were asked to identify locations that walkers, runners, and bikers would travel if conditions were better. Souhegan High School, Amherst Middle School, Town Hall, Town Library, Baboosic Lake Town Beach, Village Common, Birch Park, Joshua's Park, Moulton's Market, Homestead Store, and Milford Oval were identified with the Middle and High School receiving the most responses. Survey respondents were also asked to identify roads that present safety concerns to pedestrians and bicyclists. Boston Post Road received the most responses, followed by NH Route 122, Amherst Street, Mack Hill Road, Baboosic Lake Road, NH Route 101A, Main Street, Christian Hill Road, NH Route 101, County Road, Horace Greeley Road, Merrimack Road, Stearns Road, Seaverns

Bridge Road, Spring Road, Mont Vernon Road, and New Boston Road. The following map visualizes destinations identified by participants who attended the public sessions.

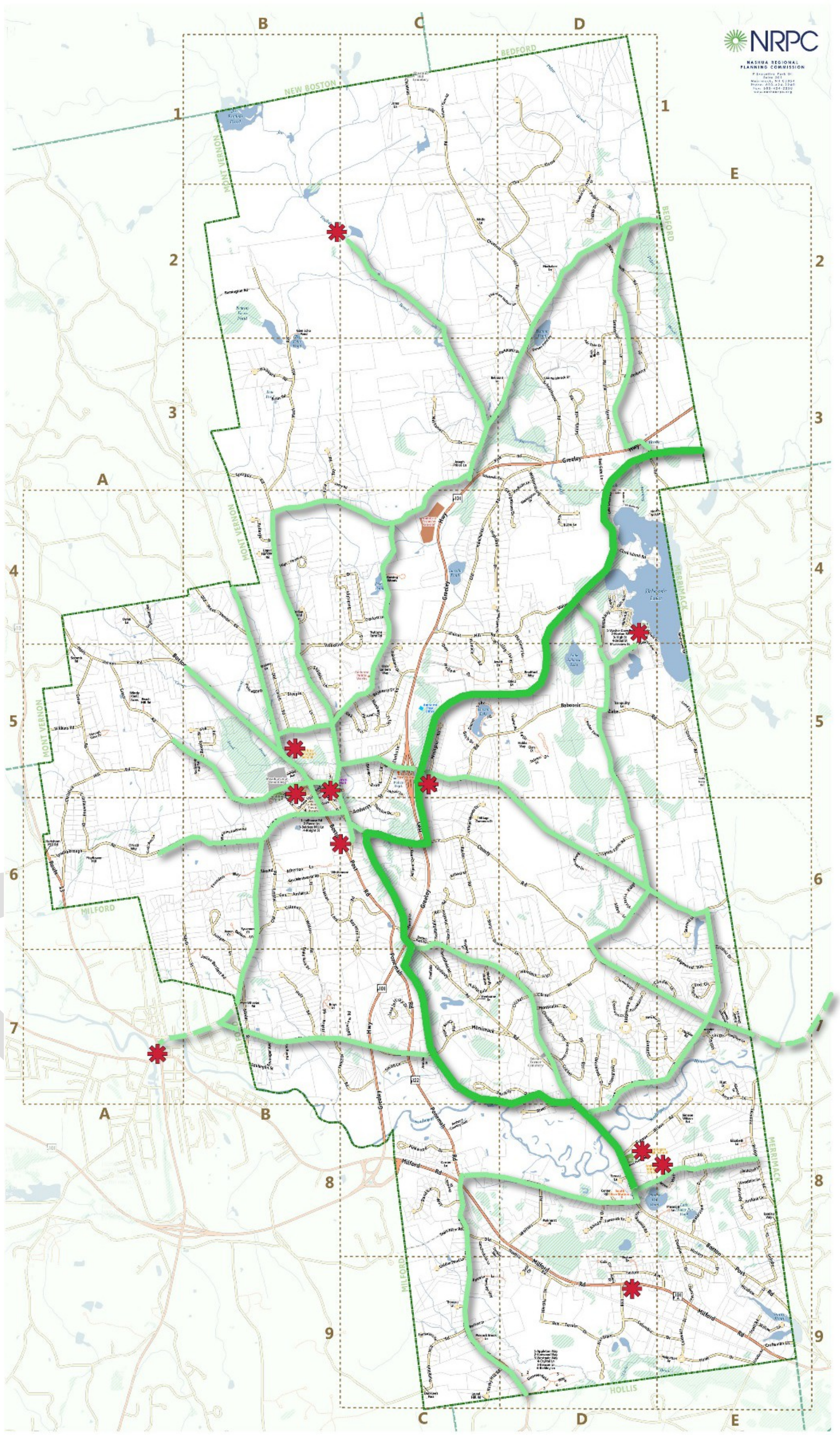


Figure 1
Destinations and routes identified by participants who attended public sessions in 2019

To learn more about bicycle and pedestrian safety, the Committee communicated with the Amherst Police Department. In the last 12 years, there were 36 reported automobile crashes involving a pedestrian, or a bicyclist. 19 of the 36 crashes occurred on a roadway, whereas the other 27 crashes occurred in a parking lot. 15 of the 19 roadway crashes took place on roads identified by survey respondents as having safety concerns. The following map visualizes the roads that were identified as presenting safety concerns, as well as the locations of automobile crashes involving pedestrians, or bicyclists.

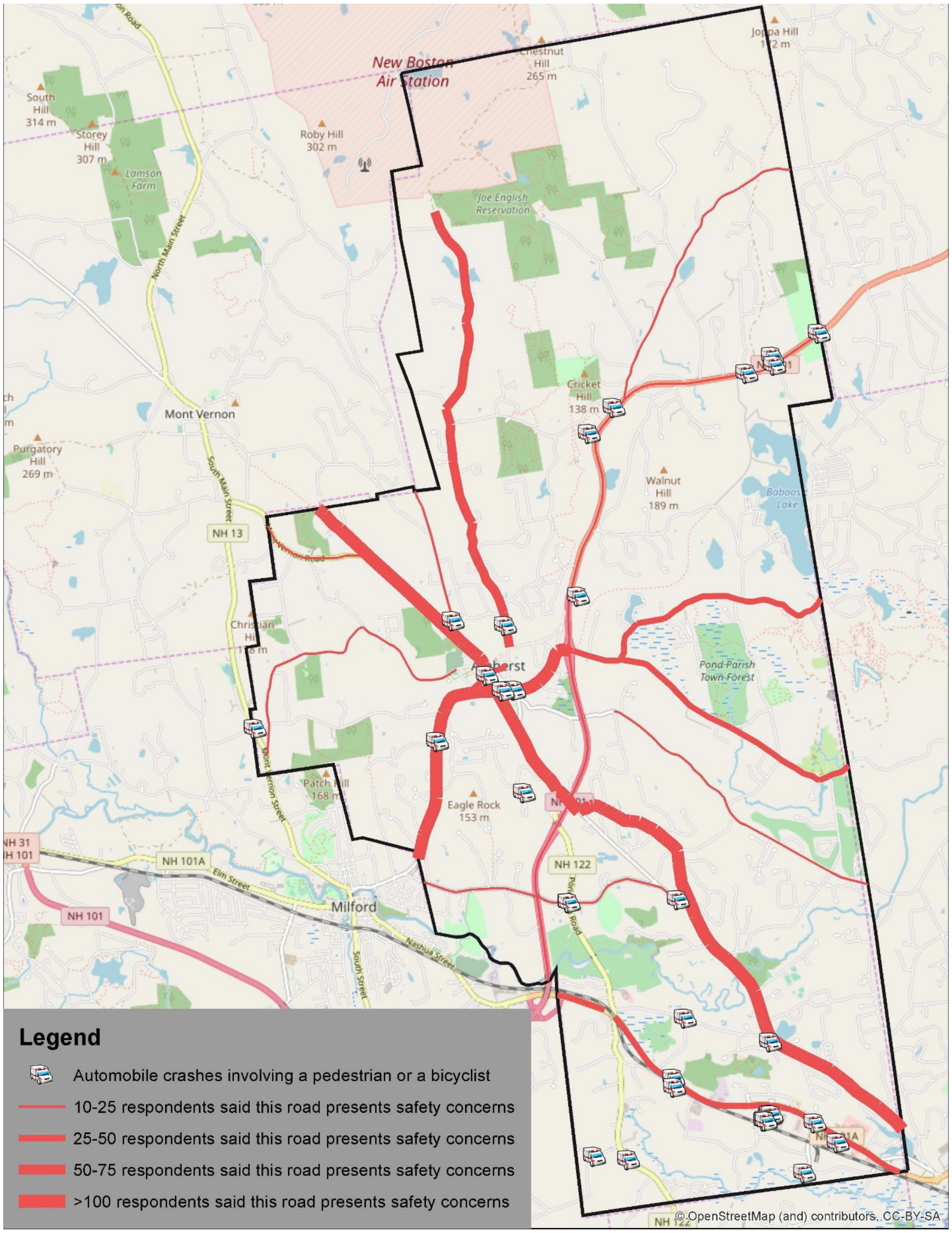


Figure 2

Bicycle-Pedestrian Transportation Survey results & Amherst Police Department crash records

In addition to the survey results, the Committee conducted infrared, video, tube, and manual counts to generate data on the use of roads and trails in Amherst. The tube counts were conducted by the New Hampshire Department of Transportation and the Nashua Regional Planning Commission. The Town partnered with the Nashua Regional Planning Commission to install infrared counting devices along sidewalks and at trailheads. By detecting heat, the device records the direction of travel and number users. An infrared device works at night and in the rain and snow. However, the device does not distinguish automobiles from bicycles and pedestrians when pointed towards traffic. The Town also collects data on the use of roads and trails with a video camera that is normally used to track animals for hunters. Commonly called a “game counter,” the camera detects motion and records a brief video. This technology captures multimodal travel at locations where automobiles would skew infrared counts. In parking lots and along roadways where automobile, bicycle, and pedestrian travel exist, the video camera provides accurate data acting as an alternative to infrared or manual counting. By employing different collection strategies, the Department is able to capture pedestrian and bicyclist data in 24-hour cycles and during inclement weather conditions. Public feedback and traffic data were used to formulate recommendations and inform the Committee throughout the planning process.

Tube Counter *Infrared “Game” Counter* *Manual Counting*

Figure 3
Traffic Counting Methods (Diamond Traffic Products 2019)

1.6 What Would Constitute the Successful Creation of a Town-wide Multimodal Network?

The town of Amherst is already home to 210 miles of roadways and 25+ miles of off-road trails, nearly all of this network can technically be used today by non-motorized users. However, after engaging with Amherst’s residents, most people do not consider these routes to be safe, multimodal spaces.

The primary reason for this is that our transportation network was constructed almost exclusively for vehicular use. Problems like this are hardly unique to the town of Amherst. For nearly 100 years, the car has dominated our roadways, and our roads have subsequently been built and re-built in a manner that reflects this singular use. A major consequence of this design practice is plainly visible—our roadways are too dangerous for non-motorized users, a sentiment clearly echoed by Amherst’s residents in our feedback sessions.

In the United States, the rate of children walking to school has plummeted from 50% (1960) to 10% (today), road cycling is limited to very few people, and non-motorized use of our roadways as a means for general transportation is virtually non-existent outside of major cities. Some might consider this “today’s reality” and concede that our roads are indeed for the exclusive use of motorized vehicles, but this need not be the case. Roadway user data has plainly indicated for decades that when roadways are designed to accommodate multimodal users safely and effectively, multimodal roadway users increase proportionally (Noland 1995). This was confirmed by respondents to the Bicycle/Pedestrian Advisory Committee’s 2017-2018 survey. Current residents consistently indicated that if our town’s transportation network were designed in a manner to accommodate multimodal use, they would use our roads multimodally.

In summary, Amherst has a network throughout the town, but this network fails to safely and comfortably accommodate our resident’s multimodal uses. This plan offers both on-road and off-road solutions to this problem, providing a *systematic safety* vision for all modes of transportation in our community.

1.6.1 Universal Connectivity

A network that is town-wide will consider multimodal treatments for *all* areas in town, not just a select few locations. While the primary goal of this network should be to seek *safety for all users as a key element of design,* the next-most important characteristic of this network should be its *ability to integrate places*. A town-wide network ought not require multimodal users to first drive to a location where they can then elect to use another mode of transportation. Rather, the network should seek to connect to all people, all areas, all points of interest, and with other towns.

1.6.2 Universal Usership

Consistent with the charter of the Bicycle Pedestrian Advisory Committee, the design of this network should incorporate users of all ages and experience levels (reference: Amherst Recreation Department’s “eight-to-eighty” campaign). Wherever possible, the network should be designed with consideration to accommodate these varied experience levels, various modes of non-motorized transportation, and persons with disabilities.

1.6.3 Multi-Functionality

Multimodal infrastructure should be constructed not just for the purpose of providing recreational/leisure space, but also for safe, non-motorized transportation. Many residents have indicated an interest in using various non-motorized means of getting from one part of town to another, and some people have no other way of personal transportation.

1.6.4 Consistency in Design

Multimodal transportation designs should be consistent in nature and in application. A network should not seek to be a collection of dissimilar pieces, but rather should seek to apply a collection of like, recognizable, and readable treatments across the entire town.

2 Engineering Systematic Safety into Roadway Design

The visual simplicity and ubiquity of our roadways can tempt many to conclude that roadway design is a simple concept, but transportation engineering can be significantly more complicated than meets the eye. In reality, modern transportation engineering is the product of a century of academic study, design evolution, and experimentation. This has led to the development of best practices for approaching various measures, including: efficiency, stormwater management, vehicular and multi-modal safety to name a few.

Many of today’s best practices for transportation design can be surprisingly counterintuitive. Sometimes, recommended solutions might appear outlandish or undesirable without understanding the rationale for their design. For this reason, it is imperative to include the following literature review that provides a vital foundation behind the desired outcomes from this report’s multimodal recommendations for town.

2.1 Driver Behavior as a Consequence of Road Design

Since the 1930’s our roadways in the United States have been designed with the primary mission of optimizing the flow of motorized vehicles efficiently across space, with little (if any) consideration of how to safely accommodate other modes of transportation. Such concepts have been such a low priority that it was not until December 2016 that the Federal Highway Administration (FHWA) published their first roadway design guide to consider non-motorized roadway treatments intended for use outside of highly-populated urban areas.

Figure 4
Bicycle infrastructure as an after-thought

It is vital to recognize that roadways which are designed solely for motor vehicles fail to accommodate the needs of multimodal users. In order to have roadways that effectively incorporate multimodal users, we must abandon the notion that all roadways are exclusive to motor vehicles; we must embrace the idea that our roadways should be designed to accommodate a variety of transportation modes–not just one.

Presented with conflicts between vulnerable road users and motor vehicles, cities across America have attempted to improve our motor vehicle-focused roadways with piecemeal road treatments. Often these amount to requests for drivers to be “safer” around multimodal users, all-the-meanwhile failing to make any substantive alterations in the way the roadways are designed. Rarely do these strategies amount to much more than a “band-aid” on an otherwise broken system—well-intentioned ideas with dubious efficacy and little practical application.

Figure 5
Shared Lane Marking aka "Sharrow"

An excellent example of this would be shared lane markings (aka "sharrows") that some municipalities have begun to install in an effort to improve bicycle safety (see **Figure 4**). These painted markings are applied to roadways that otherwise remain unchanged and continue to resemble any other motor vehicle-centered road. While such efforts are well-intentioned and seek to make drivers more aware of other transport modes, they fail to alter the motor vehicle-centered roadway in any substantive manner. This is done while simultaneously giving some cyclists the false impression that the roadway is somehow designed to accommodate their presence when no changes have been made to alter the character of the road. Consequently, the effects of installing shared lane markings have been shown to be questionable and even dangerous (Ferenchak and Marshall 2015).

In general, ideas like these fail to acknowledge some key topics which have surfaced in the transportation engineering community since the 1980's—that driver behavior is principally influenced by the manner in which a road is designed (Adams 1995). Considering this, if a road is fundamentally designed for motor vehicles, drivers will always understand the road as a space exclusively for motor vehicles, and thus will be less likely to accept, expect, and/or safely handle the presence of non-motorized users. **Indeed, drivers respond to the *way a road is engineered* above all else—far beyond the appeals of a road sign or the threat of a traffic stop**. So long as the way a road is engineered is one that resembles a space designed exclusively for motor vehicles, other attempts to influence driver behavior will have, at most, a minor or temporary impact (Vanderbilt 2009).

2.2 "Traffic Calming" without Considering the Psychology of a Roadway's Design

All too often we mistakenly assume that what makes our roadways dangerous (whether to motor-vehicles or multimodal users) is the behavior of "bad drivers" who are too reckless, absent-minded, ignorant, or distracted to drive safely. We assume that if only we can appeal to these drivers to drive more responsibly, we will have a safer community—meanwhile not recognizing that the design of the road itself is likely communicating to drivers that they should behave as they do.

In the past, the common engineering prescription for these "unsafe drivers" was to apply an arsenal of highway safety mechanisms to make the roads safer. Many of these design elements were borrowed from the so-called "traffic zone" (highways)—where they have been successfully implemented to increase safety on high speed roads—wider lanes with painted lines, segregation of multimodal users, forgiving shoulders, high curbs, signage, etc. The consequence of applying the "traffic world" onto local, rural streets (aka the "public zone") has resulted in a surprising and counterintuitive mix of results.

One consequence of this is that drivers began to behave in a manner consistent with the "traffic zone"—higher speeds, a greater sense of territory ("the space between the lines cars only"), and reliance on formal road cues which are misaligned with local realities. The design of all roadways, even those on local streets, have slowly become indistinguishable from the "traffic world." As noted in the book *Traffic* by Tom Vanderbilt, traffic engineers began to recognize this problem in the 1990s. Vanderbilt discussed this predicament in an interview with world-renowned traffic engineer Hans Monderman.

"When you built a street in the past in our villages, you could read the street in the village as a good book, it was as readable as a book. Here is the entrance to the village, over there is a school, maybe you can shop in that shop over there. There's a big farmyard and perhaps there's a tractor coming out. Then the traffic engineers came, and they changed it into an absolute uniform piece of space." (Vanderbilt 2009, 189)

According to engineers like Monderman, drivers no longer take cues from the context of their surroundings. Instead they are left to interpret the features of this "traffic zone." Features of our traffic experience that have become so commonplace that, according to traffic psychologists, "we don't see them anymore."

Suddenly, the village's road is just another segment of the highway passing through, with only a few small signs to tell anyone otherwise. This may be why speeding tickets are so common at the entrances to small towns all over the world. The road through the village so often feels the same as the road outside the village—the same width, the same shoulders. The speed limit has suddenly been cut in half, but the driver feels as if he or she is still driving the same road. That speeding ticket is cognitive dissonance (Vanderbilt 2009, 189).

Ironically, decades of traffic safety efforts have been emphasizing our roadway design as high-speed, single-purpose, and uniform. This practice is clearly at odds with the realities of the "public zone" they bisect.

Despite the way our roadways now appear, the contrasts between these two "zones" are striking; the traffic zone (such as a divided highway) serves a single purpose, is impersonal, and uniform. It is highly regulated by the state through rules, regulations, examination and legal enforcement and is, in theory, predictable. But the qualities that we most associate with a local public zone are exactly the opposite. Neighborhood roads accommodate a multitude of simultaneous functions. They are highly diverse and are governed by a complex web of ever-evolving social and cultural conventions. Village roads are unpredictable, and the best and richest environments offer surprise, serendipity, and ambiguity. The traffic zone is not a place for anything but the movement of traffic, and segregation is usually appropriate. But this is inaccurate and unrealistic in local contexts, as traffic can also coexist with other social activities within the public realm, *so long as the cultural messages that govern human behavior are made explicit by the roadway design itself. The driver must become a citizen of the space. But for this to work, the transition between the two worlds needs to be made clear* (see **Section 3.5** Special Roadway Districts on page 43) (Hamilton-Baillie and Jones 2005).

The 'Public Zone' *Rural Roads/Neighborhoods/Downtowns*	**The 'Traffic Zone'** *Major Roadways/Highways*
Culturally Defined Personal Spatial Multi-Purpose Constantly Changing Unpredictable Contextual Cultural and Social Rules Eye Contact	Regulated Impersonal Linear Single Purpose Consistent Predictable Systematic State-controlled Signs and Markings

Table 1
Defining Characteristics of the 'Public Zone' vs. the 'Traffic Zone' (Engwicht 2005)

Considering the powerful influence that roadway design has on drivers, it is vital to consider the roadway features that are truly emphasized by road itself—even features that we closely associate with safety such as lane width, sight-distance, intersection controls, or painted lines.

"If you build a road that's wide, has a lot of sight distance, has a large median, large shoulders, and the driver feels safe, they're going to go fast, it doesn't matter what speed limit or sign you have. In fact, the engineers who built that road seduced the driver to go that fast"
Tom Granda, United States Federal Highway Administration.

But those same means of "seduction"—the wide roads, the generous lane widths, the capacious sight distances, the large medians and shoulders—are the same things that are theoretically meant to ensure the driver's safety (Vanderbilt 2009). Acknowledging this dilemma is the concept of "Risk Compensation," the notion that when drivers feel the roadway is "safe" they are more likely to "consume" that additional safety apparently afforded by the roadway, resulting in actually more dangerous behavior on the part of drivers. Counter-intuitively, in public zone contexts, it is much safer to instill a reasonable sense of discomfort and risk into drivers—a feeling that accurately reflects the risk of driving a 4,000 lb. machine through a public place with vulnerable users. By designing it into the roadway design itself, this feeling of mild discomfort can result in surprisingly effective results, forcing drivers to be more alert and engaged in their surroundings out of a feeling of necessity (Adams 1995).

2.3 Engineering Psychology into Roadway Design

Good design, whether in industry or in transportation, generally arises from an item's ability to communicate human-centric properties. The general public should be able to interact with an object and naturally infer how to interact with it (discoverability) and receive some prompt from the object to reinforce that innate impression (feedback). This should be accomplished by the design of the item itself, and not rely on supplementary instructions (Norman 2002). This certainly applies to the design of our roadways, which should communicate the expectations and realities of the road by design. This can be done in a manner that, when prompted by the roadway's design, drivers are *automatically compelled* to engage with the environment appropriately. If the roadway is in this manner, desired driver behavior can be achieved almost universally as they tend to feel the roadway itself gives them no alternative. This is far more effective than relying upon drivers' "good nature," judgement, skills, education, or mood (Adams 1995). The Federal Highway Administration refers to this utilization of the geometric design of the roadway itself to compel the driver to react appropriately as **self-explaining** or **self-enforcing roadways** (Federal Highway Administration 2018).

Generally, self-explaining roadways seek to communicate the realities of the local area to drivers, as opposed to relying on signals from traditional highway furniture. They rely on a combination of physical and psychological means of compelling drivers to interpret particular messages, usually with the goals of automatically reducing speed and greater alertness. These designs are often installed with the expressed intent of eliciting discomfort in the driver by, for example, feeling as though the roadway is too narrow to fit their car at high speeds. Other examples use alternative pavement types to distinguish particular roadways from their surroundings, optical illusions using different color shoulder materials, and the elimination of comfort-inducing lane markings.

It might normally seem preposterous to intentionally design roadways to result in driver discomfort, but after considering the real risks associated with driving heavy vehicles amongst vulnerable road users, this is precisely the feeling drivers should have on certain types of roads.

The design recommendations provided by this report (see section 3 Multimodal Roadway Recommendations below) were selected for their utilization of many self-enforcing principles.

2.3.1 Examples of Self-Enforcing Roadway Designs

Transportation engineer Joost Váhl, a pioneer of psychological traffic techniques once highlighted the counterintuitive nature of self-enforcing traffic calming techniques, stating that 'the only way to make a traffic junction safe, is to make it (feel) dangerous!' Such a statement can be aimed both at the desired perception by drivers as they approach and at the realities of conflict between vehicles and vulnerable road users (Hamilton-Baillie and Jones 2005).

Figure 6
Flat, painted optical illusion as a crosswalk in Ísafjörður, Iceland

Figure 7
"Pedestrian crosswalk signs" likely have much higher effect on influencing driver behavior not because of the words on the sign, but because their placement in the roadway leads drivers to feel they may collide with the sign.

In general, drivers react more consistently to circumstances that convey a personal threat, and many self-enforcing roadway designs incorporate a driver's instinct for self-preservation to trigger a reaction that yields safer behavior. This notion is embodied by the concept of *risk compensation* in transportation psychology (Adams 1995). A general overview of some self-enforcing concepts and designs are provided below.

2.3.1 a Physical Narrowing

Different traffic lanes widths correspond to different travel speeds. A typical lane width is 10 feet, which comfortably supports speeds of 35 mph. A typical highway lane width is 12 feet, which comfortably supports speeds of 70 mph. Drivers instinctively understand the connection between lane width and permissible driving speed, and consistently speed up when presented with wider lanes, even in non-highway locations (Speck 2014). Put bluntly by the Texas Transportation Institute, "Higher speeds should be expected with greater lane widths" (Fitzpatrick, et al. 2000). By reducing physical lane width to the lower standard widths suggested by the AASHTO Green Book and the FHWA, it has a measurable reduction in road speeds, as seen below.

Reduction in Free-Flow Speed				
Lane width	***Shoulder Width***			
	≥0<2 ft	***≥2<4 ft***	***≥4<6 ft***	***≥6 ft***
9<10 ft	6.4 mph	4.8 mph	3.5 mph	2.2 mph
≥10<11 ft	5.3 mph	3.7 mph	2.4 mph	1.1 mph
≥11<12 ft	4.7 mph	3.0 mph	1.7 mph	0.4 mph
>12 ft	4.2 mph	2.6 mph	1.3 mph	0.0 mph

Table 2
Reduction in Free-Flow Speed (Federal Highway Administration 2014)

2.3.1 b Visual Narrowing

Road surface modifications can be used to make a roadway look narrower than it is. This is called visual narrowing, which reduces the *perceived* space in which vehicles can drive, resulting an intuitive reduction in speed (Saviskas 2016). Though the roadway surface can be wide enough for two large trucks to pass each other, the road *appears* as though it is uncomfortably narrow and consistently results in speed reduction (Kennedy, et al. 2005).

This technique can even be combined with physical narrowing to yield the most powerful result. By physically narrowing lane widths to the minimum, and then applying a colored edge to the road surface, drivers feel there is insufficient width for two cars to safely pass each other, resulting in further reduction of speed (Ewing 2009).

Figure 8
Before/after mock-up from a visual narrowing study using colored shoulders (Kennedy, et al. 2005)

2.3.1 c *Road Surfaces: Tactile and Auditory Feedback*

Alternative road surfaces can have a profound effect on the way drivers behave across an area. Several studies have been conducted which indicate that road surfaces such as brick, cobblestone, or interlocking pavers produce several measurable results. The perception of an uneven surface helps to slow down drivers, something that is further enforced by the vibration and auditory feedback of the roadway (Federal Highway Administration 2006). These types of paving surfaces have been shown to reduce traffic speeds by 2.5–4.5 mph, compared with speeds on asphalt surfaces (Bradbury, et al. 2007). This is especially noteworthy as the road surface applies this traffic calming effect *across the entire area* where these surfaces exist. This is especially useful when used to demarcate “special districts” (see **Section 3.5 Special Roadway Districts** below) or in known conflict areas. By creating visual interest in the roadway surface, studies indicate that there is an intuitive signal to drivers “that something is different about this area” and results a measurably safer result (Bradbury, et al. 2007).

Figure 9
Textured street materials used for traffic calming at Market Square in Pittsburgh

2.3.1 d *Edge Friction*

By placing nearby vertical elements in a driver’s peripheral vision such as trees or lamps, visual cues act as a means of articulating a driver’s speed. The more activities and areas of interest happening in the peripheral vision of a driver, the more they slow down to absorb that information. The closer the activities are brought to drivers, the greater reduction in “traffic zone” properties. These could include benches, trees, bicycle racks, bollards, and public art (Saviskas 2016).

2.3.1 e *Reduction of Linear Sight Lines*

Research has indicated that there is a relationship between linear sight lines and speeds. The more straight a roadway seems and the farther ahead a driver can focus, the faster they are likely to drive (Department for Transport 2007). This can be reduced by occasionally breaking up the appearance of the roadway in important areas (crossings, intersections, etc.) reducing speeds and forcing the driver's attention away from the horizon and towards they area in which they are (Marceau, Bradbury and Halcrow 2007).

Figure 10
Road Surface Coloring to Reduce Linearity

2.3.1 f *Horizontal Deflections*

The installation of horizontal deflections causes drivers to slow due to a need to navigate physical curve in the roadway. The most common forms of this are *roundabouts* and *chicanes*.

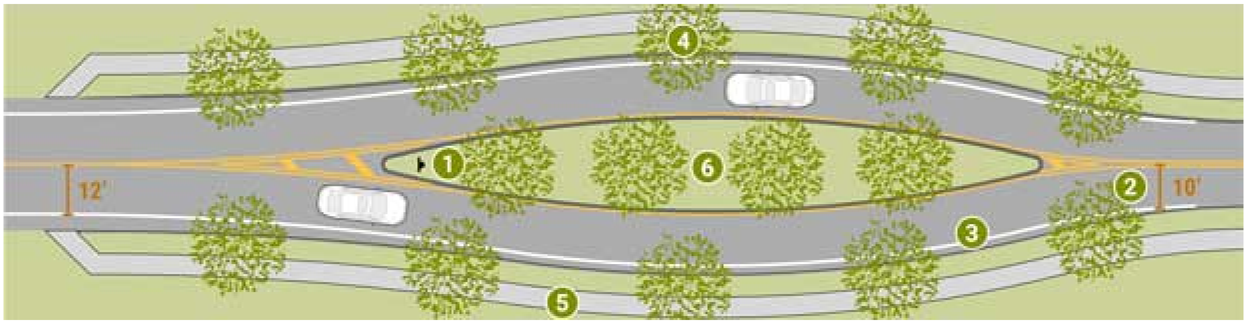


Figure 11
A horizontal deflection as a gateway treatment with lane narrowing

2.3.1 g *Vertical Deflections*

The use of vertical deflections causes drivers to reduce speeds by physically raising the roadway. The raising of entire intersections and crossings can be very effective in reducing speeds in pivotal conflict areas (National Association of City Transportation Officials 2013).

The use of "speed bumps" as a general speed reduction mechanism should be discouraged, as they can be a hazard to cyclists, are viewed as "punitive" by drivers and thus encourage resentment. Punitive traffic calming techniques such as speed bumps have a very limited effect on speeds over distance as drivers tend to "make up" for reduced speed within 100 feet, often with an overall higher speed than before (Vanderbilt 2009).

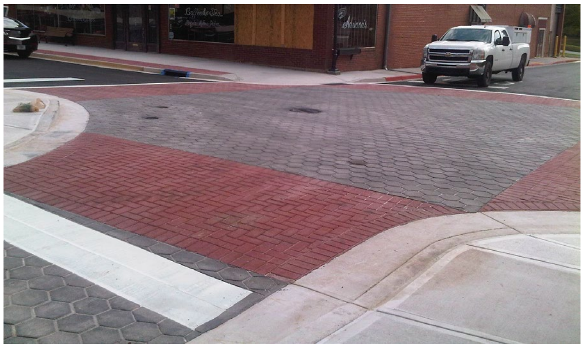


Figure 12
A Raised Intersection

Figure 13
A Raised Crossing

2.3.1 h Small Corner Radii

By reducing the corner radius at an intersection, drivers must slow down as they turn. It is essential to minimize the size of corner radii for the safety of vulnerable users, as intersections are consistently the most dangerous place for conflict. Small corner radii also yield more safety by reducing the range drivers have to look in order to see vulnerable road users. There is no consensus on the most appropriate corner radius (Saviskas 2016). According to NACTO's Urban Street Design Guide, standard corner radii are 10–15 feet, but many cities use corner radii as small as 2 feet (National Association of City Transportation Officials 2013).

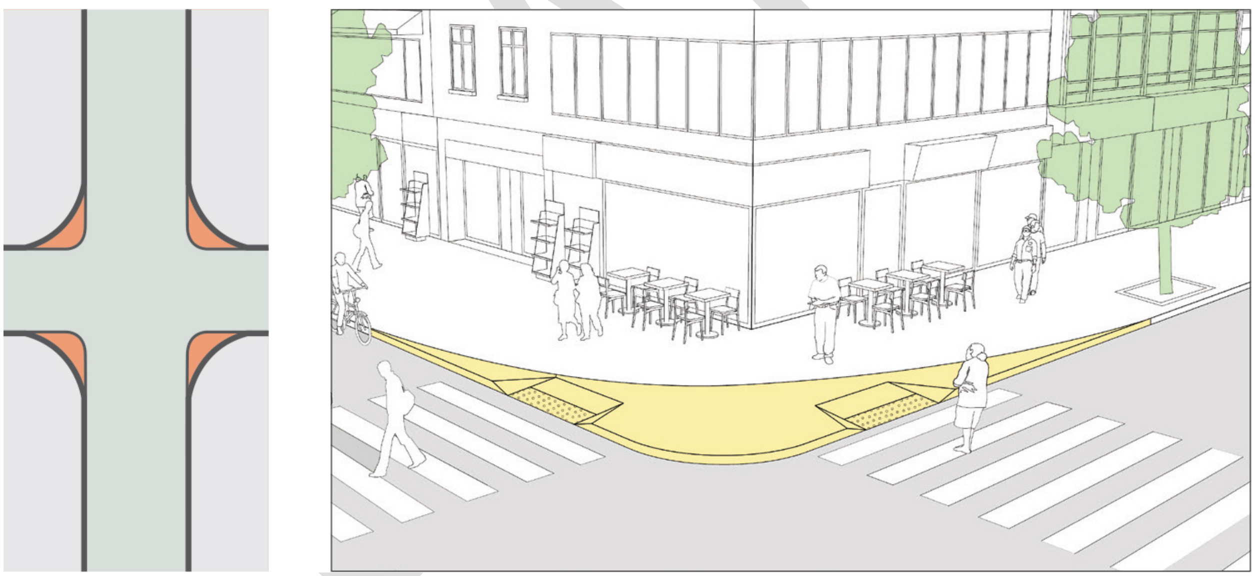


Figure 14
Reducing Corner Radii (Marked in Red and Yellow) (National Association of City Transportation Officials 2013)

2.3.1 i *Removal of Superfluous Highway Furniture*

Figure 15
Traffic signs have little effect on driver behavior

The use of painted center lines, edge markings, and other road paint can be a significant factor in determining the road character and resulting speeds. Painted lines are a defining characteristic of the "traffic zone." Originally used on highways to aide drivers to exercise spatial judgment at speed; their removal leads drivers to react to the feeling of uncertainty. Though no physical changes have been made to the roadway, drivers tend to assume they may impede into other cars' space. The removal or omission of center lines has already been trialed and tested by highway authorities, and the relationship with speed reduction has been shown to be positive (Cooper and Wrigght 2014). Painted lines also tend to give drivers a sense of "territory" leading to more dangerous reactions when other road users are found on the roadway (Vanderbilt 2009). The use or omission of road markings can be exploited as a useful transition between higher and lower design speed areas, such as on the entrances to special roadway districts (Marceau, Bradbury and Halcrow 2007). Painted lines are often applied at the request of well-intentioned residents to "enhance safety" of neighborhood streets, but their accelerating properties are fairly counterintuitive—consequently, municipalities often install them to appease residents even if they are not warranted. (Vanderbilt 2009).

The superfluous use of signage should be discouraged for similar reasons. Navigating public spaces should be conveying a message that drivers ought not to be reading signage and relying on their messages, but rather to keep their eyes on the roadway in anticipation of the unpredictable events that unfold in public spaces (Vanderbilt 2009). The Federal Highway Administration's Manual on Uniform Traffic Control Devices sets a standard that signage should generally be minimized. "Regulatory and warning signs should be used conservatively because these signs, if used to excess, tend to lose their effectiveness (Federal Highway Administration 2009, 2A.04)." Furthermore, excess signage or non-compliant signage should be removed, as "Design, application, and placement of traffic control devices other than those adopted in this Manual shall be prohibited unless the provisions of this Section are followed (Federal Highway Administration 2009, 1A.10)" and "Information of a less critical nature should be moved to less critical locations or omitted (Federal Highway Administration 2009, 2A.16)."

2.4 Systematic Safety: Designing our Roadways According to Naturally-Occurring Categories

Systematic safety is a fundamentally proactive approach by systematically eliminating the opportunities that create high crash and injury risk. Our traffic safety problems stem from two inherent human properties: (1) humans are vulnerable and (2) humans make mistakes, whether inadvertently or knowingly. If everybody obeyed every traffic law all the time, there would be very few crashes. But this is simply not reality. ***"A system that is made safe only if people don't make mistakes is not a system that is made for humans*** (Furth and Wagenbuur 2017).***"*** A systematic safety approach to road design recognizes these fundamental human properties and builds them into the roadway network proactively. By proactively building these designs into the network over time, the entire network will eventually exhibit systematic safety properties.

There is a maximum safe speed for every type of conflict on the roadway. For vulnerable road users, three separate datasets show a similar pattern in fatality risk. The risk increases slowly until impact speeds of around 30 mph. Above this speed, risk of fatal injury increases rapidly – the increase is between 3.5 and 5.5 times from 30 mph to 40 mph (See **Figure 14** below). For passengers in motor vehicles, fatality rates increase dramatically at approximately 50 mph (See **Figure 15** below), though side impact figures indicate even greater risk at lower speeds. These data provide general categories of roadways, each with their own design needs in order to minimize safety risks.

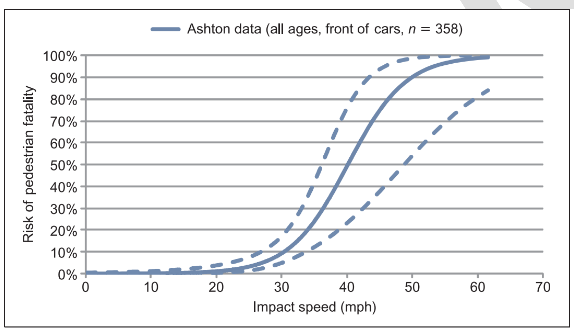


Figure 16
Risk of pedestrian fatality calculated using logistic regression from Ashton and Mackay data (Richards 2010, 12)

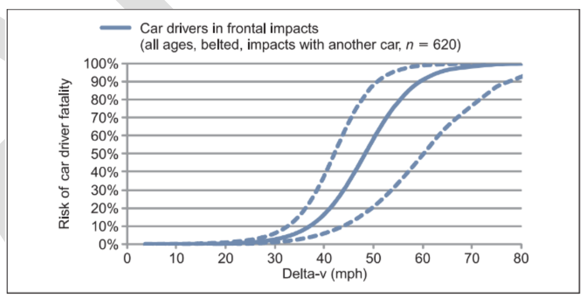


Figure 17
Risk of car driver fatality calculated using logistic regression from the OTS and CCIS dataset (Richards 2010, 22)

This systematic safety approach utilizes commonly accepted safety data to inform a categorization of road types and their appropriate corresponding design. The underlying concept of all designs will be that ***roads should be designed either to separate users so that conflicts do not occur, or else to limit traffic speed based on the conflicts that will occur*** (P. G. Furth 2009)**.**

Where vulnerable road users are more commonly found and may cross the street anywhere or act in an unpredictable manner, the target speed achieved by the road design should be less than 30 mph (optimally, 20 mph or below) as at higher speeds, the chance of surviving a collision falls rapidly. At the upper limit, road design should separate vehicles from vehicles by direction, based on the physical limitations of vehicles to absorb energy from head-on collisions without resulting in fatality (Furth and Wagenbuur 2017).

When considering the above data regarding the relationship between speed and safety risk, there are effectively three categories that emerge from the data:

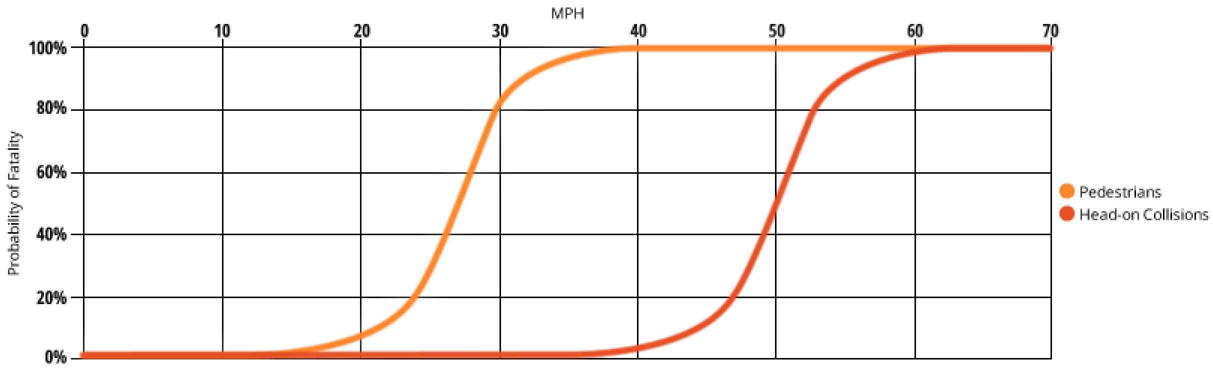


Figure 18

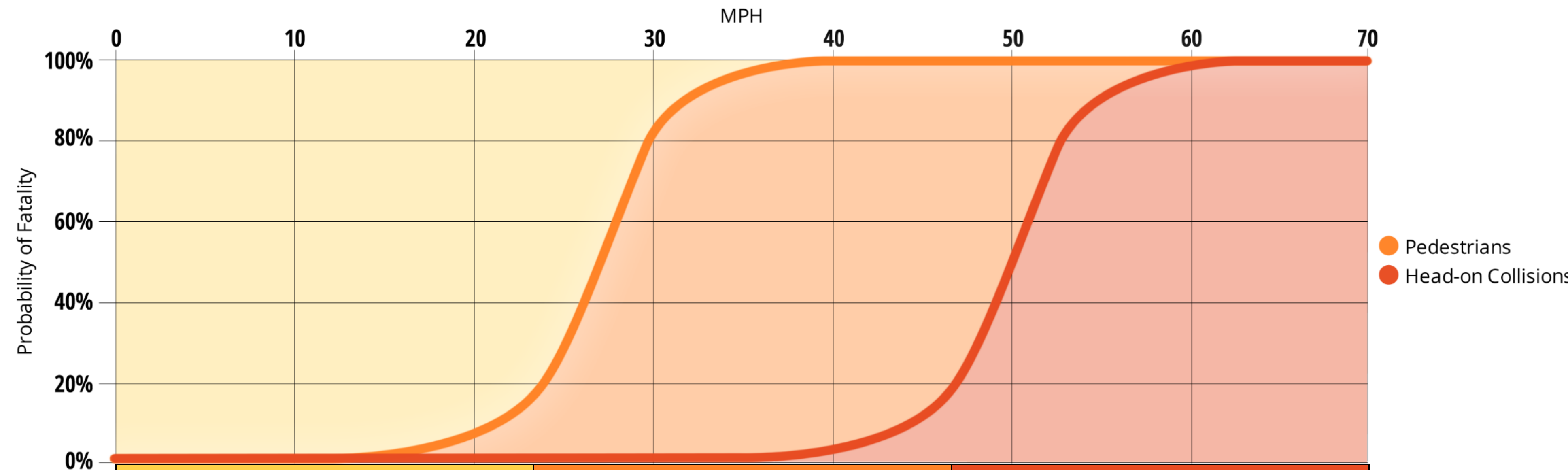
Wramborg's model for fatality probability vs. vehicle collision speeds (abridged) (Jurewicz, et al. 2016)

- Low speed/low volume roads in which motor vehicles and multimodal users may safely mix so long as the design speed of the roadway is kept to permanently enforce speed below ~30 mph
- Medium speed/higher volume roads in which motor vehicles and multimodal user should be segregated due to risk of serious injury/death in the event of a collision
- High speed roads in which motor vehicles should be segregated from multimodal users *and* motor vehicles (by direction) due to risk of serious injury/death in the event of a head-on collision

Each of these categories have unique needs and appropriate designs in order to maximize safety for all users. These categories are arranged below to illustrate their corresponding recommended designs and the rationale that informs their selection. Section 3 Multimodal Roadway Recommendations below will describe the recommended roadway designs for each category and their specific attributes in detail.

2.5 Systematic Safety Road Categorization Table

In order to clearly articulate the committee's vision for a systematic safety approach to self-enforcing roadway design, each roadway design recommendation is organized into the following table. This table separates road categories according to *Wramborg's model for fatality probability vs. vehicle collision speeds*[1], and describes the recommended roadway treatments (along with their desired characteristics) for each corresponding category.



		Local Roads	***Connecting Streets***	***Highways***
Roadway Characteristics	Actual Speed[2]	~30 mph and below[3]	~30 mph to ~50 mph[4]	~50 mph and above[5]
	Volume	~5000 ADT and below[6,7]	~5000 ADT and above[6,8]	Irrelevant
Desired Interpretation by Drivers		Discomfort, Sense of Unpredictability, Caution, Forced-Engagement (reflect the realities of local roads)	Some predictability, some uniformity (on the open roadway). Caution and Discomfort at Intersections/ Crossings.	Predictability, Uniformity
Vulnerable Road Users	Method of Protection	Permanent speed limitation through roadway design (Psychological traffic calming, Physical Traffic Calming)[9]	Permanent speed limitation through design (primarily lane narrowing), additional measures especially at conflict points (intersections and crossings) [10]	Wide margins and/or physical barriers
	Placement	Integrated	Segregated (except at crossings)	Entirely Segregated
Recommended Treatment		Enhanced Shoulders or Advisory Shoulders	Sidepath	Separated travel lanes (by direction) with sidepath[11]

[1] (Jurewicz, et al. 2016)
[2] Actual speeds of motor vehicles, not necessarily "posted speed limits"
[3] (Richards 2010, 12), even lower speeds preferred wherever possible (18-25 mph optimal)
[4] (Richards 2010, 12), (Richards 2010, 22), and (Furth and Wagenbuur 2017)
[5] (Richards 2010, 22) and (Furth and Wagenbuur 2017)
[6] ADT = "Average Daily Traffic"
[7] (Williams, Advisory Bicycle Lane Design Guide 2018, 5)
[8] Volume can be lower depending on use, ~4200 ADT
[9] (Hamilton-Baillie and Jones 2005)
[10] (Hamilton-Baillie and Jones 2005)
[11] With additional physical protections including barriers and very wide separation

3 Multimodal Roadway Recommendations

Four multimodal roadway treatments have been selected for their ability to safely apply self-enforcing properties to each category of road type. Details regarding the designs of these treatments can be found below.

Space defined for multimodal users will be found throughout these different treatments, and it is strongly recommended designs be applied with consistency. One example of this application would be the use of FHWA color *terra cotta* to be applied universally for multimodal space.

Consistency in design is vital across application for several reasons but is most useful for its ability to define multimodal space from traditional road space.

Figure 19
Hot-mix terra cotta asphalt colorant

3.1 Local Roads

In a systematic safety context, local roads are defined by their ability to safely mix vehicular and non-vehicular traffic at low speeds. These roads are generally characterized by their lower vehicular traffic volumes and (comparatively) higher volumes of multimodal users. The upper limit of this category is defined by exponentially higher risk of death in a collision between a vehicle and a vulnerable road user at ~30 mph. Consequently, local roads are specifically defined by vehicular traffic speeds of *~30 mph and below* and volumes of *~5000 Average Daily Traffic (ADT) and below*.

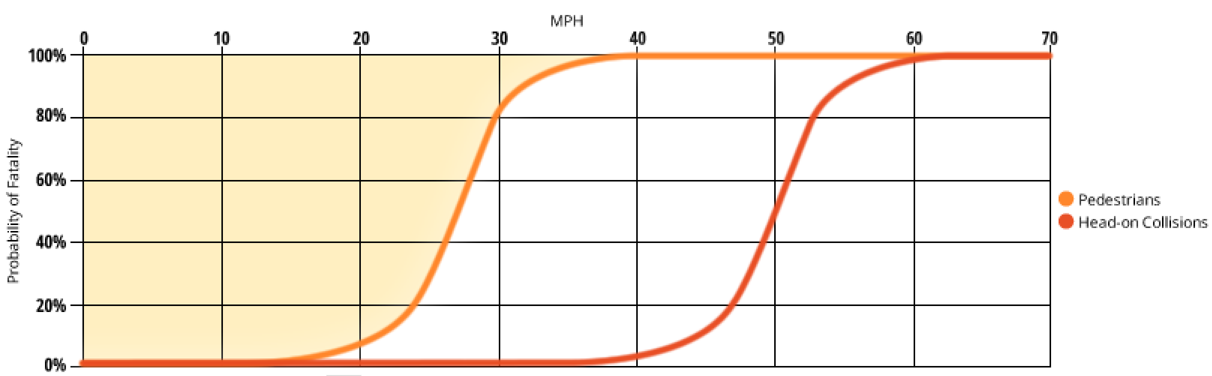


Figure 20
Wramborg's model for fatality probability vs. vehicle collision speeds, with the "local roads" category highlighted in yellow (Jurewicz, et al. 2016)

On these roads it is unnecessary and impractical to segregate motor vehicles from vulnerable road users. Segregating away vulnerable road users also conveys a message to drivers: "the roadway is for you" which results in several negative outcomes. As drivers behave in a manner primarily prompted by the design of the roadway, successful design of these roadways must clearly define themselves as different than conventional motor vehicle-dominant roads.

It is crucial to reduce the road's emphasis of the formal traffic world in these contexts. Formal roadway rules, while imperative on other categories of roadways, do not accurately reflect the reality of local roads. Multimodal users are unlikely to adhere to most highway conventions and the roadway must instill this unpredictability. Failure to emphasize the unpredictability of local streets through overemphasis of highway infrastructure results in a dangerous gap between driver expectations and reality. Drivers must receive their cues from the roadway and other road users, not from formal highway furniture (such as signage, wide lanes, center lane lines, etc.). View every element of the formal traffic world as an attack on the intended roadway design itself, and reserve their installation for only when it is absolutely unavoidable. The driver must feel as though they have no choice but to be engaged and alert, and the comforts normally afforded them by signs, lines, and wide margins for error must be stripped away. In a sense, motor vehicles should feel like a "guest" on these roadways, much like they are in reality.

Figure 21
Advisory Shoulders

In order to achieve these design goals, "Enhanced Shoulder" or "Advisory Shoulder" designs are selected and recommended for this category of roadway.

3.1.1 Enhanced Shoulder

The enhanced shoulder design, sometimes called "colored shoulders" is a roadway design that takes existing road design and by using visual traffic calming techniques, enshrines the areas already utilized by multimodal users. This design is largely defined by its lack of any painted lane markings and terra cotta-colored edges. Technically, none of these design elements are MUTCD traffic control devices, therefore the regulatory perspective and use of this roadway is completely identical to conventional roadways.

By changing the shoulders of the roadway to a darker color, there is also a significant psychological traffic calming effect, as the roadway seems to appear much narrower. Despite the roadway being exactly as wide as any conventional road, the absence of center lines and the optical illusion of the coloring results in an obvious change in driver behavior. Furthermore, the absence of painted center lines allow drivers to more comfortably provide a wider birth to multimodal users while passing.

It is strongly recommended that when asphalt is installed, hot mix asphalt colorant be utilized as it tends to color the surface for the life of the asphalt, as opposed to surface-applied paints, which tend to require regular maintenance.

3.1.1 a Key Design Features

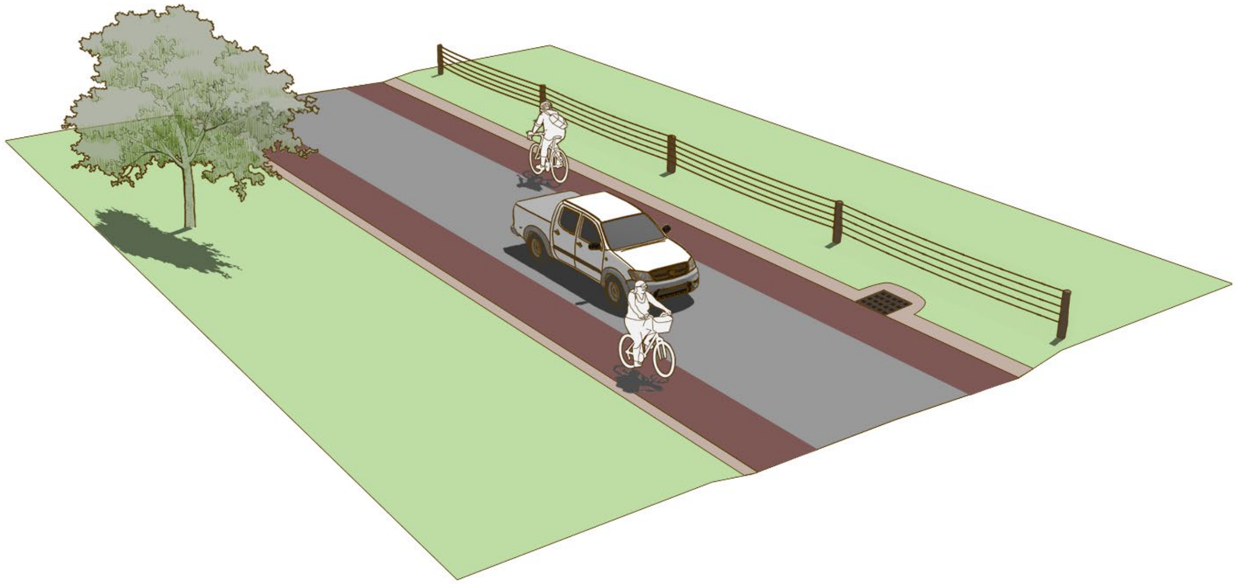


Figure 22

Enhanced Shoulders (Federal Highway Administration 2016) – image modified to mirror recommendations

Design Attributes	
Attribute	**Description**
Roadway Category	Local Road
Volume	~5,000 ADT and below
Actual Speeds	30 mph and below, preferred 25 mph and below
Layout	Standard roadway design with colored shoulders
Total Roadway footprint	18-24 ft wide
Self-enforcing speed mitigation	Significant visual narrowing of the roadway
Context of emphasis	Public zone
Signage	Discouraged, only use when required. Temporary use of MUTCD W6-3 and MUTCD W8-12 reasonable after initial installation
Painted lines	Incompatible by design
Intersection treatments	Special treatments not required, maintain traffic calming throughout intersections
Traffic control devices	Design uses none
Desired interpretation by drivers	Discomfort, Sense of Unpredictability, Caution, Forced-Engagement (reflect the realities of local roads)
Accessibility	Required to meet guidelines

Continued below…

Multimodal Space	
Attribute	**Description**
Separation	Visual (by coloring), expected to be shared by vehicles as needed
Width	No standard. Recommended at least 4 ft wide
Color	FHWA Terra Cotta. Technically “aesthetic treatment” to provide visual differentiation of the shoulder from the vehicular space (AASHTO Green Book 2011, p. 4-13).
Color application method	Recommended hot-mix asphalt colorant over conventional paint (Significant price savings, color lasts the life of the asphalt)
Treatment at crossings	N/A
Vehicular Space	
Attribute	**Description**
Width	No standard. Variable. 10-18 ft
Color	None
Sight Distance	Requires assessment of route
Separation by direction	No
Other Roadway Features	
Attribute	**Description**
Curbing	Discouraged, creates an egress obstacle to multimodal users
Storm Drain Placement	Out of multimodal space, or with wheel-friendly grates (Federal Highway Administration 2006)
Guardrail Placement	N/A
Landscaping	N/A

3.1.2 Advisory Shoulder

An advisory shoulder (sometimes called advisory bicycle lane) is a roadway striping configuration which provides for two-way motor vehicle and multimodal traffic using a central travel lane and “advisory” shoulders on either side. The center lane is dedicated to, and shared by, motorists traveling in both directions. Unlike colored shoulders, advisory shoulders utilize a dashed white line along the vehicular travel lane, and therefore utilizes a regulatory traffic control device, altering the rules of the roadway. Consequently, multimodal users are given preference in the advisory shoulders, but motorists can move into the advisory lanes in order to pass other road users after yielding.

Though use of such a design might seem impossible to those unfamiliar with the concepts of *risk compensation* and *psychological traffic calming*, it has demonstrated its effectiveness for decades in numerous places, including successful installations in United States and even New Hampshire. The advisory lane concept originated in the Netherlands where they have decades and many kilometers of experience with this facility since the 1890s (Williams, Advisory Bicycle Lanes – Reality Versus Design Guidance 2017).

It is strongly recommended that when asphalt is installed, hot mix asphalt colorant be utilized as it tends to color the surface for the life of the asphalt, as opposed to surface-applied paints, which tend to require regular maintenance.

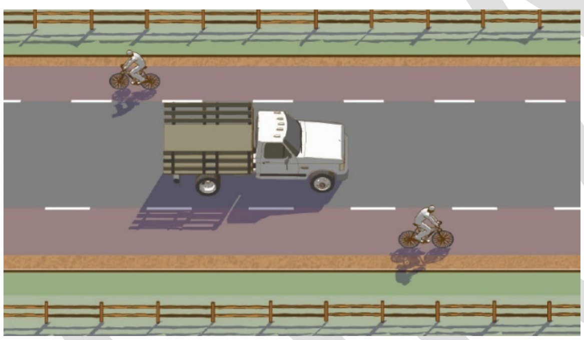


Figure 23
Motorists travel in the center two-way travel lane. When passing a bicyclist, no lane change is necessary (Federal Highway Administration 2016).

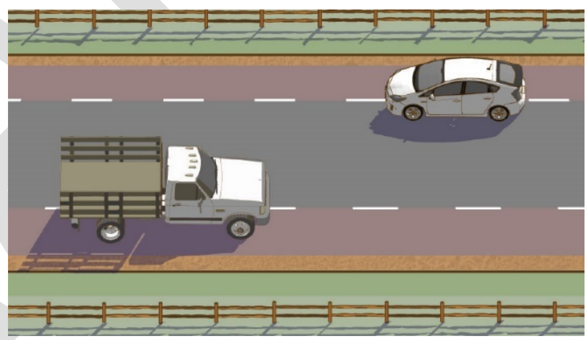


Figure 24
When two motor vehicles meet, motorists may need to encroach into the advisory shoulder’s multimodal space (Federal Highway Administration 2016).

3.1.2 a Key Design Features

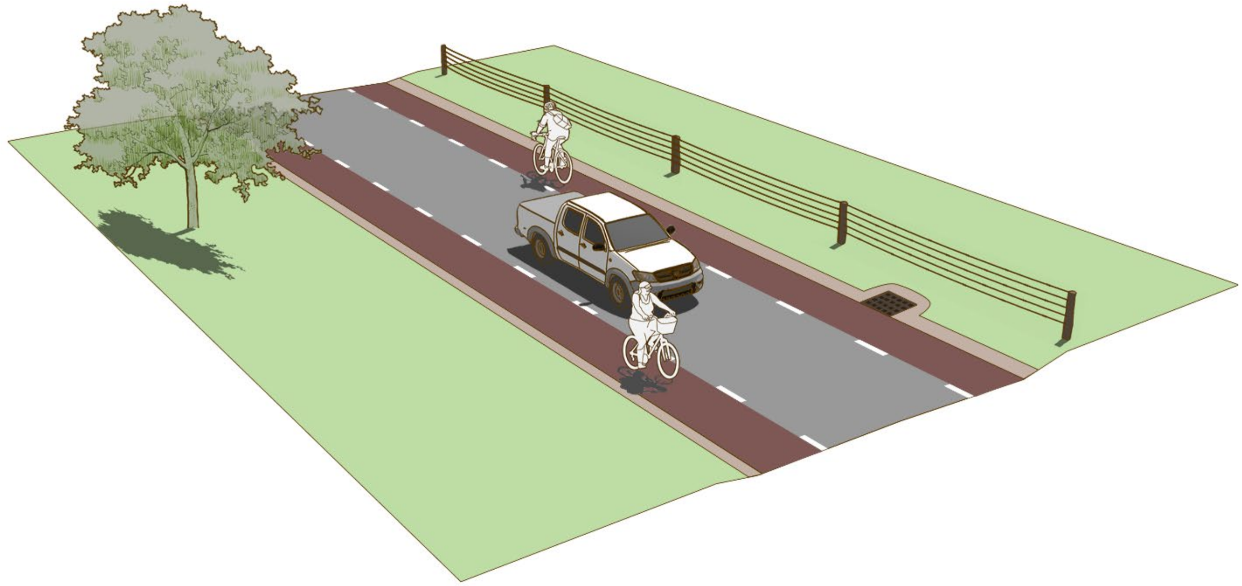


Figure 25
Advisory Shoulders (Federal Highway Administration 2016) – image modified to mirror recommendations

Design Attributes	
Attribute	**Description**
Roadway Category	Local Road
Volume	~5,000 ADT and below
Actual Speeds	30 mph and below, preferred 25 mph and below
Layout	Two-way center lane separated from advisory shoulders (preferential lanes) by a broken lane line
Total Roadway footprint	17-24.5 ft wide
Self-enforcing speed mitigation	Significant visual narrowing of the roadway
Context of emphasis	Public zone
Signage	Discouraged, only use when required. Temporary use of MUTCD W6-3 and MUTCD W8-12 reasonable after initial installation
Painted lines	Broken lane line used to delineate the advisory shoulder should consist of 3 ft line segments and 6 ft gaps.
Intersection treatments	Special treatments not required, maintain traffic calming throughout intersections, termination of advisory shoulders prior to intersection to be considered
Traffic control devices	Yes. Consider FHWA request to experiment for first application.
Desired interpretation by drivers	Discomfort, Sense of Unpredictability, Caution, Forced-Engagement (reflect the realities of local roads)
Accessibility	Required to meet guidelines

Continued below...

Multimodal Space	
Attribute	**Description**
Separation	Visual (by painted line and coloring), expected to be shared by vehicles as needed
Width	No standard. Recommended at least 4 ft wide
Color	FHWA Terra Cotta. Technically "aesthetic treatment" to provide visual differentiation of the shoulder from the vehicular space (AASHTO Green Book 2011, p. 4-13).
Color application method	Recommended hot-mix asphalt colorant over conventional paint (Significant price savings, color lasts the life of the asphalt)
Treatment at crossings	N/A
Vehicular Space	
Attribute	**Description**
Width	9-12.5' (Williams, Advisory Bicycle Lane Design Guide 2018)
Color	None
Sight Distance	Requires assessment of route. Likely to impact application of design. See section 3.1.2 b *Reduced Sight Distance*
Separation by direction	No
Other Roadway Features	
Attribute	**Description**
Curbing	Discouraged, creates an egress obstacle to multimodal users
Storm Drain Placement	Out of multimodal space (preferred), or with wheel-friendly grates (Federal Highway Administration 2006)
Guardrail Placement	N/A
Landscaping	N/A

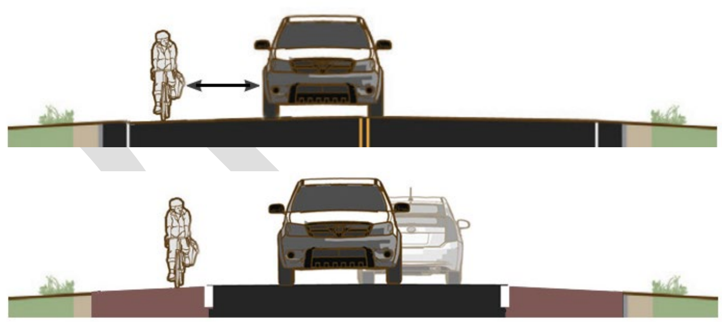


Figure 26

Advisory Shoulders effectively take current practice regarding space between vehicles and multimodal users, and enshrine it into the design of the road itself. On conventional roads, drivers will be reluctant to provide appropriate spacing due to painted lane lines. (Federal Highway Administration 2016)

3.1.2 b Reduced Sight Distance

Most advisory shoulders are installed on existing streets which were converted from a two-lane configuration. A street configured with two lanes has different sight distance requirements than an advisory shoulder. Sight distance requirements can be critical on advisory shoulders when visual obstructions, vertical curves, or horizontal curves may prevent drivers from seeing oncoming traffic.

Current domestic guidance on sight distance is at odds with established norms in the European Union and thus it is recommended to consult transportation engineering guidance in such situations (Williams, Advisory Bicycle Lane Design Guide 2018).

3.2 Connector Streets

Connecting streets are generally characterized by their traffic speeds/volumes being higher than those of local roads, but lower than those of highways. While the lower limit of this category is defined by exponentially higher risk of death in a collision between a vehicle and a vulnerable road user at ~30 mph, the upper limit of this category is defined by the exponentially higher risk of death in a collision between a vehicle and another vehicle at ~50 mph. Consequently, connecting streets are specifically defined by vehicular traffic speeds of *~30 mph to ~50 mph* with traffic volumes of *~6000 ADT and above.*

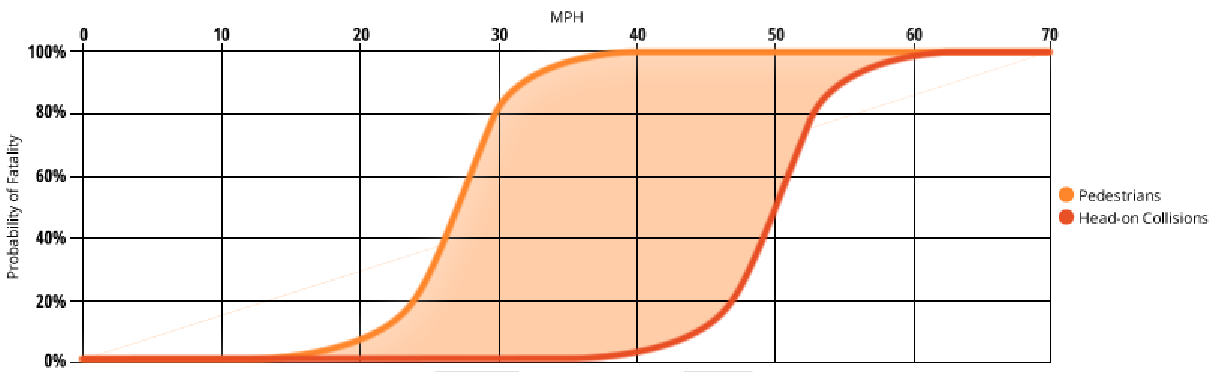


Figure 27
Wramborg's model for fatality probability vs. vehicle collision speeds, with the "connector streets" category highlighted in orange (Jurewicz, et al. 2016)

For these streets, mixing of motorized traffic with vulnerable road users is no longer safe, thus segregation of vulnerable road users away from motorized traffic is the primary means of protection. Along most of these streets, after successful construction of segregated multimodal infrastructure, these roadways may even be able to safely accommodate higher speed limits than posted today. Segregation on these roadways cannot be universally applied however, as intersections and crossings are an inevitable reality. As a result, physical and psychological traffic calming techniques must be employed at intersections and crossings in order to alter driver behavior in these areas.

3.2.1 Sidepath

The recommended roadway treatment for this type of road is a **sidepath**–a paved, bidirectional, multiuse space beside the street. Continuing to employ consistency in design, the sidepath and its crossings should be colored *terra cotta*. Optimally, the sidepath is separated from the street by (at least) 5 feet of space, but this space can temporarily be narrowed by adding crashworthy decorative obstacles or adding a curb. Lane widths on accompanying streets should be reduced to 10 feet, a width that will fully accommodate all streets in this category.

It is strongly recommended that when asphalt is installed, hot mix asphalt colorant be utilized as it tends to color the surface for the life of the asphalt, as opposed to surface-applied paints, which tend to require regular maintenance.

3.2.1 a Key Design Features

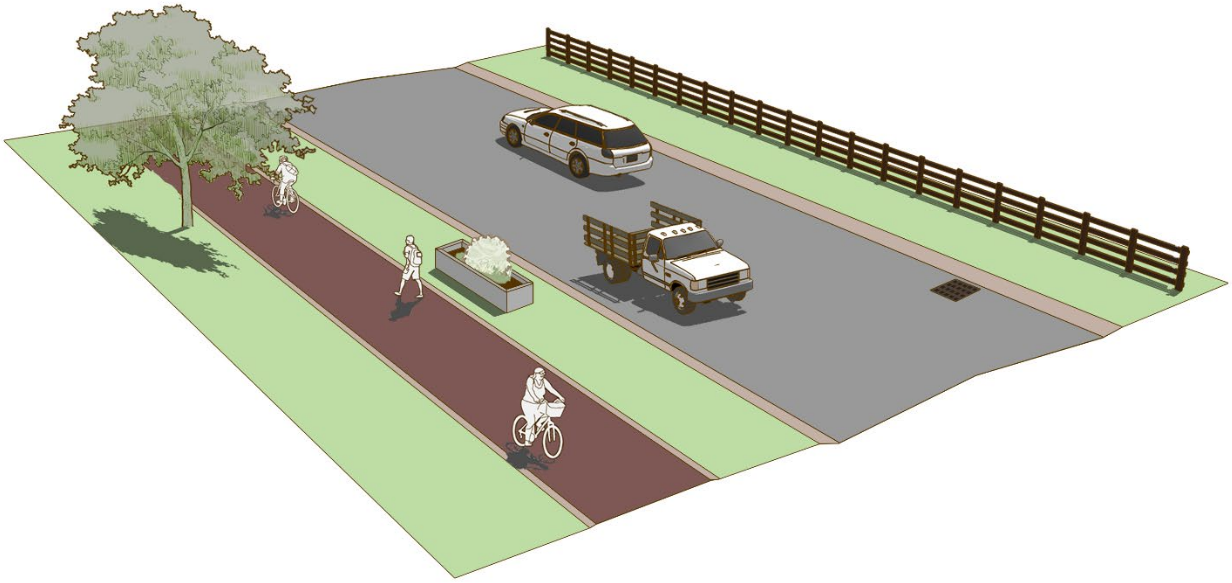


Figure 28
Sidepath road treatment at a conventional intersection (Federal Highway Administration 2016) – image modified to mirror recommendations

Design Attributes	
Attribute	**Description**
Roadway Category	Connecting Street
Volume	Can be used at any volume, generally reserve for higher volumes (~4200 ADT and above). Consider the function of the roadway when applying this treatment outside of standard ADT: "is this a local road or a connecting street?" Application may be appropriate if the function of the roadway does not reflect local character.
Actual Speeds	30 mph to 50 mph
Layout	Standard street with separated multimodal space
Total Roadway footprint	28+ ft wide (typically between 28-35 ft)
Self-enforcing speed mitigation	Permanent speed limitation through design (primarily lane narrowing, keep lanes as narrow as possible, strive for 10 ft lanes in most areas), removal of painted lines where appropriate (see MUTCD, avoid center lane application below 6000 ADT), additional measures especially at conflict points (intersections and crossings)
Context of emphasis	Traffic zone on the open road, public zone at intersections
Signage	Limit signage to absolute requirements
Painted lines	May be used, though may be beneficial not to use for traffic calming (see MUTCD)
Intersection treatments	Wherever sidepaths intersect with roadways, alter the character of the intersection using self-enforcing traffic calming techniques to keep actual speeds at 30 mph or below. Consider use of roundabout or mini-roundabout where appropriate.
Traffic control devices	Optional
Desired interpretation by drivers	Some predictability, some uniformity (on the open roadway). Caution and Discomfort at Intersections/ Crossings.
Accessibility	Required to meet guidelines

Continued below...

Multimodal Space	
Attribute	**Description**
Separation	- Physical - Preferred minimum separation width is 6.5 ft. - Minimum separation distance is 5 ft. - Separation narrower than 5 ft may be accommodated with the use of a physical barrier between the sidepath and the roadway. - Barrier and end treatments should be crashworthy which may introduce additional complexity if there are frequent driveways and intersections. Refer to the AASHTO Roadside Design Guide 2011 for additional information. Several separation techniques exist where space is limited, see section 3.2.1 b Required Roadway Footprint below.
Width	8 ft
Color	FHWA Terra Cotta. Technically “aesthetic treatment” to provide visual differentiation of the shoulder from the vehicular space (AASHTO Green Book 2011, p. 4-13).
Color application method	Recommended hot-mix asphalt colorant over conventional paint (Significant price savings, color lasts the life of the asphalt)
Treatment at crossings	- Maintain physical separation of the sidepath at crossings. - Consider widening separation at crossings. - Where side path cross street, provide multimodal crosswalks (terra cotta background with white zebra stripes). - Consider configuring crossings with raised speed table or “dustpan” style driveway geometry to create vertical deflection of turning vehicles. This physically indicates priority of path travel over turning or crossing traffic and helps reduce the risk associated with bidirectional sidepath use. - Consider raised median island on the cross street to provide additional safety and speed management benefits. - Consider MUTCD yield line at crosswalk
Vehicular Space	
Attribute	**Description**
Width	Varies
Color	None
Sight Distance	Standard
Separation by direction	No
Other Roadway Features	
Attribute	**Description**
Curbing	No preference
Storm Drain Placement	No preference
Guardrail Placement	Between sidepath and street
Landscaping	Trees and landscaping can maintain community character and add value to the experience of using a sidepath. They provide shade for users during hot weather and help to absorb stormwater runoff. Provide a 3 ft horizontal clearance between trees and the pathway to minimize pavement cracking and heaving of the paved surface. Consult a local arborist in the selection and placement of trees. When trees are desired within the roadway separation area, consider planting small caliber trees with a maximum diameter of 4 inches to alleviate concerns about fixed objects or visual obstructions between the roadway and the pathway.

3.2.1 b *Required Roadway Footprint*

When considering modern road design and incorporating multi-modal treatments in New England, a common problem arises. Our roadways are often legacies of the horse-and-carriage era with serpentine routing and narrow space between houses. This often poses a challenge when trying to incorporate a separate space for multimodal road users. Sidepaths will require the use of an 8' wide space offset from vehicles by separating gap or design furniture. These key design features might lead one to quickly dismiss this design as too wide for many roadways, but this likely isn't the case.

By incorporating psychological traffic calming principles and narrowing the street's lane widths, sidepaths can be installed without a need to claim a substantial amount of space beside the street. This design can be further adapted to temporarily incorporate particularly narrow areas by adding a crashworthy barrier or curb in place of the typical 5' roadway offset (see **Figure 27** below for a visualization of this). Many of Amherst's larger throughways span 24' wide or wider today and would span 28' or wider with added conventional sidewalks. This provides valuable context in considering the space needed for a sidepath.

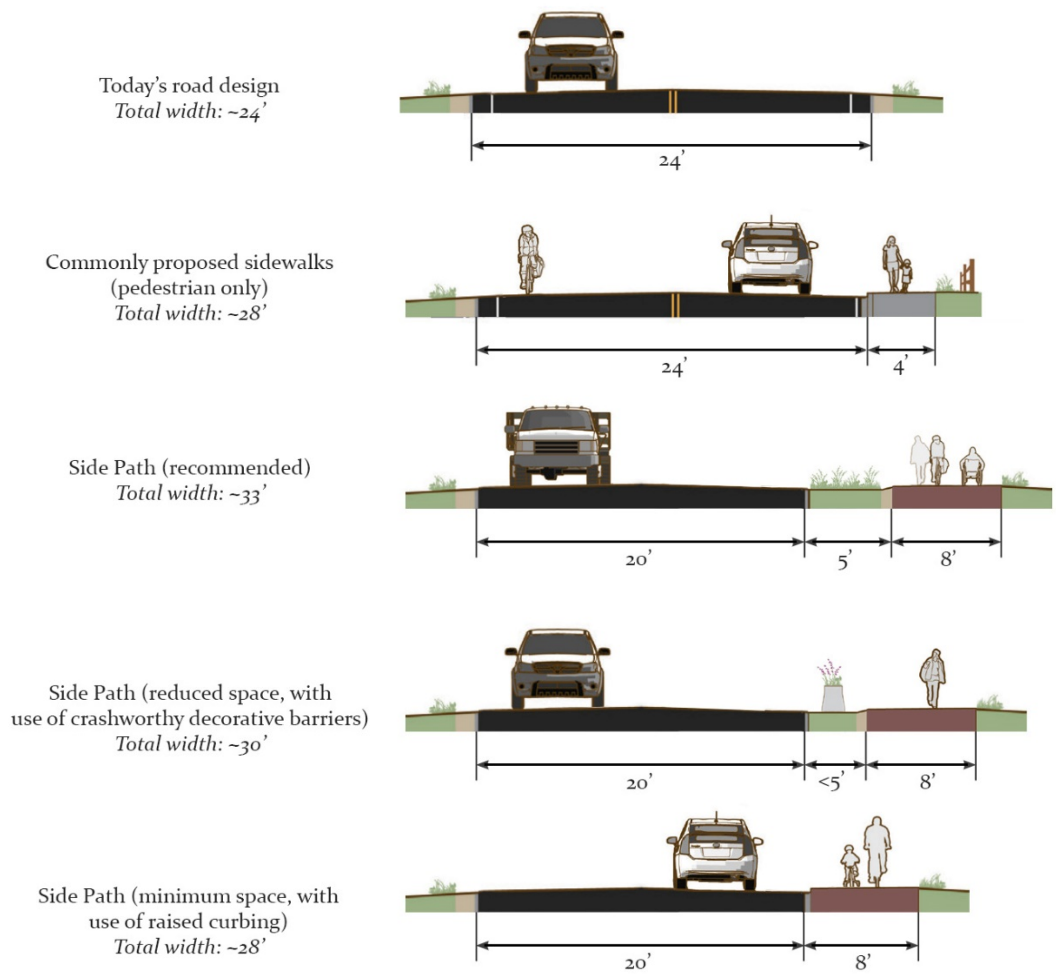


Figure 29

Comparative space required for various sidepath designs (Federal Highway Administration 2016) – image modified to mirror reccomendations

3.2.1 c *Why not sidewalks?*

Sidewalks are most appropriate in locations where, in addition to separating motor vehicles from vulnerable road users, pedestrian and bicycle traffic rates are also so high that they should be separated from each other (e.g. a sidewalk next to a bike lane). These installations are very appropriate for urban environments but are inappropriate in a town like Amherst.

The population of Amherst is so low and sparse that it would be unlikely for any sort of multimodal traffic congestion to appear in town. Furthermore, Amherst's housing and main points of interests are very sparsely distributed over a wide geographical area. This further complements the need for a *multimodal* network as opposed to a network of separate pedestrian facilities (sidewalks), as it is far more likely for users to use non-motorized wheeled modes (bicycles, roller skates, skateboards, etc.) to move across town.

The installation of conventional sidewalks in Amherst should be especially discouraged, as state law forbids their use with wheeled vehicles, and thus would become permanent fixture that fails to accommodate other multimodal users (State of New Hampshire RSA 265:26 n.d.).

3.2.1 d *Determination of Sidepath Positioning*

Because sidepaths are bi-directional, only one sidepath is required alongside vehicle space. As a result, great care should be made to determine which side of the roadway the sidepath rests. **This must be done early in the planning process for every candidate road**, so that all future segments of the sidepath can be constructed in the appropriate position. Failure to do this will result in a more dangerous design in which the sidepath frequently crosses the vehicle space.

The following factors should be considered when selecting the sidepath's position:

- Minimizing number of intersections and other roadways
- Minimizing the number of necessary crossings
- Location of important destinations
- Connection with other sidepaths

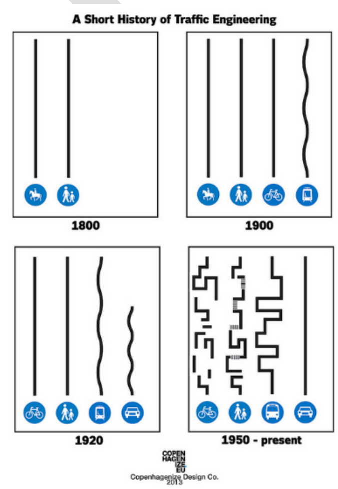


Figure 30
An illustration of fragmented multi-modal accommodations when positioning is not prioritized. (Copenhagenize 2013)

3.2.1 e *Grade Breaks/Transitions*

The character of the grade of sidepaths should be similar that of a road: gradual slopes that are accommodating of wheeled vehicles. The position of the sidepath should usually result in a space that is smooth and of a similar grade to that of the accompanying roadway. At some intersections and at driveways (especially if a sidepath is curbed), there may be a temptation to break the grade of the sidepath. This can result in a turbulent ride rendering the use of the sidepath to be undesirable, resulting in wheeled multi-modal users electing instead to use the roadway.

Figure 31

A sidepath/roadway intersection in which the sidepath's grade is maintained throughout (Wagenbuur 2011).

The priority should be made to maintain an even slope of the sidepath as much as possible (especially at driveways and other interruptions) as frequent or radical changes in grade will make the space undesirable for any wheeled traffic. Sharp, frequent, or partial-width breaks in the sidepath's grade should always be avoided.

Driveways should not interrupt the sidepath

Driveways should not influence the grade of the sidepath.

Driveways should not have priority over multi-modal users in the sidepath, just as they would not have priority over vehicles in the roadway

The benefit of coloring multi-modal space terra cotta is best represented at these intersections, where color and grade clearly delineate sidepaths from vehicle space

Figure 32
Examples of important considerations of sidepaths at intersections with other roads and driveways (Wagenbuur 2011).

3.3 Highways

At speeds of 50 mph and above, car vs. car collisions have a high fatal potential, especially with frontal (head-on) and frontal overlap (off-center head-on) collisions.

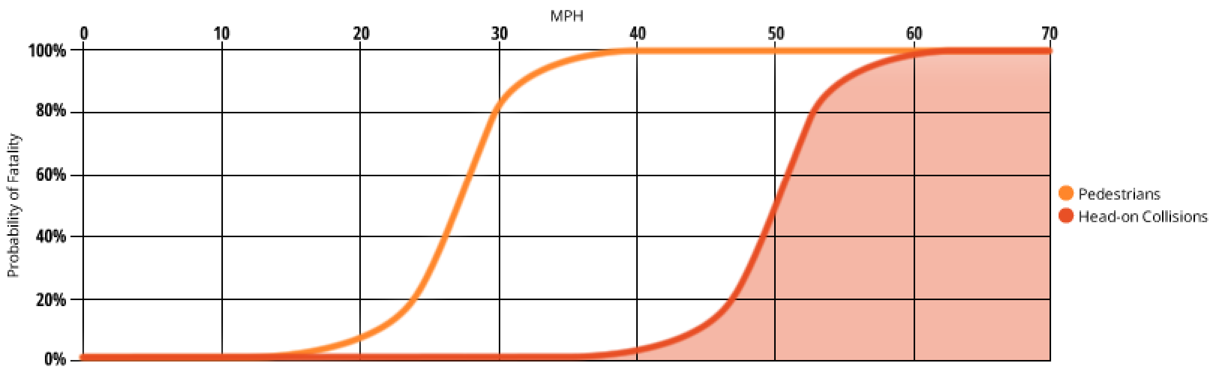


Figure 33

Wramborg's model for fatality probability vs. vehicle collision speeds, with the "highways" category highlighted in red (Jurewicz, et al. 2016)

For these reasons, any street designed with actual speeds of 50 mph or above should include a physical separation of vehicles by direction as well as a physical separation of vehicles from multimodal users (Furth and Wagenbuur 2017). This divided highway design has the greatest amount of available safety research of any type of roadway.

3.3.1 Divided Highway (with Sidepath)

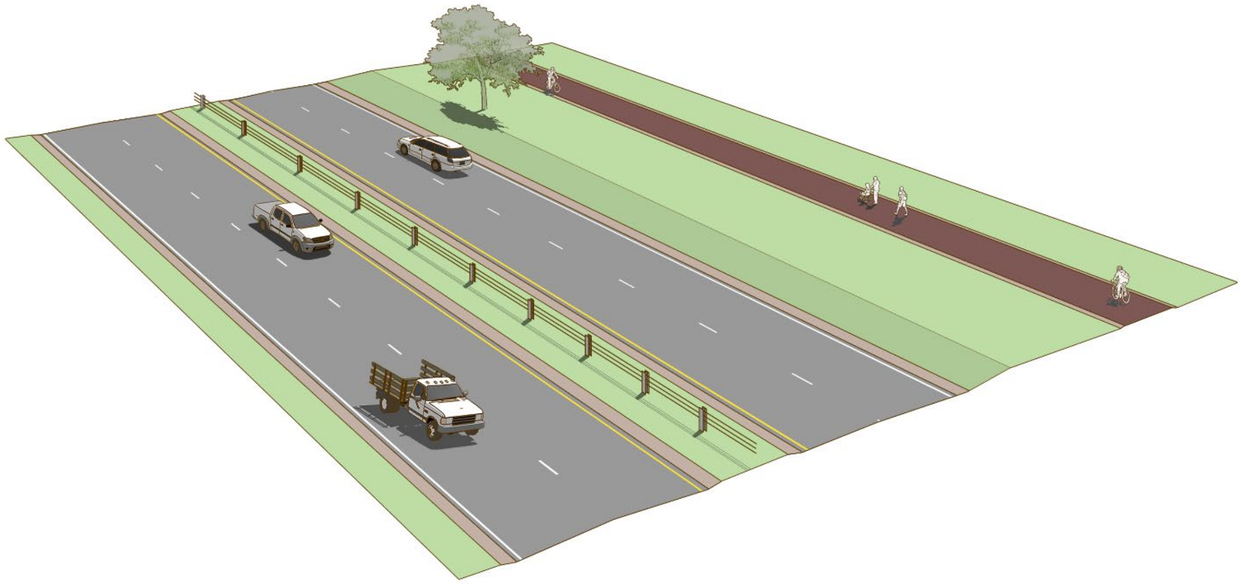
For highways, the use of safety techniques from the "traffic world" are certainly appropriate. The human body is not naturally equipped to travel at 50+ mph speeds and thus the street must provide predictability, uniformity, wide lanes, painted lane markings, physical barriers, and other means of absorbing human error.

It is worth mentioning that these roads have an entirely different function than other categories of roadways: for motor vehicles to travel across greater distances at high speeds. This function is singular and ought not be mixed with other functions, as local, slow-moving, and turning traffic can provide a serious hazard to others on these roadways (reaction time and stopping distance at these speeds are generally hazardous). Finding "functional harmony" between the roadway design and its appropriate use on high-speed roads is known as "access management" (National Cooperative Highway Research Program 2010).

For similar reasons, multimodal space must also be kept entirely segregated from vehicle traffic and should never cross motor vehicle lanes. Any collision between motor vehicles and vulnerable road users at these speeds would almost certainly result in fatality. Even crossings assisted with signalized devices will not be safe as traffic signals begin to fail at speeds above 45 mph (Furth and Wagenbuur 2017).

The use of a sidepath is still the preferred multimodal treatment, though in this application, the sidepath must be offset from the roadway at a distance of 16.5–24 ft and/or be separated with a crashworthy barrier (Federal Highway Administration 2016).

3.3.1 a Key design features



Design Attributes	
Attribute	**Description**
Roadway Category	Highway
Volume	N/A
Actual Speeds	50 mph and above
Layout	Divided, limited access highway with separated multimodal space
Total Roadway footprint	Wide. Varies
Self-enforcing speed mitigation	None
Context of emphasis	Traffic Zone
Signage	Standard highway use. See MUTCD.
Painted lines	Required throughout
Intersection treatments	- Utilize divided highway specifications - Do not mix direction of vehicles - Do not mix vehicles with multimodal users
Traffic control devices	Required
Desired interpretation by drivers	Predictability, Uniformity
Accessibility	Required to meet guidelines on sidepath

Continued below…

Multimodal Space	
Attribute	**Description**
Separation	- Physical. - At these speeds, the sidepath must be offset from the roadway at a distance of 16.5–24 ft and/or be separated with a crashworthy barrier (Federal Highway Administration 2016).
Width	8 ft
Color	FHWA Terra Cotta. Technically “aesthetic treatment” to provide visual differentiation of the shoulder from the vehicular space (AASHTO Green Book 2011, p. 4-13).
Color application method	Recommended hot-mix asphalt colorant over conventional paint (Significant price savings, color lasts the life of the asphalt)
Treatment at crossings	No crossings. Keep separated from vehicles
Vehicular Space	
Attribute	**Description**
Width	Varies
Color	None
Sight Distance	Standard
Separation by direction	Yes
Other Roadway Features	
Attribute	**Description**
Curbing	No preference
Storm Drain Placement	No preference
Guardrail Placement	Between sidepath and street
Landscaping	N/A

3.4 Intersection Treatments

The vast majority of dangerous incidents that occur on the roadway happen at intersections, whether between motor vehicles or motor vehicles versus vulnerable road users. Some intersection treatments offer significantly better protection for all road users than today's conventional intersections.

3.4.1 Modern Roundabouts

Roundabouts can provide lasting benefits and value in many ways. They are safer, more efficient, less costly and more aesthetically appealing than conventional intersection designs. Furthermore, roundabouts are an excellent choice to complement other transportation objectives – including multimodal networks, and corridor access management – without compromising the ability to keep vehicles efficiently moving. The FHWA Office of Safety identified roundabouts as a Proven Safety Countermeasure because of their ability to substantially reduce the types of crashes that result in injury or loss of life. Roundabouts are designed to improve safety for all users, including pedestrians and bicycles (Federal Highway Administration 2018).

Most significantly, roundabouts **reduce the types of crashes where people are seriously hurt or killed by 78-82%** when compared to conventional stop-controlled and signalized intersections, per the AASHTO Highway Safety Manual (American Association of State Highway and Transportation Officials 2010). Roundabouts have been consistently shown to reduce fatal accidents by up to 93% in some studies, especially considering collisions between motor vehicles and vulnerable road users (Vanderbilt 2009). This fact alone should be enough to encourage the implementation of roundabouts wherever possible.

It's important that a modern roundabout design is not the same thing as their unpopular cousins the rotary or the traffic circle. Roundabout proposals in the region have occasionally been met with criticism due to the failures of these other circular intersection designs. The modern roundabout differs in many key ways with decades of empirical data to show it as the safest and most efficient form of any intersection.

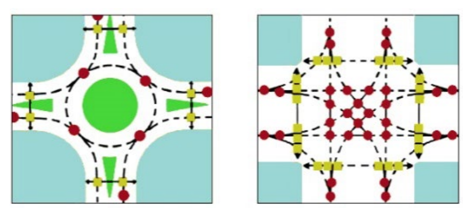


Figure 34
Conflict points in Roundabouts (8) vs. four-way Intersections (32).
Red = Vehicular Conflict Point; Yellow = Vulnerable User Conflict Point

By reducing the number and severity of conflict points, and because of the lower speeds of vehicles moving through the intersection, roundabouts are a significantly safer type of intersection. The diagram below excerpted from Roundabouts: An Informational Guide, Second Edition (published as NCHRP Report 672) illustrates the difference in conflict points between a conventional, four-legged intersection and an equivalent single lane roundabout. There are 32 conflict points associated with a conventional intersection – 8 merging (or joining), 8 diverging (or separating) and 16 crossing. In contrast, there are only 8 total conflict points at an equivalent roundabout – 4 merging and 4 diverging. Not only are conflict points halved with the roundabout, the type of conflicts that remain are the same-direction variety, which result in substantially less severity, and as a result, less likelihood of injury. The reduction of both the total number of conflict points and their severity is also true for pedestrians, also shown below in diagrams excerpted from the Guide (Transportation Research Board 2011).

Drivers entering the roundabout must only negotiate whether traffic is coming from one direction as opposed to three, this makes for easier decision-making and thus requiring less individual judgment to safely negotiate an intersection. Furthermore, they need only look to the left (the direction they can see most clearly from the driver's seat) to find a gap in traffic, as opposed to looking across a 180˚ span at a conventional 4-way intersection. The most dangerous of all turns: the left turn across traffic is completely eliminated from the intersection (Federal Highway Administration 2018).

Figure 35
Roundabout design at an intersection that keeps multimodal users outside of the traffic circle

3.4.1 a *Key Elements of Design*

- **Counterclockwise Flow -** Traffic travels counterclockwise around a center island.
- **Entry Yield Control -** Vehicles entering the roundabout yield to traffic already circulating.
- **Unparalleled Protection (and priority) for Vulnerable Road Users -** Vulnerable road users are kept out of the roundabout, effectively having their own roundabout outside of the intersection. Vulnerable road users should be given priority at these crossings. This allows for drivers to see vulnerable users plainly and to the front, requiring no turning of the head. Furthermore, there should be enough space to fit one car between the vulnerable road users' crossing and the entrance of the roundabout. This significantly reduces the probability of blocked crossings while drivers wait for a gap inside of the roundabout.
- **Consistency in Design -** Multi-use space must continue to be colored FHWA *Terra Cotta* to distinguish from vehicular road space.
- **Low Speeds -** Sharp angles branching out from the roundabout prevent drivers from being able to speed through the intersection.

- **Psychological Traffic Calming -** The center island itself functions as a way of optically breaking up the roadway, taking drivers' eyes off of the distant horizon and forcing them into the foreground.
- **Scalable Design -** Roundabout design can be scaled down to be very small. The National Association of City Transportation Officials have published approved design guidance for "mini-roundabouts" which have the exact same footprint as a conventional 4-way intersection. *"Mini roundabouts … at minor intersection crossings are an ideal treatment for uncontrolled intersections* (National Association of City Transportation Officials, 2013)."
- **Segregation -** When approaching a modern roundabout intersection, sidepaths *and* advisory shoulders should never enter the intersection itself, but rather should have its own circle outside of the roundabout with some physical barrier. (National Association of City Transportation Officials 2013)

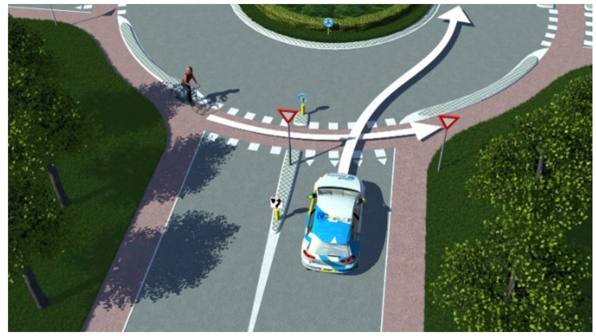


Figure 36
Advisory Shoulders at a Roundabout

3.4.2 Mini Roundabouts

Mini-roundabouts, sometimes called a "neighborhood traffic cirle" or "residential roundabouts" are a raised center island is constructed in an intersection. Landscaping can be added to the island for aesthetic value but should not obstruct the view of the intersection. Shrubs or trees in the roundabout further the traffic calming effect and beautify the street, but need to be properly maintained so they do not hinder visibility (National Association of City Transportation Officials 2013). Traffic circles have been found to reduce speeds by up to 15 mph.

Figure 37
Neighborhood roundabout (Federal Highway Administration 2012)

Mini-roundabouts and residential roundabouts are approaches to unsignalized (no traffic light) intersections that, unlike the improper use of multi-way stop signs, has been shown to increase safety at intersections (National Association of City Transportation Officials 2013).

"Mini roundabouts and neighborhood traffic circles lower speeds at minor intersection crossings and are an <u>ideal</u> treatment for uncontrolled intersections (National Association of City Transportation Officials 2013)*."*

A mini roundabout on a residential street is intended to keep speeds to a minimum. Provide approximately 15 feet of clearance from the corner to the widest point on the circle. Shrubs or trees in the roundabout further the traffic calming effect and beautify the street, but need to be properly maintained so they do not hinder visibility (National Association of City Transportation Officials 2013).

These roundabout systems are designed to use no more real estate than a conventional 4-way intersection and do not require a major redesign, and yet they are wide enough to accommodate any through traffic. Over the last 30 years, the City of Seattle for example, has already installed over 1,000 roundabouts (National Association of City Transportation Officials 2013).

These types of intersections are proven to *increase* safety, accommodate all forms of traffic, slow speeds, and beautify the street through the application of landscaping and masonry. This should be considered as an intersection to strive for.

3.5 Special Roadway Districts

Some areas of town may be more prominently defined by their need to accommodate a higher volume of multimodal users. The roadways in these areas would be functionally different than other roadways in town. This could merit supplemental treatments to further define these areas from their surroundings and also to achieve the universal application of self-enforcing traffic calming across the entire (as opposed to localized spots). By contrasting these areas using select additional roadway treatments, motorized transportation can be affected throughout the entire area, enhancing both the safety and the comfort of multimodal users.

The key design features of a special roadway district would be the use of **gateway treatments** and **alternative pavement surfaces** so as to distinctively define these areas from other types of roadways. These treatments would be utilized in tandem with other self-enforcing traffic calming techniques already defined in section 2.3.1.

3.5.1 Gateway Treatments

An effective way to define special roadway districts from other roads is to install gateway treatments (also known as "transition zones") at their entrances. Gateway treatments can range from a cheap, small sign up to an expensive, elaborate, roadway feature. Successful gateway treatments however, should use a combination of psychological and physical traffic calming techniques and very clearly define the special district from the open road.

To date there are no national design guidelines for transition zones found in the AASHTO "Green Book," so the Federal Highway Administration and Transportation Research Board developed an official publication known as *National Cooperative Highway Research Program Synthesis 412: Speed Reduction Techniques for Rural High-to-Low Speed Transitions* as a technical guide for communities to engineer empirically-supported transition zones (American Association of State Highway and Transportation Officials 2011).

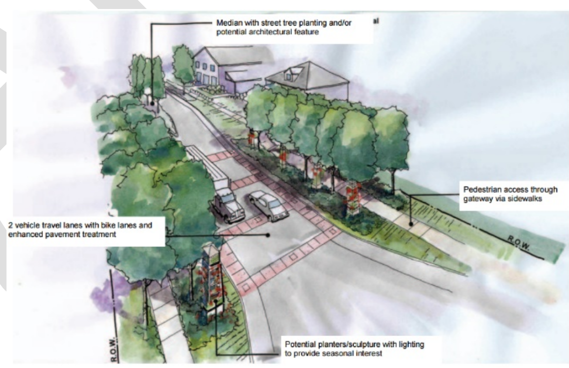


Figure 38
Example gateway design from the City of Binbrook (City of Binbrook, Hamilton, 1999)

3.5.1 a Key Design Features

As well as other findings, the FHWA and TRB offered some key take-aways regarding transition zones/gateway treatments:

- More extensive and aggressive measures tend to produce greater reductions in speed and crash occurrence than less extensive and passive measures.
- There needs to be a distinct relationship between a residential/village speed limit and a change in the roadway character.
- No one particular measure is appropriate for all situations. Each residential area must be assessed and treated based on its own characteristics and merits.
- To maintain a speed reduction downstream of the transition zone, it is necessary to [continue to define the special roadway character] through the area. Otherwise, speeds may

rebound to previous levels as soon as 820 ft from the start of the lower speed zone. (Federal Highway Administration, Transportation Research Board 2011, 1)

- The gateway needs to be conspicuous to be effective. It is also important to ensure that devices used as part of a gateway treatment (1) are crashworthy if placed within the clear zone and (2) do not obstruct sight distance, as gateways placed in the roadway may become fixed object hazards. (Federal Highway Administration 2012)
- Deflection of incoming and outgoing traffic to force a slowing such as a center island, roundabout, etc. (Reduces speeds by up to 9% (Gilmore, et al. 2012, 10))
- Narrowing of the road and absence of painted lines that remains consistent throughout the village (Reduces speeds 11% to 20% (Gilmore, et al. 2012, 10))
- Textured and/or non-asphalt surface to provide clearly visible change in streetscape
- Landscaping and other non-traffic-world elements

According to the Transportation Research Board *Design Guidance for High-Speed to Low-Speed Transition Zones for Rural Highways*, **a comprehensive gateway design (with many of the above elements incorporated) reduce speeds by 15% to 27% and reduce injury crashes by 36%** (Gilmore, et al. 2012, 13)

3.5.2 Alternative Pavement Surfaces

Alternative road surfaces can have a profound effect on the way drivers behave across an area. Several studies have been conducted which indicate that road surfaces such as brick, cobblestone, or interlocking pavers produce several measurable results. The perception of an uneven surface helps to slow down drivers, something that is further enforced by the vibration and auditory feedback of the roadway (Federal Highway Administration 2006).

This is a very effective way to distinguish an entire district as unique from other roads, while simultaneously using its physical properties to have self-enforcing speeds. These types of paving surfaces have been shown to reduce traffic speeds by 2.5–4.5 mph, compared with speeds on asphalt surfaces (Bradbury, et al. 2007). This is especially noteworthy as the road surface applies this traffic calming effect *across the entire area* where these surfaces exist.

By creating visual interest in the roadway surface, studies indicate that there is an intuitive signal to drivers “that something is different about this area” and results a measurably safer result (Bradbury, et al. 2007).

Figure 39
The Portsmouth Streetscape Improvement Project was completed in 2018 and included the installation of with roadway pavers for both vehicular and multimodal use.

Not only do textured roadway surfaces provide a powerful, area-wide traffic calming effect, but they can be quite aesthetically pleasing, which further helps to emphasize local contexts as a space separate from the surrounding "traffic world." Some examples of permeable pavers that have been used in other locations in New Hampshire are found below.

Figure 40
Unilock COURTSTONE® (basalt/Belgian blue color) simulated cobblestone

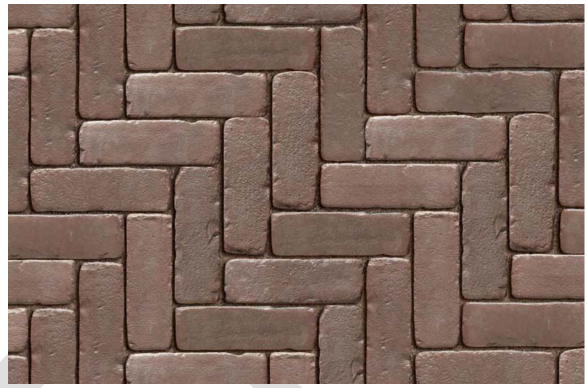


Figure 41 Unilock COPTHORNE® (burnt clay terra cotta color) simulated bricks

These materials are not natural stones, but are rater manufactured, interlocking pavers engineered to emulate the appearance of natural stones. These materials have been specifically manufactured for their use as roadways, their ability to be plowed, to enhance drainage, and to outlast asphalt. The permeable nature of these materials offers a simultaneous storm water management solution. As a result, if a segment of roadway is to be reconstructed in tandem with storm water infrastructure, the use of interlocking permeable pavers supposedly is often the less expensive option when compared to conventional asphalt with underground stormwater system installation (UNILOCK n.d.).

3.5.2 a Interlocking Paver New Hampshire Plowability Study & Local Examples

In 2013, the University of New Hampshire concluded a study on the effects of installing pavers in a New England climate (see **Figure 40**). According to the study, "winter snow plowing was done with no problems and there was no de-icer damage" (Smith 2013). The pavers remain in place with regular use today.

Figure 42
Before and after application of interlocking pavers on a roadway at the University of New Hampshire

Alternative pavement surfaces are already utilized in the town of Amherst. This surface treatment was installed at 123 NH Route 101a for the purposes of achieving area-wide multimodality.

In 2018, the city of Portsmouth completed installing pavers for roadway and sidewalk use in a downtown streetscape improvement project (see **Figure 37**).

4 Off-Road Multimodal Network

Off-road trails provide Amherst residents with a unique opportunity to move throughout town with little or no interaction with motor vehicles. This can provide exceptionally safe and convenient mobility for multimodal users, especially if they are a member of a vulnerable population or if their route would otherwise take them along a busy roadway.

By design, off-road trails offer network connectivity opportunities beyond that of any roadway network. They provide nonmotorized transportation access to natural and recreational areas and in particularly scenic environments. These routes support outdoor activities through convenient access to natural areas or as an enjoyable recreational opportunity itself.

Often these off-road trails can become a cultural backbone of outdoor activity, providing residents and visitors opportunities to see and interact with other members of their community, something that over-reliance of motorized transportation has largely removed from our daily lives. For these and many other reasons, the safety and cultural value of off-road trails as a part of greater multimodal network cannot be overstated.

4.1 Amherst's Current Off-Road Network

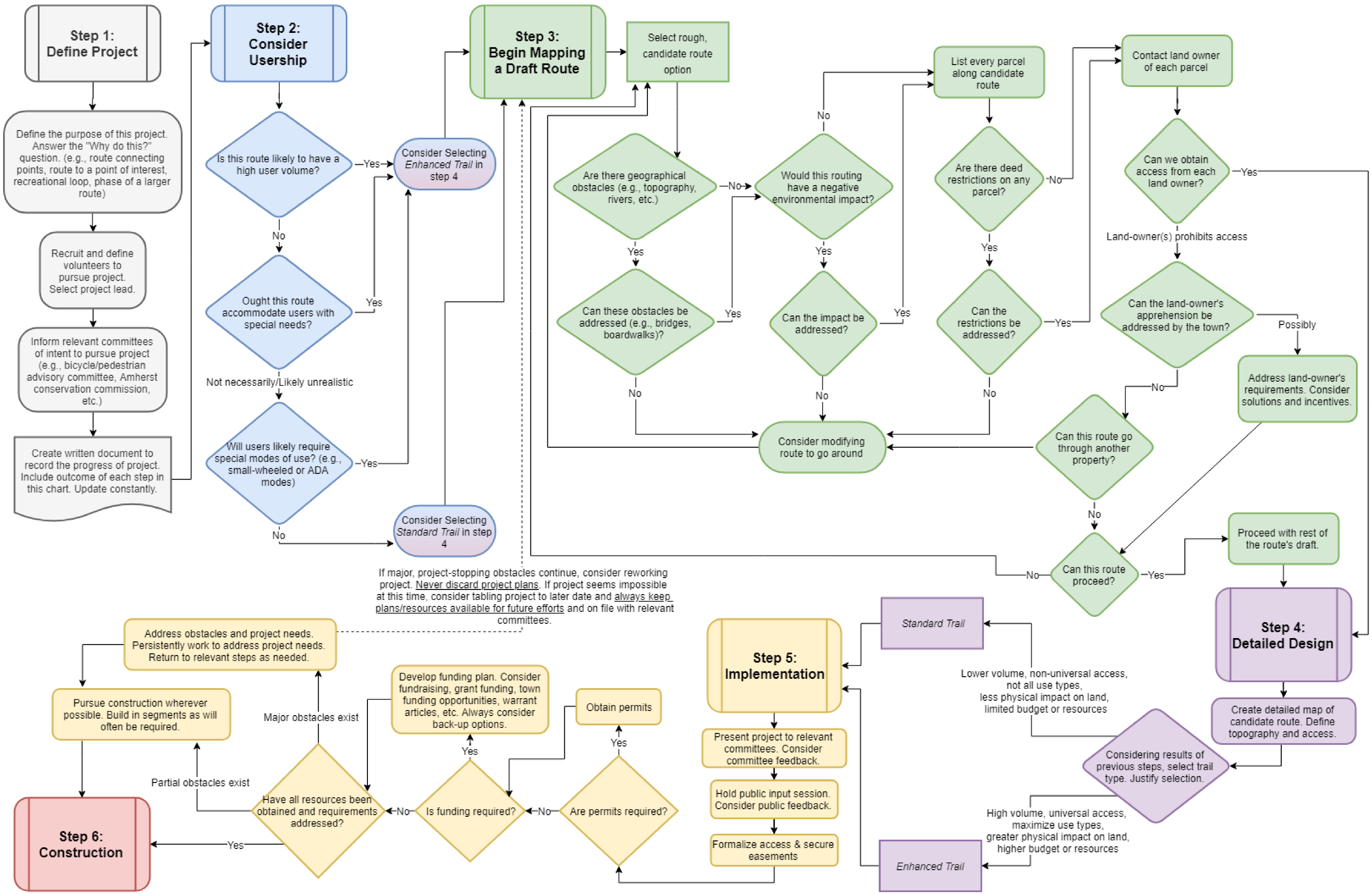
Today, Amherst has a robust network of off-road trails which span across more than 25 miles. These trails are maintained by the Amherst Conservation Commission and offer a wide variety of mobility options to residents. Some trails may connect points of interest while others may offer solely recreational opportunities. Many of these trails form an existing network that is robust in some areas and limited in other areas. Given Amherst's largely forested and rural geography, a multimodal network limited to roadside options would fail to meet our town's full potential. Thus, a driven and organized effort to pursue the development and enhancement of a network of trails would offer vastly expanded opportunities for Amherst's multimodal residents.

4.2 Developing a Network of Trails

The creation of any broad network is a lengthy and complicated process which requires dedicated volunteers to coordinate a long-term effort with creative problem-solving. Amherst's current network of roads was created over hundreds of years and required the efforts of generations of Amherst residents. The planning and development of off-road trails is no different in this regard.

Each potential route through town offers unique challenges, from geographical obstacles to reluctant land-owners and more. Some of these obstacles may be plainly obvious (e.g., a river with no bridge), while others may be completely hidden until well into the development process (e.g., deed restrictions). It is paramount that volunteers working on trail planning understand that their efforts to further the development of a network are invaluable, despite the fact that the process may be very challenging or require a persistent effort that spans many years.

To aid in the process of developing a network of off-road trails, the Amherst Bicycle/Pedestrian Advisory Committee has developed a planning process to help volunteers. Created with the joint effort of Amherst Bicycle/Pedestrian Advisory Committee, Amherst Conservation Commission, Amherst Recreation Commission members, the chart found below represents the requisite process for creating a new trail from inception to construction.



Step 1: Define Project
Define the purpose of this project. Answer the "Why do this?" question. (e.g., route connecting points, route to a point of interest, recreational loop, phase of a larger route)
Recruit and define volunteers to pursue project. Select project lead.
Inform relevant committees of intent to pursue project (e.g., bicycle/pedestrian advisory committee, Amherst conservation commission, etc.)
Create written document to record the progress of project. Include outcome of each step in this chart. Update constantly.
Step 2: Consider Usership
Is this route likely to have a high user volume?
Yes
No
Ought this route accommodate users with special needs?
Not necessarily/Likely unrealistic
Will users likely require special modes of use? (e.g., small-wheeled or ADA modes)
Consider Selecting Enhanced Trail in step 4
Consider Selecting Standard Trail in step 4
Step 3: Begin Mapping a Draft Route
Select rough, candidate route option
Are there geographical obstacles (e.g., topography, rivers, etc.)
Can these obstacles be addressed (e.g., bridges, boardwalks)?
Would this routing have a negative environmental impact?
Can the impact be addressed?
List every parcel along candidate route
Are there deed restrictions on any parcel?
Can the restrictions be addressed?
Consider modifying route to go around
Contact land owner of each parcel
Can we obtain access from each land owner?
Land-owner(s) prohibits access
Can the land-owner's apprehension be addressed by the town?
Possibly
Address land-owner's requirements. Consider solutions and incentives.
Can this route go through another property?
Can this route proceed?
Proceed with rest of the route's draft.
If major, project-stopping obstacles continue, consider reworking project. Never discard project plans. If project seems impossible at this time, consider tabling project to later date and always keep plans/resources available for future efforts and on file with relevant committees.
Step 4: Detailed Design
Create detailed map of candidate route. Define topography and access.
Considering results of previous steps, select trail type. Justify selection.
Lower volume, non-universal access, not all use types, less physical impact on land, limited budget or resources
Standard Trail
High volume, universal access, maximize use types, greater physical impact on land, higher budget or resources
Enhanced Trail
Step 5: Implementation
Present project to relevant committees. Consider committee feedback.
Hold public input session. Consider public feedback.
Formalize access & secure easements
Are permits required?
Obtain permits
Is funding required?
Develop funding plan. Consider fundraising, grant funding, town funding opportunities, warrant articles, etc. Always consider back-up options.
Have all resources been obtained and requirements addressed?
Major obstacles exist
Partial obstacles exist
Address obstacles and project needs. Persistently work to address project needs. Return to relevant steps as needed.
Pursue construction wherever possible. Build in segments as will often be required.
Step 6: Construction

4.3 Categories of Off-Road Trails

Off-road trails can be organized into two general categories: standard trails and enhanced trails. All of Amherst's trails are currently standard trails while some current or future routes may lend themselves to an enhanced trail design.

Standard Trails are defined by the Amherst Conservation Commission Trail Standard (Amherst Conservation Commission 2018), while Enhanced Trails may be defined by or be similar to the Federal Highway Administration's Standard for Multi-Use Trails (Federal Highway Administration 2016). The selection of either of these categories should be based on the needs of the users and the circumstances dictated by the route, resources, and other considerations. Most trails in the town of Amherst are likely to lend themselves to a Standard Trail design while there may be a few select opportunities for an Enhanced Trail.

	Standard Trail	**Enhanced Trail**
Route Criticality	Connecting other locations, recreational loops, etc.	Connecting two or more highly important locations that serve larger populations
Volume	Lower volume	High volume
Usership	Potentially limited	Broadly accessible
Character of trails	Defined by *Amherst Conservation Commission Trail Standard*	May be defined by or be similar to Federal Highway Administration *multi-use trails* where appropriate

5 Summary of Key Recommendations

The recommendations of this plan are derived from the overarching goal of creating a safe and accessible network for bicyclists and pedestrians.

The Bicycle and Pedestrian Advisory Committee recommends:

- Developing actionable plans and projects to enact the recommendations of this plan
- Continuing outreach and engagement efforts to understand the needs of the public as well as keeping the public informed about infrastructure projects, funding opportunities, and multimodal educational programs
- Collaborating with the Amherst Department of Public Works to implement recommended roadway treatments when feasible and fiscally responsible, especially when scheduled road construction is planned. Roadway designs should be based on principles of **systematic safety**, gradually redesigning our roadways proactively to minimize known safety risks and incorporate multimodal users
    - Local Roads – Safely integrating vehicles with multimodal users
    - Connecting Streets – Segregating vehicles from multimodal users
    - Divided Highways – Segregating vehicles from vehicles (by direction), and vehicles from multimodal users
- Requesting the NH Department of Transportation to incorporate recommended systematic safety road designs into any current or future state road reconstruction
- Consider the designation of *special roadway districts* in town that are defined by a higher and/or special volume of multimodal users and installing district-wide safety systems in their design
- Aiding in the expansion of an off-road network of trails following the process defined in this plan, with the coordination of the Amherst Conservation Commission and Amherst Recreation Commissions
- Helping the Amherst Conservation Commission publicize the 25+ miles of running, walking, and biking trails that currently exist in town and encourage residents of all ages to use them. Creating a video/photo library for existing trails to help the public discern the locations, availability of parking, degree of difficulty, as well as the natural and historical resources present
- Supporting the Amherst Recreation Department's "8 to 80" initiative by promoting multimodal activities and educational opportunities

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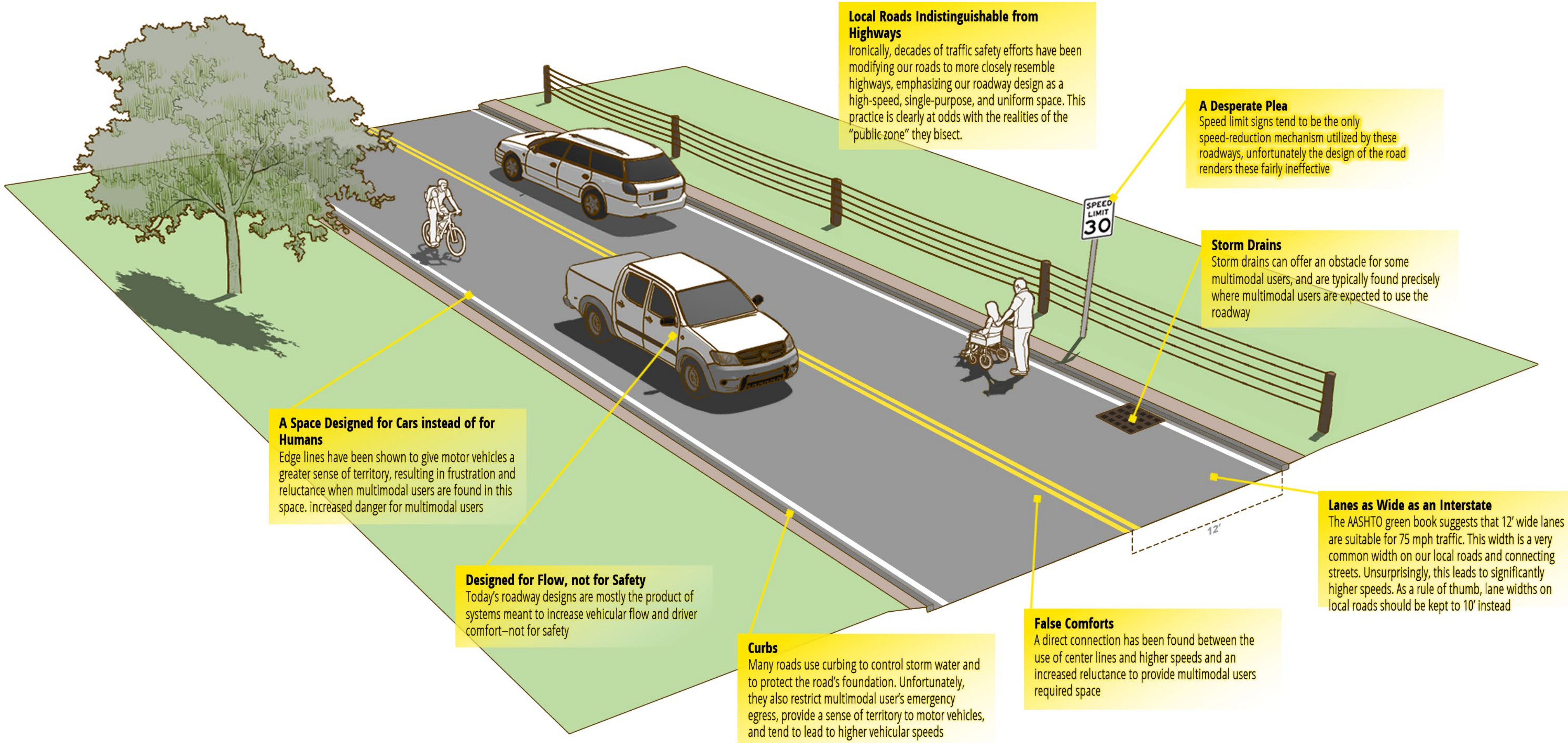
The "Multimodal Network" of Today

Today's Roads

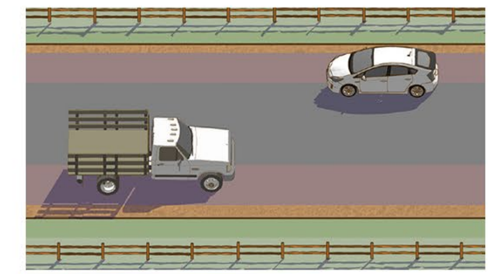
The roadways we have today were constructed almost exclusively for vehicular use. This type of roadway design is hardly unique to the town of Amherst. For nearly 100 years, the car has dominated our roadways, and our roads have subsequently been built and re-built in a manner that reflects this singular use. A major consequence of this design practice is plainly visible—our roadways are not designed for multimodal users and is too uncomfortable or dangerous their use.



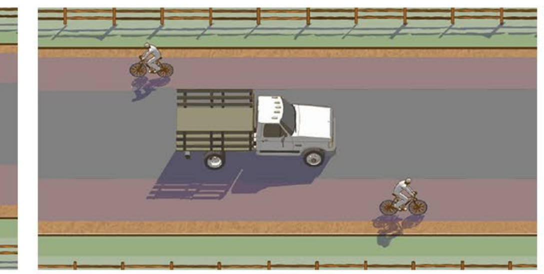
Local Roads

Enhanced Shoulders

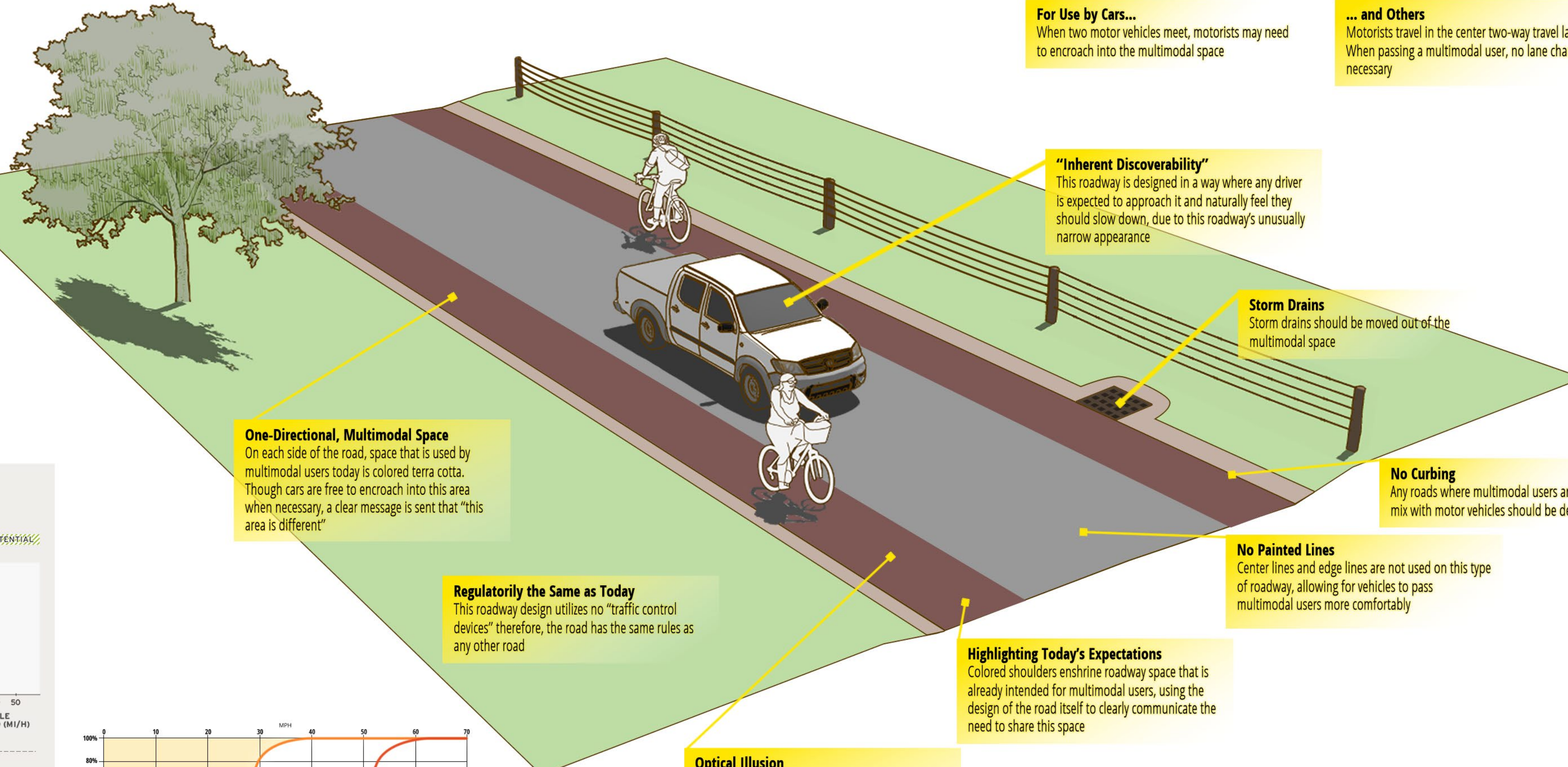
The enhanced shoulder design, sometimes called "colored shoulders" is a roadway design that takes existing road design and by using visual traffic calming techniques, enshrines the areas already utilized by multimodal users. This design is largely defined by its lack of any painted lane markings and terra cotta-colored edges. The primary goal of this design is to naturally slow motor vehicles by making the roadway appear very narrow, while simultaneously demarcating existing multimodal roadway space.



For Use by Cars...
When two motor vehicles meet, motorists may need to encroach into the multimodal space



... and Others
Motorists travel in the center two-way travel lane. When passing a multimodal user, no lane change is necessary



"Inherent Discoverability"
This roadway is designed in a way where any driver is expected to approach it and naturally feel they should slow down, due to this roadway's unusually narrow appearance

Storm Drains
Storm drains should be moved out of the multimodal space

One-Directional, Multimodal Space
On each side of the road, space that is used by multimodal users today is colored terra cotta. Though cars are free to encroach into this area when necessary, a clear message is sent that "this area is different"

No Curbing
Any roads where multimodal users are expected to mix with motor vehicles should be devoid of curbs

No Painted Lines
Center lines and edge lines are not used on this type of roadway, allowing for vehicles to pass multimodal users more comfortably

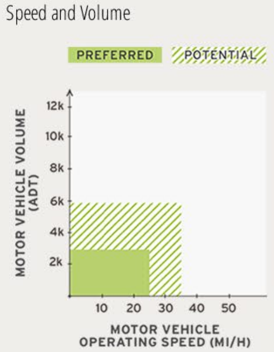
Regulatorily the Same as Today
This roadway design utilizes no "traffic control devices" therefore, the road has the same rules as any other road

Highlighting Today's Expectations
Colored shoulders enshrine roadway space that is already intended for multimodal users, using the design of the road itself to clearly communicate the need to share this space

Optical Illusion
Using *terra cotta* colored shoulders create an optical illusion, making the roadway feel far narrower than it actually is. This is designed to make the roadway feel uncomfortable to drivers, resulting in appropriately increased alertness

Design Applications

Speed and Volume



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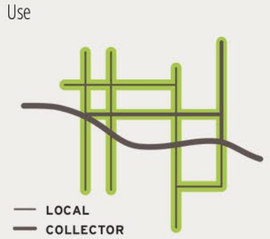
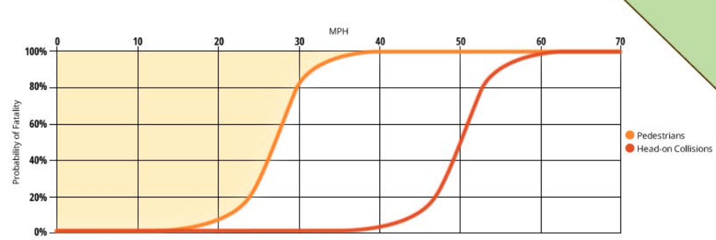


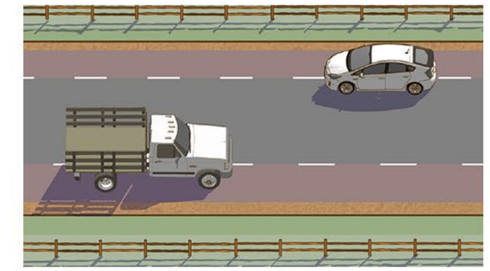


For Local Roads Only
This roadway design is only intended for low-volume, low-speed applications. It is designed to keep actual speeds below 30 mph.

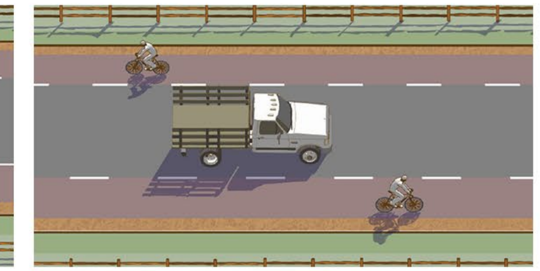
Local Roads

Advisory Shoulders

Roads with advisory shoulders accommodate low to moderate volumes of two-way motor vehicle traffic and provide a prioritized space for bicyclists with little or no widening of the paved roadway surface. Unlike a conventional shoulder, an advisory shoulder is a part of the traveled way, and it is expected that vehicles will regularly encounter meeting or passing situations where driving in the advisory shoulder is necessary and safe. The advisory shoulder space is a visually distinct area on the edge of the roadway, offering a prioritized space for people to bicycle and walk.



For Use by Cars...
When two motor vehicles meet, motorists may need to encroach into the multimodal space



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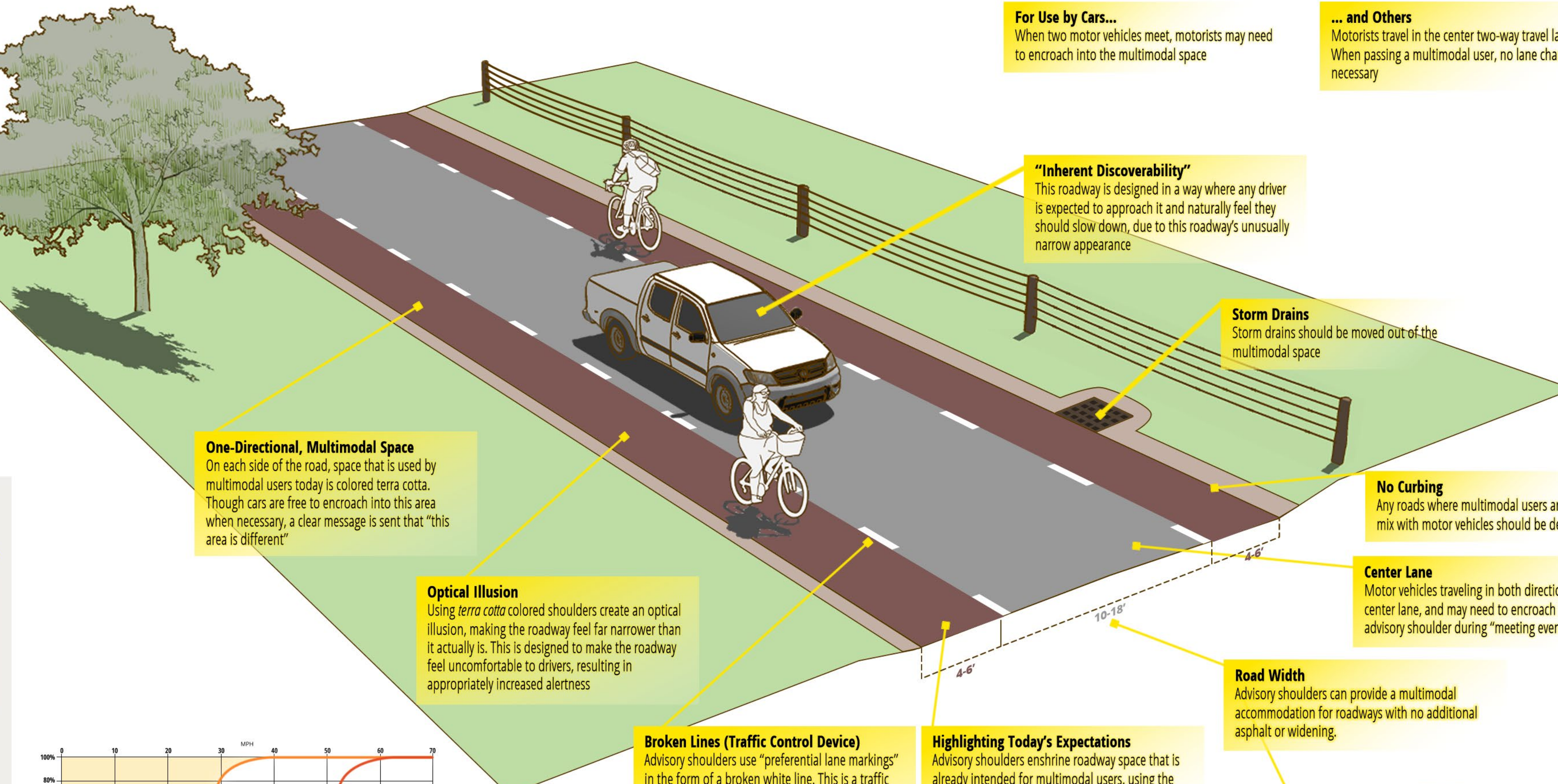


"Inherent Discoverability"
This roadway is designed in a way where any driver is expected to approach it and naturally feel they should slow down, due to this roadway's unusually narrow appearance

Storm Drains
Storm drains should be moved out of the multimodal space

One-Directional, Multimodal Space
On each side of the road, space that is used by multimodal users today is colored terra cotta. Though cars are free to encroach into this area when necessary, a clear message is sent that "this area is different"

No Curbing
Any roads where multimodal users are expected to mix with motor vehicles should be devoid of curbs

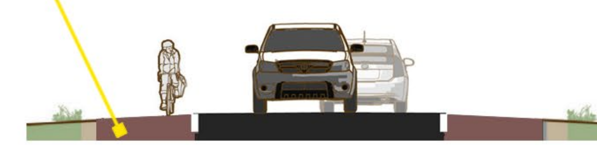
Center Lane
Motor vehicles traveling in both directions share a center lane, and may need to encroach into the advisory shoulder during "meeting events."

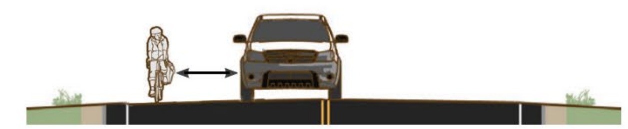
Optical Illusion
Using *terra cotta* colored shoulders create an optical illusion, making the roadway feel far narrower than it actually is. This is designed to make the roadway feel uncomfortable to drivers, resulting in appropriately increased alertness

Road Width
Advisory shoulders can provide a multimodal accommodation for roadways with no additional asphalt or widening.

Broken Lines (Traffic Control Device)
Advisory shoulders use "preferential lane markings" in the form of a broken white line. This is a traffic control device, which formalizes the rules of this road. As a result, cars are expected to keep to the middle of the road, though they are permitted (and expected) to use the advisory shoulder as needed (usually when passing)

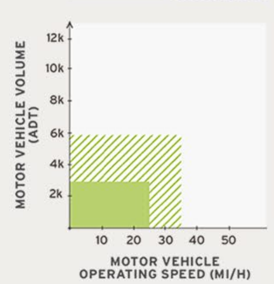
Highlighting Today's Expectations
Advisory shoulders enshrine roadway space that is already intended for multimodal users, using the design of the road itself to clearly communicate the need to share this space





Design Applications

Speed and Volume



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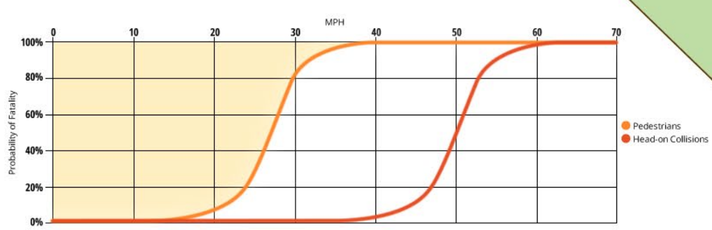


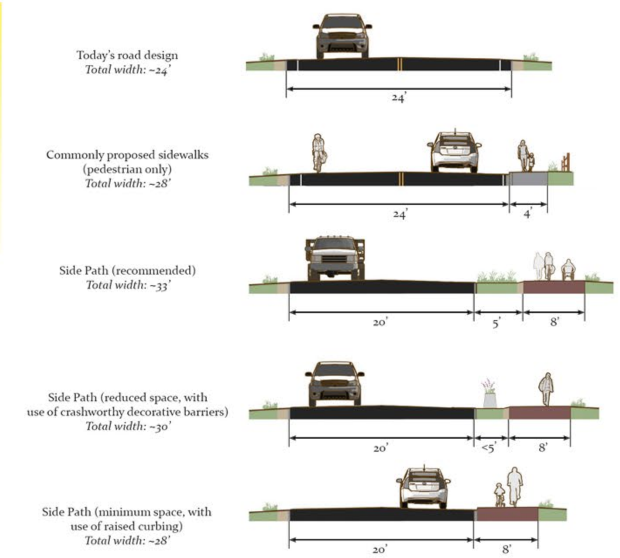
For Local Roads Only
This roadway design is only intended for low-volume, low-speed applications. It is designed to keep actual speeds below 30 mph.

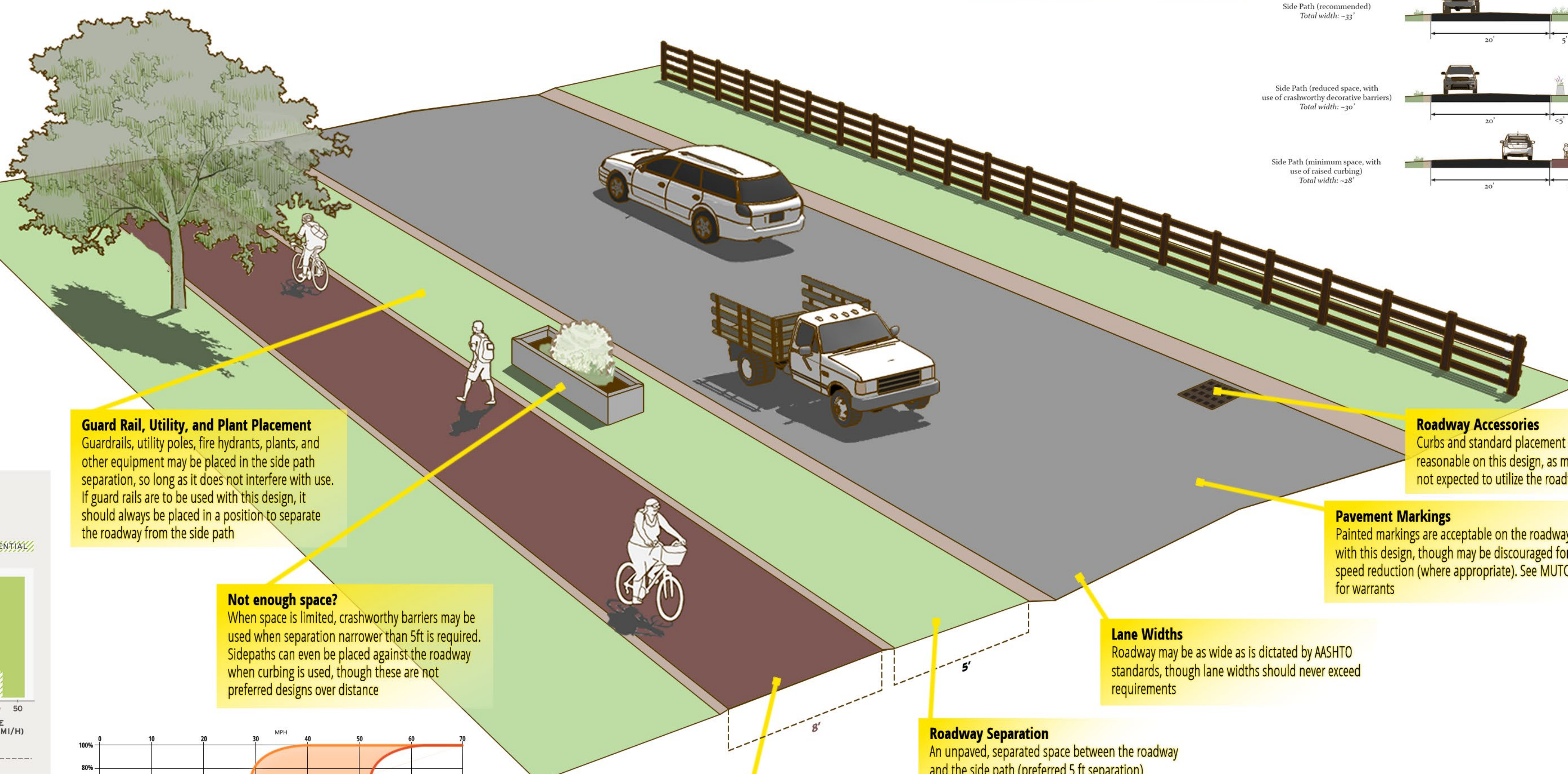
Collectors

Sidepath

A sidepath is a bidirectional shared use path located immediately adjacent and parallel to a roadway. Sidepaths can offer a high-quality experience for users of all ages and abilities as compared to on-roadway facilities in heavy traffic environments, allow for reduced roadway crossing distances, and maintain rural and small town community character. Unlike sidewalks, side paths legally accommodate non-pedestrian multimodal uses, making it a more appropriate roadway treatment in sparsely populated communities such as ours.

Roadway Footprints
Sidepaths require additional space beside the street, but their requirements are very similar to those of conventional sidewalks, especially when coupled with lane narrowing. Though the standard side path foot print requires an 8' path with 5' separation, temporary alternative options are available where space is otherwise too narrow





Guard Rail, Utility, and Plant Placement
Guardrails, utility poles, fire hydrants, plants, and other equipment may be placed in the side path separation, so long as it does not interfere with use. If guard rails are to be used with this design, it should always be placed in a position to separate the roadway from the side path

Not enough space?
When space is limited, crashworthy barriers may be used when separation narrower than 5ft is required. Sidepaths can even be placed against the roadway when curbing is used, though these are not preferred designs over distance

Roadway Accessories
Curbs and standard placement of storm drains are reasonable on this design, as multimodal users are not expected to utilize the roadway

Pavement Markings
Painted markings are acceptable on the roadway with this design, though may be discouraged for speed reduction (where appropriate). See MUTCD for warrants

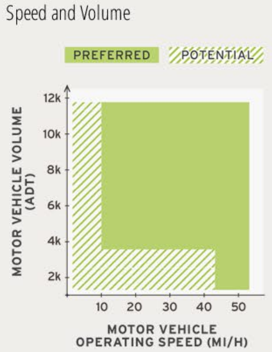
Lane Widths
Roadway may be as wide as is dictated by AASHTO standards, though lane widths should never exceed requirements

Roadway Separation
An unpaved, separated space between the roadway and the side path (preferred 5 ft separation)

Side Path Width
8 ft is the preferred minimum width of the side path, allowing for easy bi-directional multimodal traffic.

Design Applications

Speed and Volume



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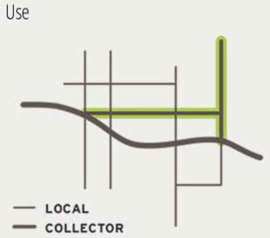
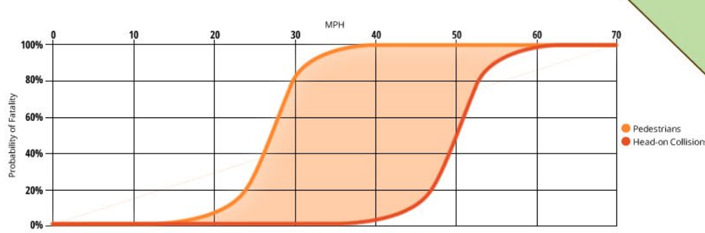
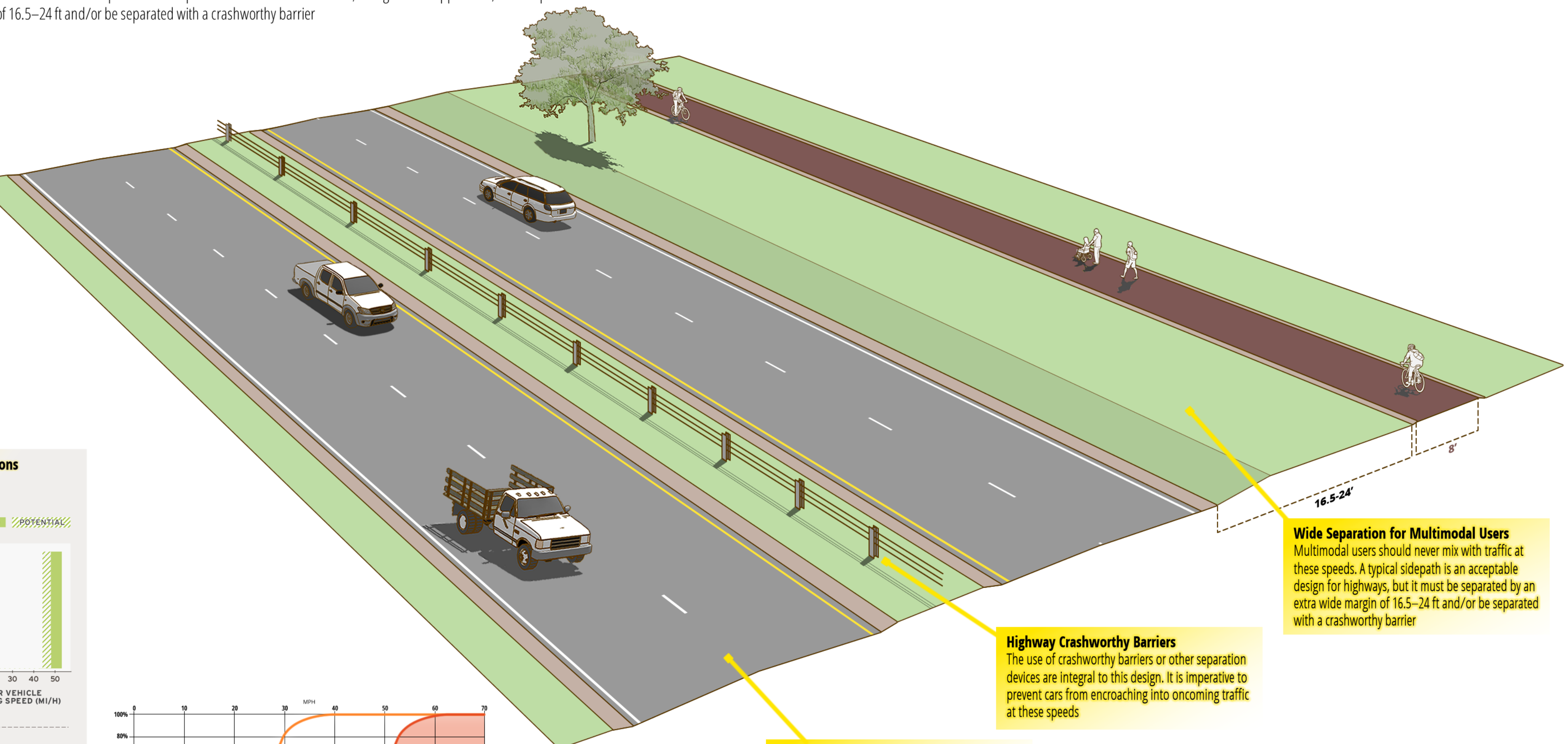




For Connecting Streets
Sidepaths are best used when roadways no longer reflect a local character. Once a roadway is a connecting street and speeds pass 30 mph, it is best to separate vehicles from multimodal users

Divided Highways

At speeds of 50 mph and above, car vs. car collisions have a high fatal potential, especially with frontal (head-on) and frontal overlap (off-center head-on) collisions. For these reasons, these streets should include a physical separation of vehicles by direction as well as a physical separation of vehicles from multimodal users. For highways, the use of safety techniques from the "traffic world" are certainly appropriate. The human body is not naturally equipped to travel at 50+ mph speeds and thus the street must provide predictability, uniformity, wide lanes, painted lane markings, physical barriers, and other means of absorbing human error. The use of a sidepath is still the preferred multimodal treatment, though in this application, the sidepath must be offset from the roadway at a distance of 16.5–24 ft and/or be separated with a crashworthy barrier



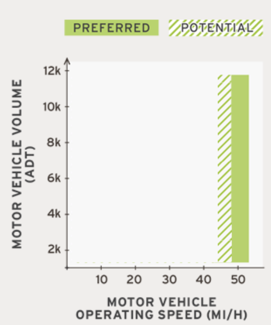
Wide Separation for Multimodal Users
Multimodal users should never mix with traffic at these speeds. A typical sidepath is an acceptable design for highways, but it must be separated by an extra wide margin of 16.5–24 ft and/or be separated with a crashworthy barrier

Highway Crashworthy Barriers
The use of crashworthy barriers or other separation devices are integral to this design. It is imperative to prevent cars from encroaching into oncoming traffic at these speeds

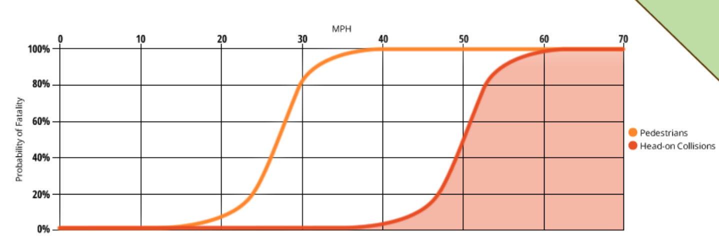
Separation by Direction
Motor vehicles are separated by direction in this design, nearly eliminating the possibility of frontal or frontal-overlap collisions

Design Applications

Speed and Volume



Use



For Highways Only
Divided highways are only for use at speeds above ~50 mph. Traffic volume is no longer a consideration at this speed