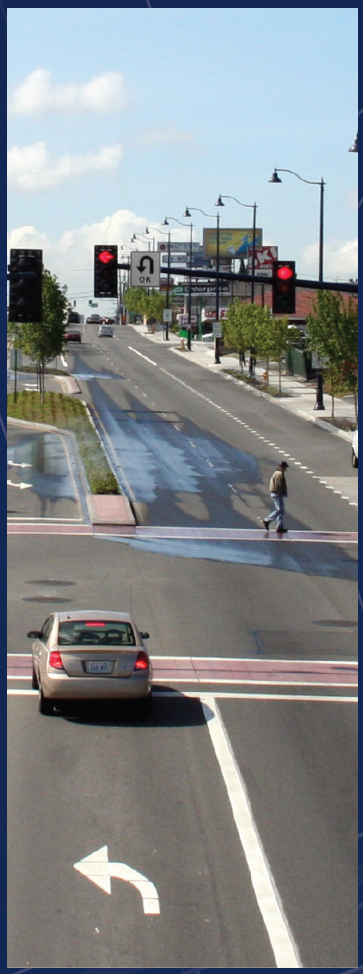

# Implementing Context Sensitive Design
## on Multimodal Thoroughfares

**A Practitioner's Handbook**

ite

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## Preface and Acknowledgments

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This report was produced by ITE with case study content development and technical review done by the Congress for the New Urbanism (CNU), and is the result of concerted effort by dedicated volunteers, including ITE members, CNU members, and many other interested parties. ITE wishes to thank the members of each of the following committees for their respective roles in the preparation of this repot.

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# Table of Contents


**1 Introduction ..... 1**

1.1 About This Report ..... 2

1.2 About Context-Sensitive Solutions ..... 8

**2 Pre-Design ..... 9**

2.1 Design Principles ..... 10

2.2 Supportive Policies and Programs ..... 14

**3 Modal Considerations & Design ..... 18**

3.1 Users of the Street ..... 19

3.2 Role of Project Street in the Network ..... 26

3.3 Understanding the Project's Street Type ..... 34

3.4 Analysis Tools ..... 38

**4 Pedestrian Mobility & Safety ..... 48**

4.1 Typical challenges ..... 49

4.2 Increase safety and pedestrian activity along the street ..... 50

4.3 Crossing Location, Treatment, and Design ..... 56

4.4 Intersection Design ..... 62

4.5 Intersection Control ..... 67

**5 Speed Management ..... 70**

5.1 Typical challenges ..... 71

5.2 Why Speed Matters ..... 72

5.3 Interventions to Manage Vehicle speeds ..... 77

**6 Case Studies ..... 86**

Introduction ..... 86

Cincinatti, Ohio ..... 87

Dallas, Texas ..... 91

Hamburg, New York ..... 95

Lancaster, California ..... 100

Raleigh, North Carolina ..... 107

San Diego, California ..... 112

South Miami, Florida ..... 117

**7 Bibliography ..... 121**

# Introduction

1

# 1.1 About This Report

## 1.1.1 What Is This Informational Report and Who Is It For?

*Implementing Context Sensitive Design for Multimodal Thoroughfares: A Practitioner's Handbook* provides guidance to practitioners who are creating multimodal thoroughfares as part of a Context Sensitive Solutions (CSS) project development and design process. CSS requires practitioners to understand their project corridor within the environment of community goals, the street network, and land use. This guidance allows practitioners to link the goals and objectives of their particular communities to the physical elements of street design that will best support those goals. The design measures and methods described here may be applied in a way that is tailored to local needs, is performance- or outcome-driven, and is responsive to established national and local policy.

This report focuses on arterial and collector roadways in suburban areas, urban edges, and small towns. In these communities, the desire for streets where people can walk and bicycle mean rethinking how existing roadway space is planned, designed, and operated. Changing a suburban roadway into a complete street may seem like a daunting task, contingent on major redevelopment or reconstruction, but much can be done within the existing land use and street framework. Communities have used materials, striping, signalization, and landscaping to make commercial and retail corridors attractive for walking (Figure 1.1).

This report is targeted for use by a range of street design practitioners, including policymakers, planners, engineers, traffic operations professionals, and others. Its primary purpose is its utilization as a resource during the planning and conceptual design phases of a corridor project in both existing and planned development areas. This report is focused on familiarizing the practitioner with design concepts and countermeasures that tackle common street design challenges.

## 1.1.2 Relationship of This Informational Report to Others

This report presents principles and approaches for the design of streets that are safe and comfortable for all users. While the information in this report is valid in a variety of communities and contexts, it is intended specifically for use in suburban communities and small towns. "Thoroughfares" in this report include arterial and collector streets (as defined under the FHWA Functional Classification system). Most Americans live and/or work in land use contexts that may be characterized as suburban, including large parts of major cities. Guidance from NACTO and FHWA already exists for downtown urban core areas; this report seeks to fill the gap in the literature pertaining to general urban (outside downtown), suburban, and rural town communities (Figure 1.2).

**Figure 1.1** Suburban arterials can be transformed from auto centric to multimodal spaces *(Source: City of Shoreline, WA)*

**Figure 1.2** This report applies to three context areas—rural town, suburban, and urban *(Source: Nelson\Nygaard. Based off contexts in* NCHRP 15-52, Developing a Context-Sensitive Functional Classification System for More Flexibility in Geometric Design.*)*

This report is one of many street design manuals now available. It updates and builds on ITE's 2010 *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice (Recommended Practice).* That document provides guidance on applying CSS principles to street design in efforts to make streets more walkable, multimodal, and/or supportive of mixed-use development. This report updates some concepts in that document and, as explained below, is intended specifically for use in general urban and suburban areas in the process of transitioning to a more walkable community.

This report is also intended to be complementary to other design guidance documents including:

- American Association of State Highway and Transportation Officials (AASHTO) *Policy on Geometric Design of Highways and Streets (2011)*, better known as the "Green Book"
- AASHTO *Guide for the Planning, Design and Operation of Pedestrian Facilities (2004)*
- AASHTO *Guide for the Development of Bicycle Facilities (2012)*
- FHWA *Manual on Uniform Traffic Control Devices (2009)*, or MUTCD
- Transportation Research Board (TRB) *Highway Capacity Manual (2010)*
- AASHTO *Highway Safety Manual (2014)*
- ITE *Traffic Engineering Handbook (2016)*
- ITE's *Planning Urban Roadway Systems: An ITE Recommended Practice (2014)*
- ITE's *Integration of Safety in the Project Development Process and Beyond: A Context Sensitive Approach (2015)*
- United States Access Board *Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (2011)*, or PROWAG

These documents are commonly-used sources for reference in street design. However, their policies provide some flexibility, and reports such as this one, the National Association of City Transportation Officials (NACTO) *Urban Streets Design Guide*[1], the NACTO *Transit Street Design Guide*, and the Dutch *CROW Design Manual for Bicycle Traffic* may be used as compatible supplemental documents.

## 1.1.3 Organization of This Report

The organization of this report reflects the planning, design, and implementation process for multimodal thoroughfares: it starts with issues that are typically addressed prior to or at the start of the planning process, proceeds to general and mode-specific design concerns, and then focuses on pedestrian accommodations and the critical topic of vehicle speed management. It concludes with a series of case studies and a literature review.

Rather than an exhaustive list of design elements, this report emphasizes problem-solving for key issues practitioners face. For example, many design resources already exist detailing the dimensions of bicycle facilities and sidewalks. This report aims to fill a gap in the literature by focusing on the project development process and common challenges faced by practitioners.

[1] Please note that the NACTO guide recommends use of some traffic control devices and treatments that are non-compliant with MUTCD, which state and local jurisdictions must comply with under federal regulations.

## 1.1.4 The Need for This Report

Communities as well as transportation and land use planning professionals are increasingly recognizing that streets play an important role beyond their late-20th century function as conduits for motor vehicle travel. Streets can support a variety of mobility and land use contexts. Streets make up a large percentage of a community's public land, and as such can become public gathering places in addition to serving transportation functions. Such functions represent a return to the traditional concept of streets as spaces for movement by various modes and as public spaces.

The breadth of community goals and objectives that are considered in design processes can include but are not limited to the following (Figure 1.3):

- Mobility
- Accessibility and quality of life
- Environment
- Economy
- Public health
- Placemaking
- Safety and security
- Equity

If properly designed in response to a community's unique needs and the specific requirements of each site, multimodal thoroughfares can provide support for that community's goals and objectives in each of these areas. Each potential goal is described in further detail below.

### Mobility

Starting in the mid-20th century, major streets in North America were designed primarily to minimize vehicle travel delay and move motor vehicle traffic, neglecting the needs of other users. Well-designed multimodal thoroughfares, however, can support a range of safe, affordable, and sustainable mobility options including walking, riding a bike, and taking transit. While not every street can support all uses, a well-designed multimodal thoroughfare within a connected network will support a variety of different trip types such as commuting, recreation, social ventures, and adjacent businesses while maintaining good access for cars and freight.

### Economy

For a community to realize its full economic potential, it needs a network of streets designed to provide access to businesses via different modes and by different groups of users, including workers and consumers at all income levels. Connected networks and space for freight deliveries ensure timely goods movement and delivery. Walkability adds a premium to real estate values, and attracts investment.

### Environment

A trip made by walking, bicycling, or transit produces less emissions per passenger mile than a trip made by car. Improved air quality, reduced greenhouse gas emissions,

**Figure 1.3** Measure transportation investments in people terms *(Source: Nelson\Nygaard)*

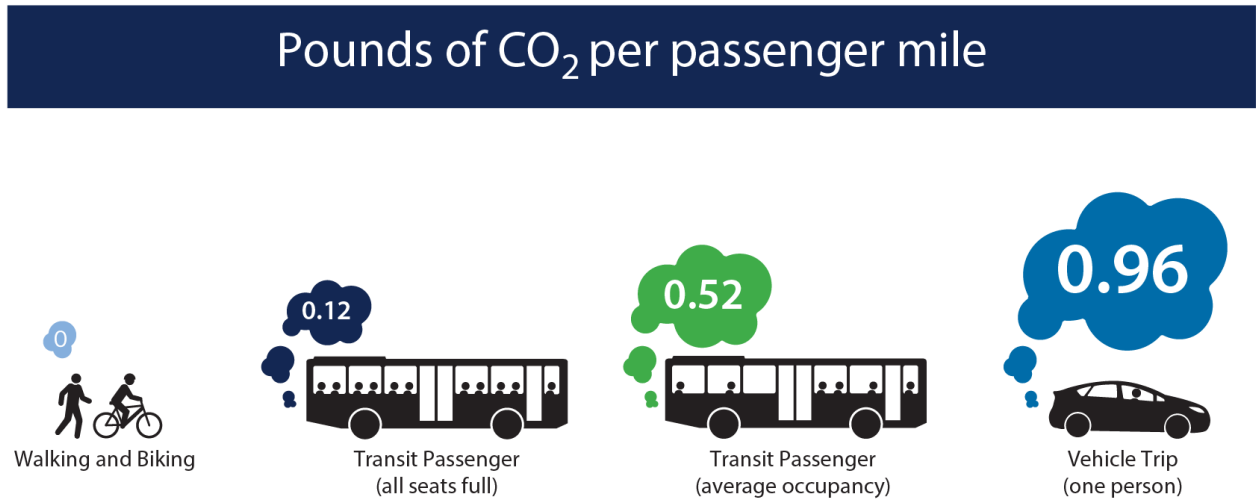


**Figure 1.4** On a per-passenger basis, transit, walking, and bicycling produce less emissions than single-occupant vehicle trips *(Source: Nelson\Nygaard)*[1]

decreased noise pollution, and more sustainable handling and quality of water are additional benefits (Figure 1.4).

## Equity

Equitable transportation systems provide mobility in a way that strives to meet the unique needs of all members of the community. Equity is distinct from equality—equity seeks to provide underserved populations with mobility options necessary to reach fair levels of access, whereas equality would provide the same amount of mobility options for all regardless of existing service levels. Equity facilitates social and economic opportunities for populations that have historically been underserved, including low-income persons, persons of color, older adults, children, persons with limited English proficiency (LEP), and persons with disabilities.

Equitable multimodal thoroughfares reduce costs and improve economic opportunity and overall quality of life for low and moderate-income households in several ways including the following (Figure 1.5):

- They help facilitate multiple mobility options such as riding a bike or taking the bus, which are generally less costly than driving an automobile. Transportation accounts for a large share of household costs.

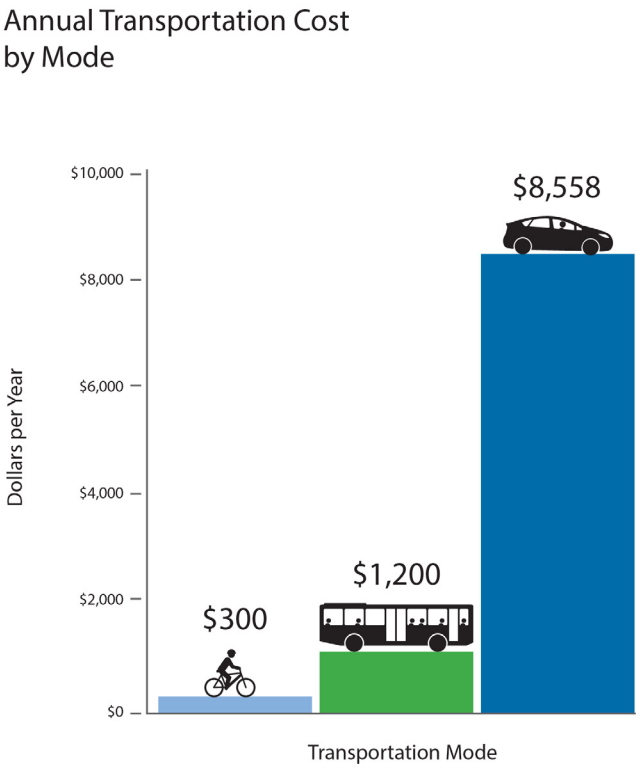


**Figure 1.5** Reliance on automobiles substantially increases transportation costs and can account for a large share of all costs in low-income households *(Source: Nelson\Nygaard)*[2]

[1] Data derived from FTA. Public Transportation's Role in Responding to Climate Change.
[2] Based on data from the following sources:
(1) The League of American Bicyclists and the Sierra Club. "The New Majority: Pedaling Towards Equity." 2013.
(2) Based on an average of the transit costs for monthly Pierce Transit rides ($864 or $72 per month) or a monthly ORCA card traveling through multiple counties ($1,512 or $126 per month).
(3) American Automobile Association. *Your Driving Costs,* 2013.

- They can enhance economic opportunities by improving access to jobs and job training opportunities.
- They can provide safety, air quality, and other benefits to low-income populations and/or minority populations who have historically been subjected to adverse or disproportionately high and adverse human health and environmental impacts.
- They can improve access to grocery stores, health care, greenspace, and provide recreation opportunities.
- Multimodal thoroughfares can improve accessibility and mobility for people with disabilities by adhering to tenets of universal design and the Americans with Disabilities Act (ADA) design requirements.

## Safety & Security

Multimodal thoroughfares improve public safety and personal security in the following two ways:

- They may reduce both crash rates and crash severity[1], particularly for crashes involving the most vulnerable users of the street—pedestrians and bicyclists **(Figure 1.6)**.
- By increasing levels of pedestrian activity, they increase the numbers of "eyes on the street," and help reduce crime and enhance personal safety through principles of crime prevention through environmental design (CPTED).[2]

## Health

Multimodal thoroughfares support public health goals by improving air quality, reducing injuries, and enabling and encouraging active transportation and recreation, including walking and bicycling **(Figure 1.7)**.

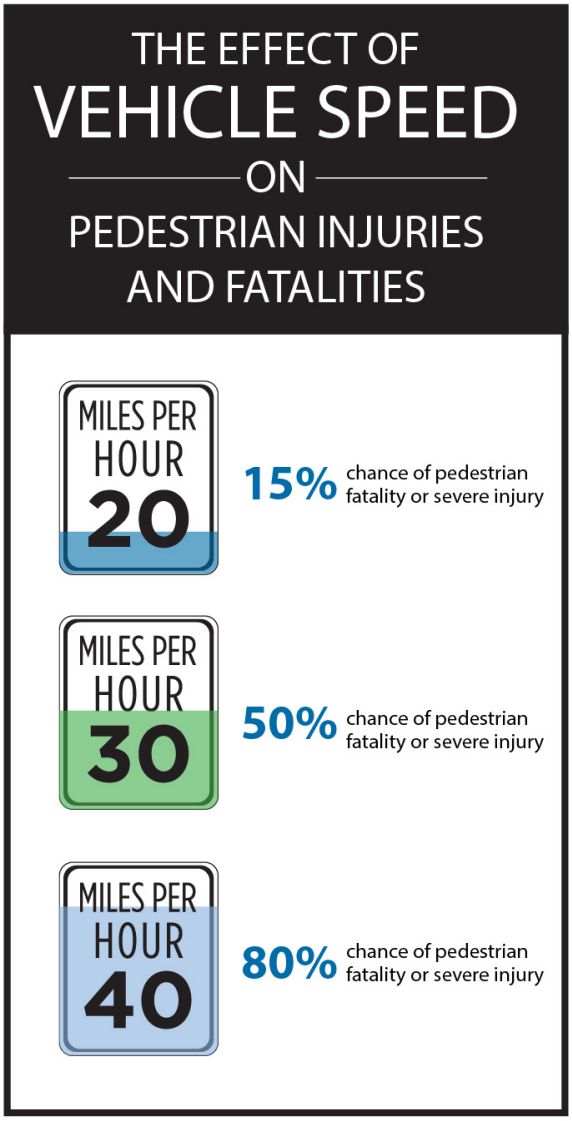


**Figure 1.6** Vehicle speed is a primary determinant of safety outcomes *(Source: Nelson\Nygaard)*[3]

[1] National Association of City Transportation Officials. *Urban Street Design Guide,* 2013. https://nacto.org/publication/urban-street-design-guide/design-controls/design-speed/.

[2] U.S. Department of Transportation, "Built Environment Strategies to Deter Crime". https://www.transportation.gov/mission/health/built-environment-strategies-to-deter-crime.

[3] Based on data from the source: AAA Foundation for Traffic Safety. *Impact Speed and a Pedestrian's Risk of Severe Injury or Death,* 2011.

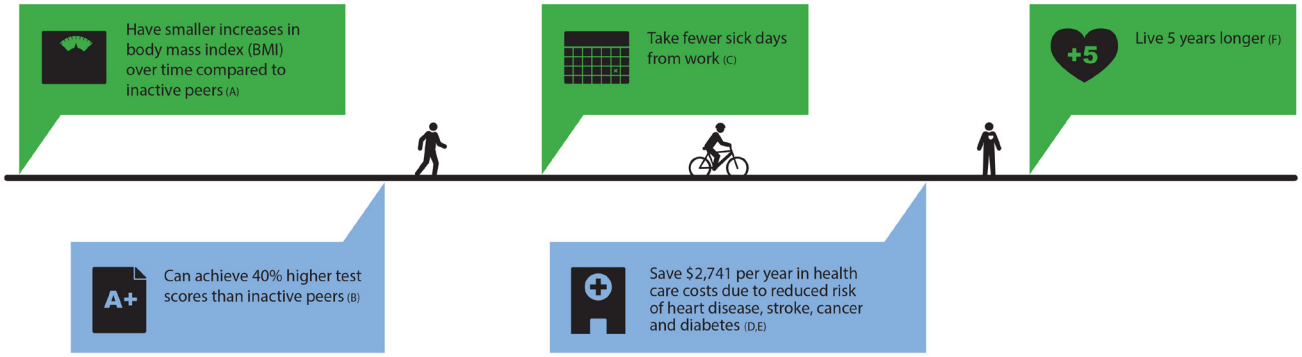


**Figure 1.7** Safe and attractive active transportation options improve public health. *(Source: Nelson\Nygaard)*[1]

**Figure 1.8** Well-designed walkable thoroughfares create places *(Source: Nelson\Nygaard)*

## Placemaking

Depending on available right-of-way, multimodal thoroughfares may include a generous public sphere designed to support public interaction, civic engagement, and other non-mobility-related objectives (Figure 1.8). They may also contribute to civic beautification and non-mobility-related environmental objectives by incorporating shade, filtering stormwater, and reducing impervious street surface.

[1] Based on data from the following sources:
(1) Moore, L., et. al. "Does early physical activity predict body fat change throughout childhood?" *Preventive Medicine* 37, (2003): 10-17.
(2) Grissom, J. "Physical Fitness and Academic Achievement." *Journal of Exercise Physiology* 8, No. 1 (2005): 11-25.
(3) Proper, K.I., et. al. "Dose-response relation between physical activity and sick leave." *British Journal of Sports Medicine* 40, No. 2 (2006): 173-178. doi:10.1136/bjsm.2005.022327.
(4) U.S. Department of Health and Human Services. "Physical Activity Guidelines for Americans." 2008. http://www.health.gov/paguidelines/default/aspx.
(5) Cawley, J. and C. Meyerhoefer. "The medical care costs of obesity: An instrumental variables approach." *Journal of Health Economics,* 31, Iss. 1 (January 2012): 219-230.
(6) Olshansky, S.J., et. al. "A Potential Decline in Life Expectancy in the United States in the 21st Century." *New England Journal of Medicine* 352, No. 11 (2005): 1138-1145.

# 1.2
# About Context-Sensitive Solutions

Context Sensitive Solutions, or CSS, is an approach to developing, delivering, and operating transportation projects that seeks to ensure affected community members are active, valued participants in the planning process, and result with a transportation project or process that supports a broad range of community needs and desires. Using a CSS approach is important as a means of planning successful transportation projects, helping facilitate community dialogue, and helping build stronger communities. It is especially applicable to the design of multimodal thoroughfares, or the major streets in a community that must serve a broad range of mobility, social, economic, and environmental needs.

To apply CSS principles, it is necessary to proactively involve community members in the area planning, project selection, project planning, and design processes to understand the needs of all users. In approaching transportation in such a way, practitioners have an opportunity to integrate community objectives and community design concepts. This includes accommodating all street users, making decisions that reflect a shared stakeholder vision, and demonstrating an understanding of the tradeoffs that come with balancing multiple needs. A CSS approach includes the following:

- *Understanding the Whole Context*—Well-designed streets match the context of the area they serve. Physical characteristics such as the placement and height of buildings, the uses within those buildings, and landscaping should be paired with streets designed to match the needs of users. In contexts that are or may be transitioning (for example from suburban to light urban) streets should be designed to be consistent with the future land use context.
- *Engaging Relevant Disciplines*—Correctly diagnosing what a corridor's context is or should be is better done with the participation of people with varying expertise. The differing perspectives of engineers, urban practitioners, and planners can help in making the best identification of context.
- *Engaging Affected Stakeholders*—In addition to multi-disciplinary professional participation, collaboration with members of the community is a key part of making the right diagnosis. Not only do people know their own communities, but early participation in the design process can help build support for the ultimate solutions.
- *Establishing Collaborative Communication*—Collaboratively developed solutions are often better supported than ideas created in isolation that often need to be explained and defended. This collaboration should begin early and carry on through the process.
- *Beginning with an Open Mind and a Blank Sheet*—While in some instances (such as critical safety issues) there is an immediate need and a clear solution to be implemented, more often street projects involve tradeoffs and opportunities that can be better resolved by groups engaged in a creative process.
- *Developing Consensus on Performance-based Goals and Targets*—Clearly documenting desired outcomes can help to resolve tradeoffs throughout the process.

These process principles are simple to state, but challenging to manage in practice. Even experienced professionals can have a tough time adopting and successfully applying these steps. Yet, they are often the differentiator between consensus outcomes and contextual solutions, versus contentious outcomes and mismatched projects.

# Pre-Design

## 2

Practitioners are faced with design decisions and opportunities to create multimodal thoroughfares in many different ways. For example, street repavings or utility work present opportunities for restriping or adding landscaping. Development applications open up conversations about changes to the right-of-way that might be paired with the development project. Planning studies or grant funds may be obtained by a community to specifically evaluate the creation of multimodal corridors and produce conceptual or 10 percent design plans, which can be used to leverage construction funds. Large capital projects such as rapid transit facilities are often implemented in tandem with street redesign. This chapter provides examples of multimodal design principles that can be established during the pre-design stages of the project and followed throughout.

Good street infrastructure can be supported by land use policies and codes in a self-reinforcing cycle. Policies can support compact development, high-quality sidewalks, and demand management strategies, for example, and open the door to multimodal street construction. This chapter also provides examples of policies that encourage multimodal thoroughfare implementation.

# 2.1 Design Principles

Project goals, purpose, and need are created by the project team at the outset of the project. These goals provide a framework for evaluating the project at various stages of planning and design. The following provides examples of design principles that can inform creation of goals and objectives.

## 2.1.1 Design for All Users

Multimodal thoroughfares facilitate usage by many types of users. Including all users in designs means assessing with equal level of rigor, outcomes for those walking, bicycling, delivering freight, or taking transit, in addition to those driving. For example, instead of focusing on vehicle Level of Service (LOS), designing for all users means looking at levels of delay, capacity, and comfort for pedestrians as well. During public outreach, ensure that people who are existing or potential pedestrians or bicyclists provide input. Include all users in analysis and outreach and reflect their needs in the design.

## 2.1.2 Emphasize Mobility for People & Goods

**Person capacity** refers to the number of persons that may theoretically use a space based on transportation right-of-way configuration. **Goods capacity** similarly refers to the amount of cargo that can be transported over a street. Traditional transportation planning reports capacity in terms of vehicle volumes such as Average Daily Traffic (ADT). This treats all vehicles as equivalent whether they are carrying one or 100 passengers, and excludes non-motorized modes altogether.

Person/goods capacity analysis will favor freight, transit, carpools, and bicycles over single-occupancy vehicles (Figure 2.1). This analysis describes the efficiency of a

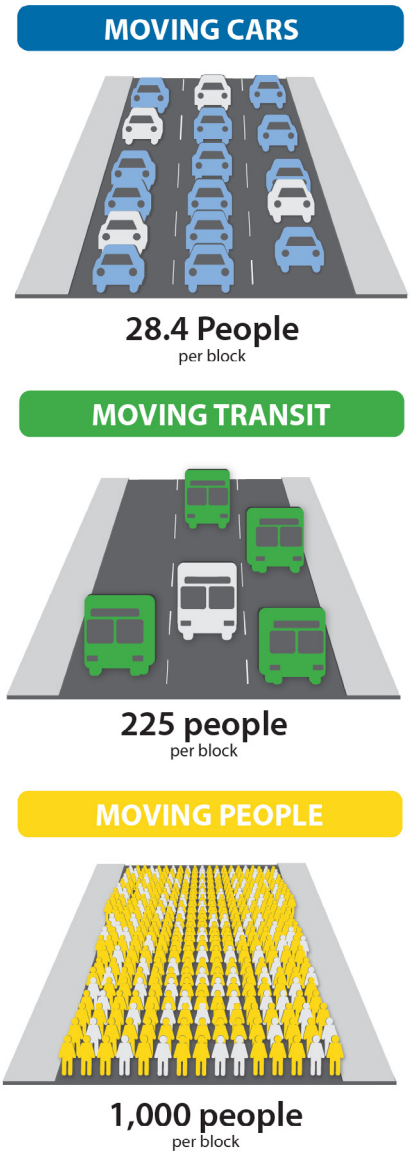


**Figure 2.1** Move people and goods, not just vehicles *(Source: Nelson\Nygaard)*[1]

[1] City Block assumed 40' curb to curb and 300' long. The space needs for pedestrians and vehicles based on source: Victoria Transport Policy Institute. "Evaluating Transportation Land Use Impacts." 2014; average number of passengers per automobile calculated based on National Household Travel Survey Summary of Travel Trends (2009).

transportation facility, which objectively illustrates return on investment.

Replace vehicle capacity metrics with person capacity metrics (persons per mile, persons per hour) and/or goods capacity metrics (such as value or volumes of goods transported).

## 2.1.3 Incorporate Legible Design

"Intuitive design" is a phrase from the design industry that means when a user sees a product, she/he know exactly how to use it without reading detailed instructions. This same concept can be applied to streets to make them legible and easy to use. For streets, legible design describes a condition where a person can understand the expected use of a street from cues in the physical environment and the design of the street, without the need for excessive signs and traffic control devices.[1]

When practitioners implement legible design, the pathway for each traveler/user is clearly delineated primarily by design cues rather than signage. In that sense, the legibility of the street, or the ability of users to "read" the street and the message it sends about speed, is maximized while potential conflicts are minimized. The street becomes self-explaining and self-enforcing.

Legibility tools include the following:

- Matching the number of entering and receiving lanes through an intersection minimizes the need for merging within the intersection (Figure 2.2).
- Compact intersections that facilitate eye contact and clearly lay out the path of travel.
- Striping bicycle lanes through intersections to show the path of travel.
- Add trees, pedestrian refuge islands, or other friction elements to keep motorist speeds at desired levels[2].

## 2.1.4 Create Equitable Streets

Development of some major thoroughfares and highways, particularly those designed exclusively for automobile transportation, has resulted in adverse environmental impacts, such as disruption of community cohesion, land consumptions, and other human health effects to communities. Historically, these negative impacts were disproportionately borne by disadvantaged and underrepresented populations. Concern for these negative impacts and for the human and natural environment led to the passage of the National Environmental Policy Act (NEPA), and subsequently motivated the development of Executive Order (E.O.) 12898. This E.O. defines the concept of environmental justice and directs federal agencies to make achieving environmental justice part of their mission. This mission is accomplished by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations. Fully-addressing environmental justice can facilitate an equitable distribution of benefits and burdens associated with transportation projects. Additionally, an equitable balance of benefits and burdens in regards to the development of multimodal thoroughfares can promote access to social and economic opportunity for disadvantaged populations.

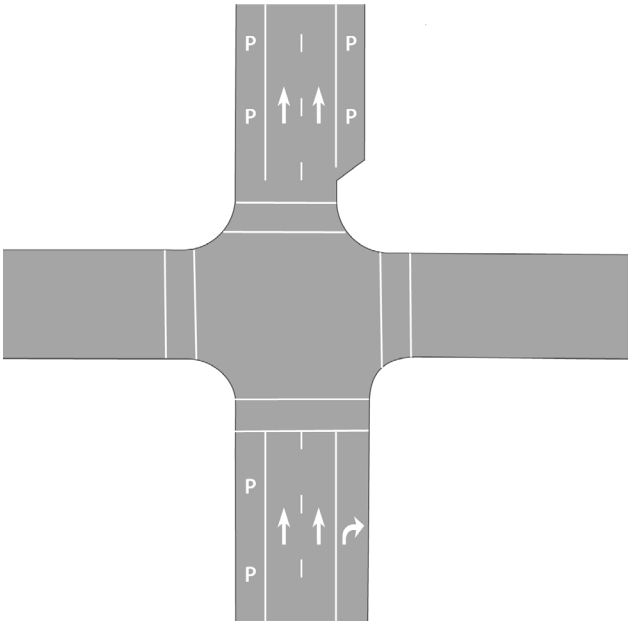


**Figure 2.2** Align entering and receiving lanes
*(Source: Nelson\Nygaard)*

[1] This idea of physical characteristics impacting motorist speed is referenced in AASHTO's publication as follows: "The speed of vehicles on a road or highway depends, in addition to capabilities of the motorists and their vehicles, on five general conditions: the physical characteristics of the highway, the amount of roadside interference, the weather, the presence of other vehicles, and the speed limitations (established either by law or by traffic control devices)." Source: American Association of State Highway and Transportation Officials. *A Policy on Geometric Design of Highways and Streets,* 6th ed. Washington, D.C., 2011

[2] National Association of City Transportation Officials. *Urban Street Design Guide,* 2013. http://nacto.org/publication/urban-street-design-guide/design-controls/design-vehicle/.

Measuring equity benefits and burdens can be achieved in a variety of ways. This can range from geographic analyses focused on mobility needs-assessments of disadvantaged communities, or an analysis of other factors that can determine whether a proposed project may have an adverse impact on a disadvantaged community. Inclusive public outreach and meaningful involvement can also improve equity by ensuring that practitioners hear from all members of the community, including those who are minority, low-income, have a disability, are elderly, and/or have limited proficiency to speak English.

## 2.1.5 Think of Streets as Community Places

In many communities, the public right-of-way makes up a large portion of public property and can be seen as a valuable resource, carefully allocated with a maximum degree of stakeholder engagement.

Where sufficient rights-of-way exist, allow for a variety of non-mobility uses, both public and private (as permitted by federal, state, and local laws), stationary and mobile, permanent and temporary, programmed and spontaneous. A few examples include seating, utilities, public art, lighting, landscaping, and drainage. Many communities also turn streets into event spaces (Figure 2.3, Figure 2.4).

## 2.1.6 Design for the Future

Think beyond solving today's problem and consider the impacts of a project during the next half-century. Planning timelines are often set at 20 years but project scale and function may last for 50 years or more. Invest today in infrastructure that can serve the community for a long time. By investing in the short-term, a street's person-capacity can be greatly increased. This "future proofing" accommodates growth without costly road expansions (Figure 2.5).

**Figure 2.3** Community events in Atlanta (left) and Columbus, OH (right), reallocate the street for community uses *(Source: Nelson\Nygaard)*

**Figure 2.4** Landscaping and parklets add greenery and a community gathering place *(Source: Nelson\Nygaard)*

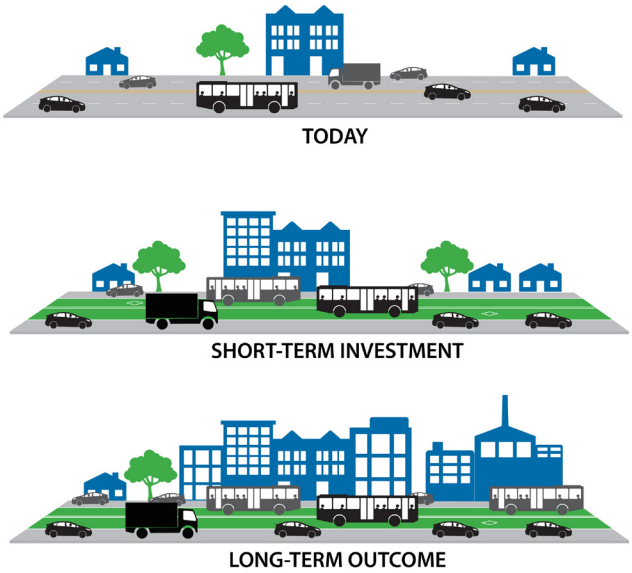


**Figure 2.5** Investments in streets with high-capacity transit in the short-term accommodate growth without costly roadway expansions over the long-term *(Source: Nelson\Nygaard)*

Long-range traffic capacity considerations are often an obstacle to multimodal street design. Dedicating space to transit or bike lanes, for example, may garner opposition because traffic models predict increases in auto traffic that pre-empt using space for other users. In many communities, traffic volumes actually decline over time; nationally, VMT per capita has exhibited more frequent downward trends since the early 2000s[1]. Policies such as mode share targets or complete streets ordinances support proactively making investments that shift some of the future projected traffic to walking, bicycling, or transit.

## 2.1.7 Create Performance Measures

Performance measures and evaluation criteria can be used in the planning, design, construction, and project evaluation phases. Align measures with goals and use evaluation criteria that can be easily measured. It is ideal if the data needed to evaluate designs is readily available and easy to collect. When possible, use quantitative evaluation criteria. In some cases, however, qualitative metrics will be needed and require judgment to evaluate. For example, measures related to community outreach or placemaking may not be quantifiable.

Expand beyond commonly-used transportation performance measures (crash rates, vehicle throughput, and vehicle level of service) to more broadly consider community goals. For example, measures could include pedestrian comfort, placemaking, vehicle speed, or freight access.

Where possible, post-project reporting can be shared with the public, in accessible formats, as a means of furthering transparency.

The FHWA *Guidebook for Developing Pedestrian and Bicycle Performance Measures* provides language to assist in the development of measures and criteria. The NACTO *Urban Street Design Guide* also includes a sample list of performance measures that may be considered during project development and evaluation.

[1] Sundquist, Eric, and Chris McCahill, State Smart Transportation Initiative, March 2015.

# 2.2 Supportive Policies and Programs

Design alone fails without policies and programs that support compact land uses, enforcement and education around the design, and incentives of multimodal usage of a street. Numerous guides exist on topics such as community outreach and land use planning, thus the following section highlights a few key policies and programs most relevant to multimodal thoroughfares.

## 2.2.1 Consideration of Compatible Land Uses

Integrated transportation and land use planning results in transportation projects that are responsive to existing and future patterns of land use in the corridor. Good land use policies that embrace compact growth in turn increase non-auto usage and spur continued community support for walkable streets, in a self-perpetuating cycle. (Figure 2.6)

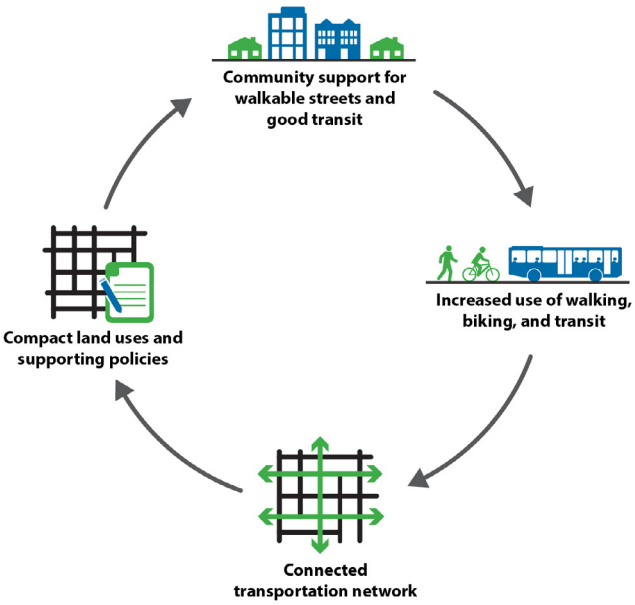


**Figure 2.6** Good land use planning supports multimodal transportation in a continuous cycle *(Source: Nelson\Nygaard)*

## 2.2.2 Development Code

The best plans and designs will never get built without supportive development codes and policies. Plans flourish when building code and developer requirements reinforce multimodal designs.

From a traffic perspective, policies that seek to minimize peak-period auto congestion and maximize vehicular throughput can be rejected in favor of broad-based, CSS-driven evaluation frameworks. These policies pop up during traffic impact studies, travel demand modeling, and development review. The explicit and implicit assumptions embedded in traditional transportation planning processes (such as background traffic growth, suburban trip generation rates, and auto-centric mode splits) dilute the ability to implement successful multimodal thoroughfares. This topic is further discussed in Sections 3.4.9 and 3.4.10.

From a modal perspective, integration of multimodal considerations into developer requirements and building codes supports multimodal design of the project. For example, bicycle facilities added to a street assist in moving people along a thoroughfare, but the person also needs a secure place for bike parking. Allowing bicycles in office buildings and requiring bike parking in residential development are two ways code can support design. Additional examples are shown in (Figure 2.7).

## 2.2.3 Least-Cost Planning

Traditional evaluation processes often conduct cost-benefit analysis only on the basis of capital costs, and do not include ongoing costs or externalities. A more robust analysis takes into account "life-cycle" costs as well as related externalities, such as the health and public safety costs associated with roadway expansions. A comprehensive process will also consider lower-cost, demand management-based

| TOPIC | EXAMPLES OF CODE SUPPORT |
|---|---|
| TRANSIT | - BUS STOP MAINTENANCE AGREEMENTS<br>- SAFE CROSSINGS AT TRANSIT STOPS<br>- AMENITIES BASED ON RIDERSHIP |
| PARKING | - REDUCED PARKING REQUIREMENTS NEAR TRANSIT<br>- PARKING LOT LANDSCAPING<br>- SHARED PARKING |
| WALKING | - SIDEWALK WIDTHS RELATED TO CONTEXT<br>- BUFFER STANDARDS<br>- DEVELOPER REQUIREMENTS |
| BICYCLING | - BIKE PARKING IN BUILDINGS<br>- BIKE RACKS ON SIDEWALKS |
| URBAN DESIGN | - TREE REMOVAL BARRIERS<br>- STREETSCAPING STANDARDS<br>- PUBLIC USE OF STREET PROGRAMMING |
| FREIGHT | - REQUIRED NUMBER OF LOADING SPACES<br>- USE OF ALLEYS FOR LOADING |

**Figure 2.7** Examples of how code can support multimodal thoroughfares *(Source: Nelson\Nygaard)*

alternatives to expensive investments in infrastructure. This is known as least-cost planning.

Least-cost planning efforts are performance-driven and outcome-based. They include solutions that may be able to achieve desired outcomes at a lower cost than capital-intensive infrastructure, such as transportation demand management strategies.

Consider the cost of the project as part of the evaluation criteria. Integrate a no-build with a demand management option into scenario planning. Demand management of shifting trips to alternate modes may achieve the same person-capacity desired without building costly new lanes or widening an intersection (Figure 2.8) Demand management also supports goods movement by reducing congestion for freight vehicles.

## 2.2.4 Community Engagement

Street redesign projects are likely to result in both benefits and impacts, "winners and losers," and may be controversial. For this reason, it is essential that practitioners of such projects use a CSS process to engage with members of the community, clarify tradeoffs, and define the community's priorities, not just in terms of narrow transportation concerns, but the broader community objectives incorporated into a CSS process.

Community engagement can take a variety of forms. Traditional open house-style public meetings are a useful tactic, but this format does not work for everyone due to mobility limitations, lack of child care, etc. In addition to open houses, public engagement held in the community can help reach those who cannot attend a traditional

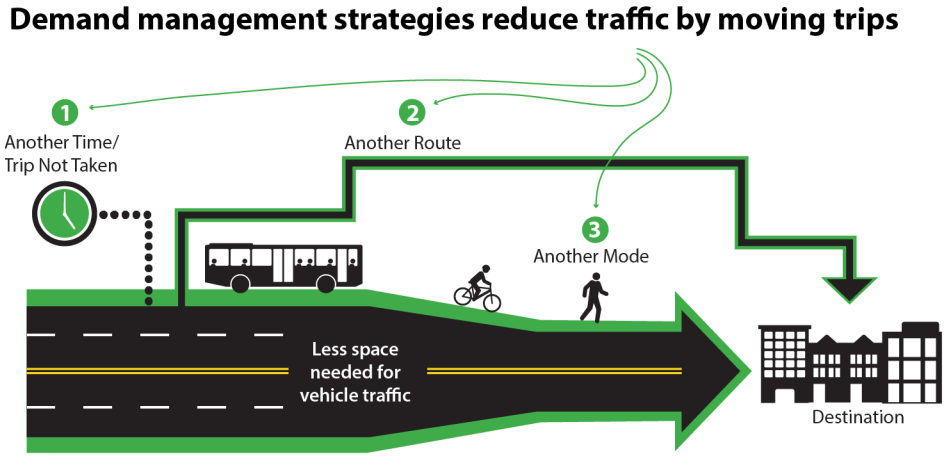


**Figure 2.8** Traditional planning processes are also often focused on capacity and infrastructure solutions, without sufficient emphasis on demand management alternatives and efficiency solutions *(Source: Nelson\Nygaard)*

**Figure 2.9** Events held in the community or that use workshop-style formats educate and inform in an interactive way *(Source: Nelson\Nygaard)*

open house (Figure 2.9). Pop-up events at community destinations or online open houses are examples of engagement that can reach a wider market.

Regardless of the specific approach, effective community engagement processes are both interactive and iterative. They are "two-way streets" in which practitioners both convey and collect information. A successful CSS public engagement process can also convert affected stakeholders into project champions or advocates for the project within the community.

## 2.2.5 Traffic Safety Programs, Vision Zero, and the Three E's

Safety is often the primary goal for community transportation departments and safety is often a goal in multimodal design. Programming and policy focused on safety can support street design changes, and vice versa.

Vision Zero is one safety policy that has become common in many U.S. cities. It has been adopted in more than 25 cities, and is being considered in about a dozen more[1]. The term originated in Sweden, where the program began in 1997. The underlying premise is that it is unethical to design and operate a system where death or serious injury is an acceptable outcome.[2]

> Vision Zero "...requires a paradigm shift in addressing the issue of road safety. It requires abandoning the traditional economic model where road safety is provided at reasonable cost and the traditional transport model in which safety must be balanced against mobility. At the core of the Vision Zero is the biomechanical tolerance of human

[1] Vision Zero Network. "Vision Zero Cities Map." Updated March, 2017. http://visionzeronetwork.org/resources/vision-zero-cities/.
[2] Vision Zero Initiative. "Vision Zero: Traffic Safety by Sweden." Business Sweden—The Swedish Trade and Invest Council. Accessed: September 20, 2017. http://www.visionzeroinitiative.com.

beings. Vision Zero promotes a road system where crash energy cannot exceed human tolerance. While it is accepted that crashes in the transport system occur due to human error, Vision Zero requires no crash should be more severe than the tolerance of humans. The blame for fatalities in the road system is assigned to the failure of the road system rather that the road user."[1]

Theory aside, Vision Zero and similar initiatives in 11 cities around the globe (Barcelona, Berlin, Chicago, Dublin, Lisbon, London, Madrid, Melbourne, New York, Paris, and Stockholm) used the following strategies:

- Traffic calming
- Slow zones, red light cameras, speed cameras
- In-vehicle speed detection; alcohol, crash avoidance & event recorders
- Bicycle infrastructure, bicycle priority traffic signals
- Outreach through schools
- Fixed or variable message warning signs
- Pedestrian priority traffic signals
- Traffic safety marketing campaigns

These strategies have proven effective in reducing severe and fatal crashes throughout the safest cities. These model cities focus on vehicle speeds, vulnerable road users, and motorist inattention; normalize enforcement; and conduct outreach via known channels like schools.[2] A summary can be found in "A Comprehensive Approach for Road Safety—The Example of Germany."[3]

These cities do *not* focus on conventional enforcement efforts. Instead, enforcement has been institutionalized using cameras and in-vehicle detection systems. It has not been left to chance and is therefore more equitable.

As Vision Zero programs develop in the United States, they are beginning to morph into conventional 4E programs (engineering, enforcement, education, emergency response). Whether they will have similar impacts on traffic safety as true Vision Zero programs have had remains to be seen, but early reports suggest issues with enforcement and equity.[4,5]

An additional resource available to practitioners seeking opportunities to integrate safety into the project development process is the report, "Integration of Safety in the Project Development Process and Beyond: A Context Sensitive Approach." The report, developed jointly by ITE and FHWA in 2015, provides practitioners tools and guidance to integrate traffic safety into various stages of project development, noting tools such as the FHWA "Interactive Highway Safety Design Model."

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[1] Whitelegg, John and Gary Haq. *Vision Zero: Adopting a Target of Zero for Road Traffic Fatalities and Serious Injuries,* Stockholm: Stockholm Environment Institute, 2006.

[2] King, Michael, "Vision Zero," *Tumblr.* Updated: October 1, 2015. http://trafficcalmer.tumblr.com/post/154430602588/vz-e3.

[3] The Sustainable Urban Transport Project, "A comprehensive approach for road safety—The example of Germany." 2015. http://sutp.org/files/contents/documents/News/2016-01-January/road_safety_poster_en.pdf.

[4] Lugo, Adonia. "Unsolicited Advice for Vision Zero." *Urban Adonia.* Updated: September 30, 2015. http://www.urbanadonia.com/2015/09/unsolicited-advice-for-vision-zero.html.

[5] Greenfield, John. "Chicago's plan to eliminate traffic deaths stirs concerns of profiling and overpolicing," *Chicago Reader.* Updated September 20, 2016. http://www.chicagoreader.com/chicago/vision-zero-traffic-deaths-cdot-emanuel-active-transportation-alliance/Content?oid=23612038.

# Modal Considerations & Design

3

Multimodal streets, as the name implies, serve many different users. Each user has its own specific operating characteristics and design needs. In multimodal thoroughfare projects, the practitioner is often trying to balance all the various existing and desired users of a street throughout the street network. For example, some streets might focus on transit and freight movement, while others focus on comfortable facilities for bicyclists. Understanding community goals and context assists in determining priorities on different streets. Community goals can be discovered through a robust public outreach process. Context can be determined by understanding land use and built form. For example, a street through a retail area benefits from ample pedestrian space, on-street parking and loading, and low vehicle speeds, while a street through an industrial area requires lane widths for trucks.

This chapter begins with an overview of each of the primary users of the street and their operating needs. Application of modal needs occurs through the network design and street type process. Finally, a series of tools that can be applied through the multimodal design process is presented.

# 3.1
# Users of the Street

Each mode of transportation has its own design needs based on both how they operate on a street as well as how they experience a street. For example, making a right turn while driving a truck has operational requirements different from making a right turn while riding a bicycle. The experience of traveling a corridor at three miles per hour on foot is very different from traveling at 30 mph in a car. These factors can inform design decisions as discussed below.

## 3.1.1 Pedestrians

Walking is the most basic form of transportation. For people to be attracted to walking it must be safe, useful, comfortable, accessible, and interesting. At the most basic level, walking is facilitated by sidewalks along the street and frequent, safe places to cross the street (Figure 3.1). Sidewalks and crossings alone, however, may not be sufficient to encourage walking trips by choice. Since pedestrians travel slowly, at about three miles per hour, shorter trips are easier to complete by walking. Short trips can be created when land uses are mixed, meaning origins and destinations are close together. Visual interest, created through street-fronting buildings and community design, make walking more pleasant. Public art and seating encourage people to linger and also enhance the street as a sense of place.

Buffers between sidewalks and vehicle lanes can make the walking space feel more comfortable by providing separation between pedestrian traffic and vehicle traffic. This buffer could be designed as concrete, grass, landscaping, seating, or other variations. See the *Recommended Practice* for details on recommended walking and buffer widths by street type.[1] Pedestrian facilities on streets where sidewalks are present must also follow the guidance set forth in PROWAG, ensuring accessibility.

**Figure 3.1** Walking requires safe facilities for walking along and crossing streets *(Source: Nelson\Nygaard)*

Pedestrian crossings are typically aligned with the most direct path between demand generators. For example, the City of Boston recommends that pedestrian crossings be located wherever there is a concentration of pedestrian origins and destinations across from each other, regardless of whether a formal street or intersection is present.[2]

[1] ITE RP, pp. 70-71.
[2] City of Boston Transportation Department. *Boston Complete Streets Design Guidelines,* 2013.

Along with bicyclists, people on foot and using mobility devices such as wheelchairs and walkers, are the most exposed and vulnerable users of the street. The chance of severe injury or fatality is 50 percent when struck by a vehicle traveling 30 mph. Minimizing the speed differential between users at conflict points is a key focus of multimodal thoroughfares. These conflict points, or intersections, must minimize crossing distance to reduce exposure to vehicle traffic. Signal timing must utilize a walking speed based on the context of expected users, and can range from 4.0 to 3.0 feet per second.[1]

## 3.1.2 Bicyclists

Bicycling is an increasingly common form of transportation, with reported trips by bicycle increasing from 1.7 billion in 2001 to 4 billion in 2009.[2] Along with pedestrians, bicyclists are exposed and vulnerable users of the street who need to be accommodated with safe and comfortable facilities. Bicyclists are not all the same and what is required to make them feel safe and comfortable will vary. For example, some bicyclists travel much slower than vehicles while others travel at higher speeds; on average, bicyclist speeds range from 12–20 miles per hour. Some experienced bicyclists (a very small percentage of the total potential bicycling population) are comfortable sharing a lane with cars. For the rest of the population, the type of bicycle facilities that feel safe and comfortable vary based on a combination of motorist speed, traffic volume, roadway width, presence of parking, and other design elements. Using traffic volume thresholds to recommend a specific type of bicycle facilities is a good starting point and guidance may be found in the NACTO *Urban Bikeway Design Guide.* Bicycle facilities physically separated from motor vehicle traffic are effective in attracting people of all ages and abilities, who may not feel comfortable bicycling with vehicle traffic **(Figure 3.2)**.[3]

Often times bicycle facilities are built next to the curb. If a gutter pan exists, enough space is needed so bicyclists are not forced to ride either closer to vehicle traffic to avoid the edge between the traveled way and gutter pan, or in the gutter pan itself where pedals could hit the curb face. For example, FHWA recommends that when gutter pans are present, bicycle lanes should measure at least four feet wide exclusive of the pan width.[4] Communities such as Minneapolis stipulate that bicycle lane widths should be measured entirely exclusive of the gutter pan.[5]

**Figure 3.2** Separated facilities provide vertical separation from vehicle traffic and may operate as one-way or two-way facilities *(Source: Nelson\Nygaard)*

Use high visibility materials for bicycle lanes, especially approaching and at intersections **(Figure 3.3)**.

Secure bicycle parking helps make sure bicyclists feel confident that they have a place to park at the end of the ride. Trip end storage facilities may be provided in the form of bicycle racks, bicycle lockers, or within buildings.

[1] For signal timing, the "flashing don't walk" phase should be timed so that a person leaving the curb at the end of the WALK phase can finish the crossing while walking at 3.5 feet per second. When people who walk slower than 3.5 feet per second routinely use a crossing, a slower walking speed can be used. Source: MUTCD 4E.06.

[2] Federal Highway Administration. "2009 National Household Travel Survey." 2009.

[3] Monsere, Chris, et. al. "Lessons from the Green Lanes: Evaluating Protected Bike Lanes in the U.S." National Institute for Transportation and Communities. 2014.

[4] Federal Highway Administration. "FHWA Course on Bicycle and Pedestrian Transportation: Lesson 19, Bicycle Lanes." 19-2. 2002. https://safety.fhwa.dot.gov/PED_BIKE/univcourse/pdf/swless19.pdf.

[5] City of Minneapolis. "Bicycle Facility Design Guidelines: Chapter 4—On-Street Facilities." 85. 2010. http://www.minneapolismn.gov/www/groups/public/@publicworks/documents/webcontent/convert_262712.pdf.

**Figure 3.3** High-visibility striping visible on a cloudy day (left) and used to separate users at intersection (right) *(Source: Nelson\Nygaard)*

## 3.1.3 Transit

Planning for effective transit is important to maintaining a multimodal thoroughfare, as transit provides an option to move large volumes of people per vehicle. Designing for transit means thinking about both transit customers as well as transit vehicles (Figure 3.4). Bus stops are pedestrian generators and require safe crossings, as the bus passenger must cross the street on one direction of the trip. For information on the impacts of design at transit stops, see Section 4.2.6. The *Recommended Practice* provides detailed guidance on bus stop locations and bus stop design.[1] An often overlooked need at bus stops is lighting; passengers riding in the early morning or evenings need lighting to increase security as well as make passengers visible to other street users.

In terms of transit vehicles, standard buses are 8.5 feet wide, (9.5 feet with side mirrors). The minimum inside turning radius for a bus is 21 to 26 feet and the minimum outer radius is 42 feet. The standard coach is 40 feet long, but articulated buses are 60 feet long (though they have a smaller turning radius). Figure 3.5 provides a review of typical bus dimensions. Note that smaller urban and rural communities may use somewhat smaller transit vehicles to efficient serve a more limited demand base. Practitioners should be aware of how these reduced dimensions can impact their design needs.

Facilitate transit by providing adequate lane widths and turning pockets. Transit can operate on streets with lanes as narrow as 10 feet. This dimension is being used for planned BRT services on the Madison Street corridor in Seattle, Washington, and the existing EmX service in Eugene, Oregon.[2,3] Other agencies such as the Healthline in Cleveland, Ohio, operate on 11-foot lanes.[4] At intersections,

**Figure 3.4** Transit customers require safe access to and from stops *(Source: Nelson\Nygaard)*

[1] ITE RP, pp. 163-168.
[2] Seattle Department of Transportation. "Madison Corridor BRT Study: LPA Summary Report." 2015.
[3] Fehr and Peers. "Draft East Bay BRT Project—Berkeley Consideration." (2008).
[4] Kenneth Sislak. "Cleveland HealthLine Bus Rapid Transit: Greater Cleveland Regional Transit Authority." http://library.ite.org/pub/54322fd1-94e9-7dc1-042d-8948c891a4ae.

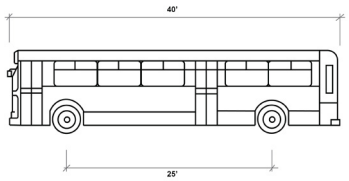
| Symbol | Image | Description | Length | Width | Width + Mirrors | Turning Radius |
|---|---|---|---|---|---|---|
| CITY BUS |  | City Transit Bus | 30–45′ | 8.5′ | 9.5′ | 42′ |

**Figure 3.5** Transit vehicle dimensions *(Source: NACTO Urban Street Design Guide http://nacto.org/publication/urban-street-design-guide/design-controls/design-vehicle/)*

transit vehicles need sufficient turning radii to make right turns without mounting the curb.

Coordinate long-term plans with transit service providers to understand the future of service for a given corridor. Designs may take into account service technology (bus, streetcar, light rail) and what is likely to serve transit needs for the long-term future of the street.

On high-volume streets, traffic signal treatments that allow transit vehicles to operate efficiently may be considered. Consider allowing transit vehicles to use right-turn lanes as queue jumpers, and equipping traffic signals with communication technology to give priority to bus movements.

The NACTO *Transit Street Design Guide* provides a comprehensive review for practitioners considering lane designations, stop amenity improvements, intersection improvements, and overall transit system improvement strategies. Additionally, practitioners may benefit from reviewing the FTA *Manual on Pedestrian and Bicycle Connections to Transit*, which further discusses how to maximize connectivity between active modes and transit.

## 3.1.4 Automobiles

On many arterial and collector roadways, automobiles are the dominant user. Motorists require travel lanes sufficiently wide to facilitate through movement (Section 5.3.6 discuses lane width in more detail). Automobiles benefit from lighting along the street and turning radii that allows larger vehicles such as sport utility vehicles to complete turns at low speeds without mounting the curb. Figure 3.6 summarizes typical automobile dimensions.

In multimodal thoroughfare projects, a common focus lies on managing automobile speeds and slightly constraining operations to the make the street more comfortable for pedestrians, bicyclists, and transit riders.

## 3.1.5 Freight

Efficient movement of goods, cargo, or freight is essential to the economic success and the everyday livelihood of a city or region. Within the realm of freight, there are many different types of freight trips that vary in terms of distance, vehicle size used, and time of movement. The *Guidebook for Understanding Urban Goods Movement* provides a good overview of freight types. It is most useful to think about two broad categories of goods movement activity (Figure 3.7):

- Local Delivery—A significant amount of truck activity in cities is related to deliveries to businesses, retail/restaurant destinations, and homes. There tends to be more variability in the size of these trucks and they often need to make deliveries on multimodal, mixed-use

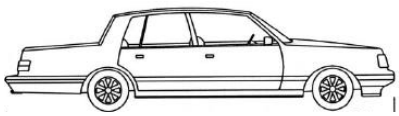
| Symbol | Image | Description | Length | Width + Mirrors | Turning Radius |
|---|---|---|---|---|---|
| P |  | Passenger Vehicle | 15–19′ | NA | 24′ |

**Figure 3.6** Typical automobiles and design parameters *(Source: NACTO Transit Street Design Guide; AASHTO Green Book)*

**Figure 3.7** Local delivery vehicle (left) and logistics-driven vehicle (right) *(Source: Nelson\Nygaard)*

streets. E-commerce is playing a continually larger role in peoples' lives, and e-commerce vendors typically use large vans or smaller trucks in residential areas.

- Logistics-Driven, Intercity Goods Movement—This relates to trucks going to or from industrially focused areas. The trucks are often coming from other cities or states via the freeway system or other major highways.

Freight vehicles are built in many different sizes, as summarized in Figure 3.8. Where in operation, freight often dictates street design elements (e.g., lane widths, curb radii) as they are typically the largest vehicles using the roadway.

Dimensions that facilitate large freight movements have tradeoffs for other users. For example, a wide turning radius lengthens the pedestrian crossing distance and facilitates higher-speed passenger vehicle turning movements. Operating on multimodal streets is challenging for freight operators, as vehicles have large blind spots.

Ultimately, strategic land use decisions can help keep the largest freight vehicles on streets that have little or no need for multimodal access. Additionally, a comprehensive logistics-driven freight design strategy may be used to strategically designate corridors for use by

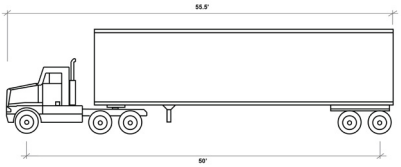
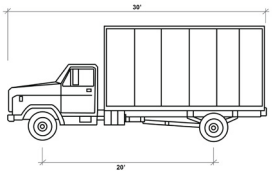
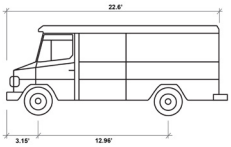
| Symbol | Image | Description | Length | Width | Width + Mirrors | Turning Radius |
|---|---|---|---|---|---|---|
| WB-50 |  | Intermediate Semi-Trailer | 55.0′ | 8.5′ | 10.5′ | 45.0′ |
| SU-30 |  | Two-Axle Single Unit Truck | 30.0′ | 8.0′ | 10.0′ | 42.0′ |
| DL-23 |  | Urban Delivery Truck | 22.6′ | 8.5′ | 10.5′ | 29.0′ |

**Figure 3.8** Freight vehicle dimensions vary widely. *(Source: NACTO Urban Street Design Guide)*

the largest freight vehicles. Following are strategies for each category of freight:

### Local Delivery Design Strategies

Local delivery trucks need to access a diverse variety of locations and stop near those locations for loading and unloading. Strategies for accommodating these deliveries include the following:

- In parts of communities that have dense, connected networks of streets, freight operators can plan routes that avoid difficult right turns since many alternate route options exist.
- Dedicated loading spaces at or near areas requiring many deliveries can prevent trucks from being forced to double park. Communities can accommodate freight activity by managing curb space to designate operationally feasible zones for loading and unloading based on nearby land development patterns.
- Ensure that loading docks are accessible without obstructing parts of the street, including sidewalks.
- Design intersections to balance all users, keeping in mind the importance of reducing risk for pedestrians and bicyclists in locations of high vehicle traffic.
- Place the stop line for opposing traffic further from the intersection and clearly mark it where longer freight vehicles need to encroach into an opposing travel lane to complete a turn.

### Logistics-Driven Design Strategies

Many communities have designated portions of their street networks as freight routes, historically intended to allow large trucks to move through the city without impact to sensitive land uses or community character. These routes can be strategically chosen to minimize impacts to communities and vulnerable road users. The FAST Act required that state and local agencies work together to designate urban and rural roadways that improve the efficient movement of freight on the National Highway Freight Network. In most communities that are analyzing design and placement of multimodal networks, one corridor is likely sufficient for designation as a heavy freight route. Strategies that cities may want to consider include the following:

- Adopt a set of street and intersection standards that can accommodate high percentages of large vehicles. Key accommodations in these standards might include slightly wider lanes (for example using 11 feet instead of 10 feet), particularly for the rightmost (outside) lane in each direction. They might also include larger intersection turn radii for right turn movements along dedicated freight routes.
- Set a policy that requires a designated freight route from each concentration of industrial zoning to the limited access freeway system (or major intercity highway if no freeway is available). This does not need to be the most direct route—it is advised that freight be routed around denser community centers rather than through them. If a single adequate route is designated, cities may not need to designate additional routes.

### Emergency Responders

There is a perceived tension between the design needs of emergency response vehicles, such as ladder trucks, and the lower-speed design characteristics of safer, and more walkable streets. This often centers around traffic calming strategies that seek to slow motorists but are perceived as also slowing down emergency responders. Design strategies that may be used to mitigate the speed of passenger vehicles without affecting emergency responders include mountable curbs, the use of different surface materials and paint to reduce the *perceived width* of the street, roundabouts, and *inset parking*. Providing a dense street grid will ensure access to properties via multiple routes. Creating emergency response routes can help ensure that design on those streets accommodates emergency response vehicles.

## 3.1.6 New Users

A range of new users of public rights-of-way have emerged in recent years, including operators of carshare vehicles and bikeshare bikes as well as passengers in new ride-hailing service vehicles (which, in terms of street design, share characteristics with more traditional taxis). Design needs might include reserved spaces for carshare vehicles, space in the pedestrian realm or parking lane for bikeshare stations, planning of curb space for passenger pick-ups/drop-offs, and other elements.

In addition, emerging users, primarily automated vehicles, will affect policy and design. It is anticipated that automation will have a significant impact on the efficiency of parking, as well as the use of curb space for passenger loading/drop-offs. Vehicle lane widths can likely be narrowed, opening up opportunities for changes to standard designs. Autonomous transit vehicles could be operated on very short headways, increasing transit's corridor passenger capacity.

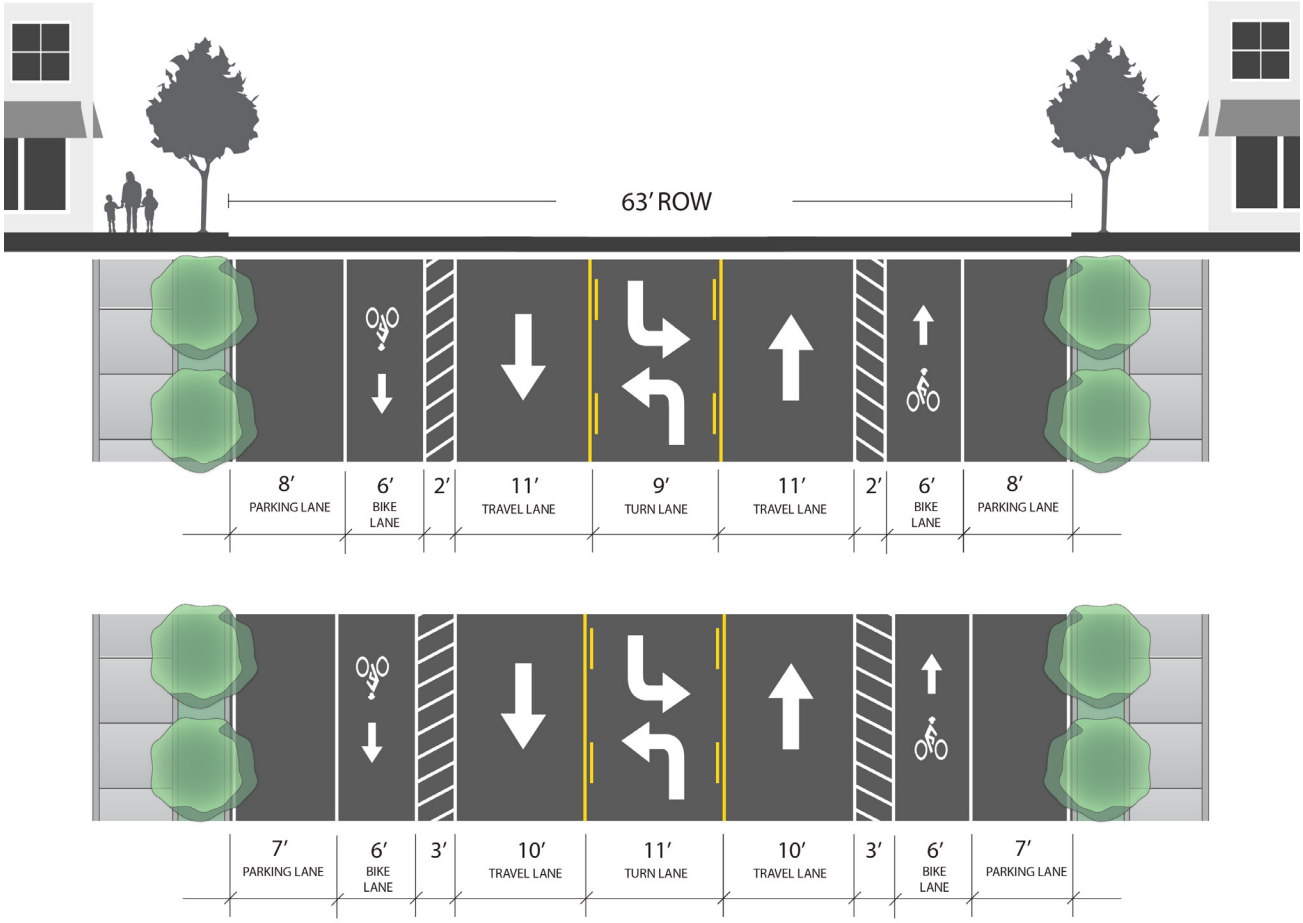



**Figure 3.9** A cross section can utilize different dimensions for the same street elements *(Source: Nelson\Nygaard)*

## 3.1.7 Assemblage

Many guides provide fixed widths for each discrete section of the right-of-way, but at many locations practitioners will find the need for flexibility to accommodate right-of-way changes, utility locations, easements, or old-growth trees. Flexibility in design means considering how individual elements work together rather than sticking to a rigid set of desirable dimensions (Figure 3.9). For example, a left turn pocket could thin down to 9 feet at an intersection when adjacent to an 11-foot through lane.

Design flexibility is a key element in the ITE guide, *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach,* as well as the recently published *Achieving Multimodal Networks* guide by FHWA. Assemblage is a term used to describe the act of assembling various roadway cross-section elements into a whole.

Conventional practice generally considers the various roadway cross-section elements starting from the vehicle lane needs moving outward to the pedestrian zone needs. The unintended consequence is often a wider cross-section as each element is designed to its preferred (wider) desirable dimension, or a street where non-motorized users are squeezed in at the end of the process with the narrowest possible dimensions. For example, a series of wider lanes leads to longer crosswalks. Striping a narrow bike lane adjacent to a narrow parking lane places bicyclists in the door zone. Instead, it can be useful to take an "outside-in" approach, thinking through the needs of pedestrians, bicyclists, transit riders, freight loading and unloading, etc., first—and motor vehicle through capacity last. Additionally, to be consistent in thinking about the needs of more sensitive users, gutter pans must be planned for in the assemblage process, to avoid having gutters make up a portion of the right of way designated for bicyclists. The Massachusetts Department of Transportation *Project Development Manual* provides a resource that elaborates on how to utilize this approach.

# 3.2
# Role of Project Street in the Network

The need to travel between land uses is universal, and streets are the main infrastructure used to connect destinations. In cities and towns, streets are connected in networks, and the strength and balance of the network affects how well streets can support a community's overall transportation needs. Two following two elements of the network are critical to the success of multimodal thoroughfares: connectivity, or having streets that connect to each other, and the density of connections, which correlates to intersection density and block size.

Well-connected networks offer multiple routes between destinations with many parallel streets and few dead ends. Less connected networks concentrate travel demand on a few large streets. This results in challenging design tradeoffs, as many users compete for a limited number of connected streets. Land use policies and street standards that support connectivity can help a community add connections over time. The density of connections affects frequency of natural crossings, visual interest, and ability to disperse traffic.

Connected networks with short blocks provide an excellent backdrop for multimodal thoroughfares. The following sections provide additional guidance on how to build stronger networks in corridor design.

## 3.2.1 Street Connectivity

Connectivity refers to the directness of links between destinations and the density of those connections. In cities and towns, higher levels of connectivity provide increasing options for distributing travel patterns more evenly. The directness of travel afforded by connectivity is also a critical factor in promoting walkable environments.

Researchers have begun to find correlations between street grids and safety. A study by Reid Ewing, Richard A. Schreiber, and Charles V. Zegeer produced a "sprawl index" for 448 U.S. counties in the largest 101 metropolitan areas, then compared it to traffic fatalities. It found that for "...every 1 percent increase in the index (i.e., more compact, less sprawl), all-mode traffic fatality rates fell by 1.49 percent and pedestrian fatality rates fell by 1.47 percent to 3.56 percent, after adjustment for pedestrian exposure."[1]

Common tools to measure connectivity include calculations of intersection density or computing a connectivity index **(Figure 3.10)**. Tools are discussed further below.

Connectivity benefits include the following:

- More route options for all users, resulting in greater convenience and directness of travel. This can reduce travel times during both peak and off-peak periods.
- More direct routes increase opportunities for active transportation, as people walking or bicycling are particularly sensitive to trip distance.
- Reduced congestion from distributed traffic and travel patterns.
- Better and faster access for emergency vehicles due to more routing options.
- Fewer large arterial streets, which can bisect and separate communities.
- Allows for a system of layered modal networks that may utilize different streets and converge at major nodes.[2]

Considerations include the following:

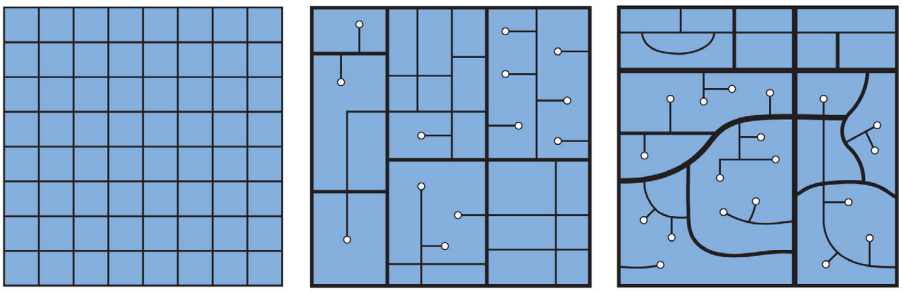
- Suburban arterials have widely spaced signals that typically allow for faster off-peak travel. Trying to add connectivity to a single suburban corridor

[1] Reid Ewing, et al. "Urban Sprawl as a Risk Factor in Motor Vehicle Occupant and Pedestrian Fatalities," *American Journal of Public Health*, September 2003.

[2] For further discussion see source: Institute of Transportation Engineers. *Planning Urban Roadway Systems: An ITE Proposed Recommended Practice*, 2011.

## Network Connectivity Comparison

1 Square Mile



| Grid Type | Grid | Fused-Grid | Curvilinear |
|---|---|---|---|
| Block Length | 660′ | Varies | Varies |
| Intersection Density | 81 | 53 | 56 |
| Links | 144 | 88 | 94 |
| Nodes | 81 | 66 | 75 |
| Connectivity Index | 1.77 | 1.33 | 1.25 |

**Figure 3.10** A grid network provides better connectivity *(Source: Nelson\Nygaard)*

without the benefit of a full network to disperse traffic can result in queues.

- Adding connections—whether paths or streets—may increase maintenance costs.

As with many themes of transportation planning, there are no one-size-fits-all approaches to connectivity, and optimal connectivity may differ by community context and among modes depending on functions to be served. Considerations include the following:

- **Land use**—Some land uses, especially industrial and large-format commercial uses, simply require larger spaces for buildings and auxiliary functions to be efficient. This may mean less density of streets and intersections in these areas.
- **Natural features** such as rivers, streams, lakes, and topographical features may make street connections impractical in some locations.
- **Privacy**—Some communities wish to limit or avoid connectivity through residential areas to preserve privacy. These concerns may be considered where possible, though may be difficult to address in instances where residential streets provide access to community assets such as schools and parks.

### Block Size

The downtowns of most North American cities were laid out based on a consistent block size, with dimensions of blocks corresponding to the transportation technologies and building types prevalent at the time (Figure 3.11).

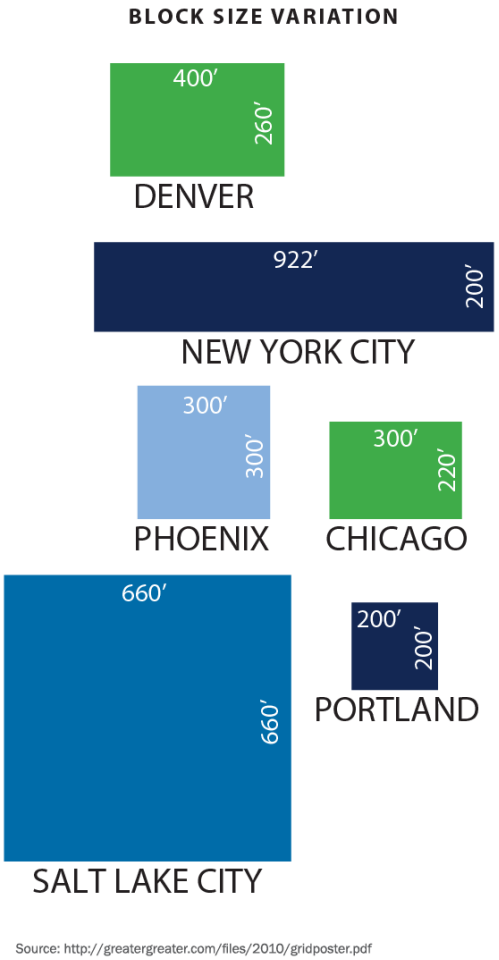



**Figure 3.11** Block size varies by community and has an effect on signal spacing, walkability, and real estate *(Source: Nelson\Nygaard)*

**Figure 3.12** One-way to two-way conversion in Lowell, MA. Before (left) and after (right). *(Source: Nelson\Nygaard)*[1]

In exurban and suburban areas that have developed since the dominance of automobile travel, blocks are often very long. This results in a concentration of travel demand on a few large streets with signalized intersections that must process a high amount of vehicle traffic. Longer block size has negative effects on walking and mixed outcomes for bicycling and transit. Fewer intersections means fewer conflict points for bicyclists, but poorer access to their final destinations. Similarly, transit may operate faster with fewer intersections, but vehicles are more likely to be delayed at traffic signals. Longer blocks can also result in long walks for transit riders trying to access stops.

## Large vs. Small Blocks

**Larger blocks** result in more acreage per block, longer distances between natural crossings, and infrequent intersections.

Longer blocks along a street corridor are generally associated with fewer conflict points, but longer distances between crossings.

**Smaller blocks** create more intersections, more frequent crossings for pedestrians, and smaller block acreage. Although they lead to a denser network as discussed in previous sections, this can also mean more traffic controls are needed.

**The *Recommended Practice* (see pgs. 29 and 32) identifies a desirable block size/intersection spacing of 400 feet, and no more than 660 feet, for areas planned for walkability.**

A commitment to a given block size is in part a policy-based decision that depends on real estate and development dynamics, demand for accommodating pedestrians and bicyclist, and existing built and natural environments.

Standard block sizes are useful as a planning target, but ranges of dimensions may be more reasonable to adopt as a standard or policy requirement.

## One-Way versus Two-Way Streets

Many streets have converted their one-way downtown streets into two-way facilities (Figure 3.12). One-way streets have higher speeds than two-way streets, and increase travel distances for motorists.[2] Conversely, two-way streets lower motorist speed and help create a destination. One-way couplets are good candidates for conversion to two-way, as they often have mixed land uses, multimodal activity, and consist of three or four travel lanes.[3]

[1] Based on "The Variety of American Grids" poster, published by Greater Greater Washington. Source: Nairn, Daniel, "The Variety of American Grids," Greater Greater Washington, last modified May 31, 2010. https://ggwash.org/view/5314/the-variety-of-american-grids.

[2] Federal Highway Administration. "Road Design: 13. One-Way/Two-Way Street Conversions." https://safety.fhwa.dot.gov/saferjourney1/library/countermeasures/13.htm.

[3] Zegeer, Charles V., Dan Nabors, and Peter Lagerway. "Pedestrian Safety Guide and Countermeasure Selection System." Federal Highway Administration. 2013. http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=23.

## 3.2.2 Connectivity Guidance

### Tools for Assessing Connectivity

Connectivity can be measured by examining the density of intersections and/or the ratio of links to nodes. *Intersection density* is the total number of intersections (including dead ends) divided by area. *Link to node ratio* is the total number of road segments (links) between intersections divided by the total number of intersections (nodes) including dead ends. For both, the higher the score, the denser the network. A link/node score of 1.4 generally indicates good connectivity.[1]

Transportation planners and decision makers have numerous policy tools to assess a network's connectivity levels.

1. Connectivity Index: A simple ratio calculating roadway links (street lengths) to nodes (network link endpoints, either intersections or dead-ends). A four-square grid, for example, has a connectivity index of 1.33 (12 links divided by 9 nodes—see 3.12). A nine-square scores 1.5; the higher the value, the better the connectivity. Research suggests that a score of 1.4 is the minimum needed for a walkable community,[2] whereas in more compact urban areas, networks with a 1.6 index should be provided.[3] The following definitions are used in calculating a connectivity index:
   a. Segment/Link: a roadway or alley open to general public auto traffic; a street section between intersections and termini
   b. Node/Intersection: a junction with three or more segments; the terminus of a street segment, such as a cul-de-sac
2. Intersection Density: Number of intersections per square mile; the higher the number, the better the connectivity
3. Access Index: A ratio comparing the direct travel distance to the actual travel distance required to access destinations. In an unconnected network with dead ends and long blocks, people travel farther to reach destinations, meaning a higher index. An index of 1.0 is the best rating, meaning traveled network paths between destinations are also the most direct. Walkable communities should strive for an index value of 1.5 or lower.[4]

### Connectivity Policies and Strategies

There are a variety of strategies towns and cities can use to improve street connectivity.

- Adopt connectivity tools, as described above, such as intersection density or connectivity index standards
- Create maximum block length or block size standards
- Establish street network master plans, especially for districts featuring large-lot development
- Add path connections linking residential areas to community resources **(Figure 3.13)**.
- Adopt a connectivity tool as a policy for site plan review, development codes, and project design manuals
- Evaluate intersections as part of a network, rather than independently. Congestion at one intersection can be mitigated by changing turning movements or circulation at adjacent locations if there is sufficient network to support these alternative patterns.
- Require development and redevelopment of larger private properties to contribute full streets to the network. These may be public or private streets from a legal standpoint, but can be designed and constructed to public street standards.

## 3.2.3 Establishing Modal Networks

Multimodal design seeks to create complete streets, and on many streets, multiple modes already coexist. For example, on a typical street, people walking, driving cars, or driving buses are all present. In a design project, the community may wish to add new users or provide more robust facilities for existing users, which has ramifications in terms of space and design requirements. For example, a street with growing businesses may need wider sidewalks and loading spaces, or a street might benefit from transit-only lanes to improve travel times. For bicyclists, the space needed to create a comfortable facility varies based on roadway characteristics such as traffic volume and speed.

The reality of limited available right-of-way means that decisions must be made about priorities and tradeoffs. Establishing modal networks can help in this decision process by clearly laying out a network for each user through a publicly inclusive planning process. Then, when corridor projects occur, a modal network map has already

[1] Congress for the New Urbanism. "Street Networks 101." https://www.cnu.org/our-projects/street-networks/street-networks-101
[2] Victoria Transport Policy Institute. "Roadway Connectivity." Online TDM Encyclopedia. Updated January 2, 2017. www.vtpi.org/tdm/tdm116.htm
[3] Virginia Department of Transportation. "Secondary Street Acceptance Requirements." July 2010.
[4] Victoria Transport Policy Institute. "Roadway Connectivity" Online TDM Encyclopedia. Updated January 2, 2017. www.vtpi.org/tdm/tdm116.htm

**Figure 3.13** Adding paths connects communities to facilities without the need for public roads
*(Source: Nelson\Nygaard)*

Use the opportunity of new development to connect existing and new retail destinations

been created to use as a basis for design decisions. The ability to have layered networks of users that minimize conflicts relates directly back to street connectivity (3.1) and block size (3.2).

## Grid Types and Networks

A traditional grid pattern supplies many opportunities to have modes concentrated on particular streets or dispersed. Yet many communities have different street patterns that present both challenges and opportunities for establishing modal networks.

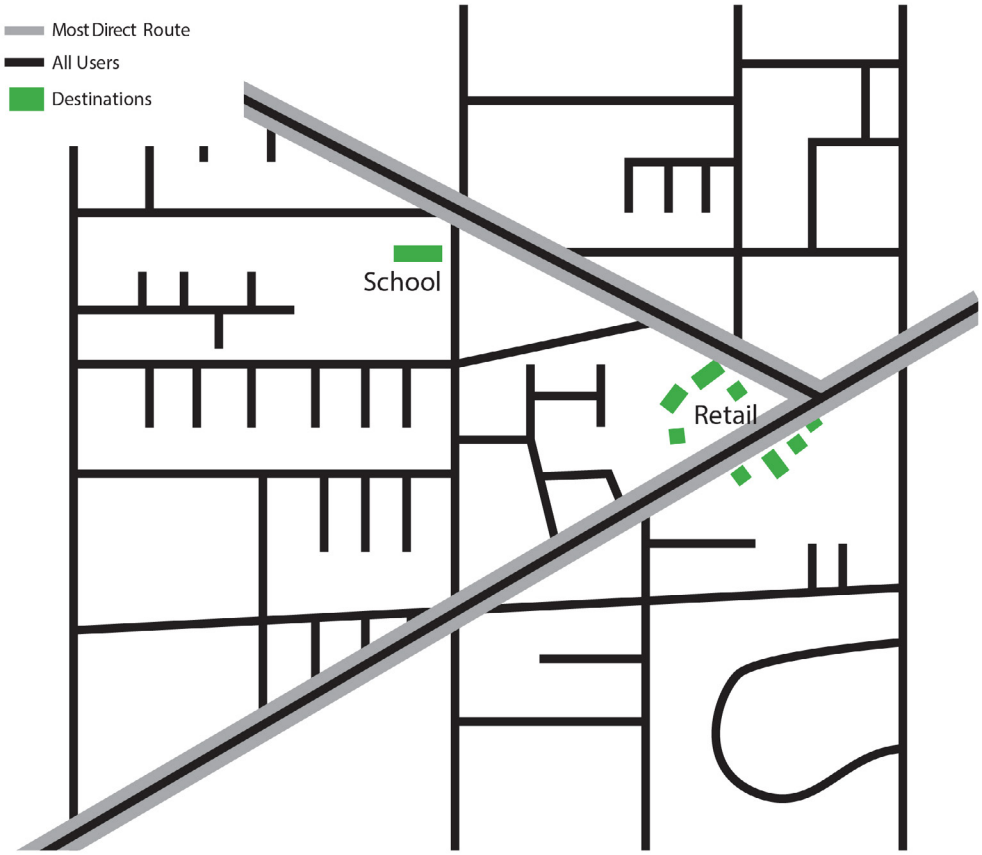
1. **Arterial-dominant:** In street grids without connectivity, arterials provide the only through connections and have high mobility functions. Because no alternate route exists aside from the arterials, all modes need to travel on a couple key streets. These streets are likely quite wide, with opportunity for multimodal design, but arterials also likely have moderate to high motorist speeds and volumes. Physical separation for vulnerable users is needed.
2. Diagonal: Many street grids incorporate diagonals. Even if an alternate street route exists, the diagonals are often the most direct path between destinations, and have high mobility functions.
3. Parallel Streets: Street grids with local streets parallel to arterials provide multiple options for mobility. Motorists may use the arterial, while bicyclists would likely be more comfortable on the parallel local route. Still, bicyclists need to cross the arterial to arrive at destinations, thus safe crossings of the arterial must be provided.

When planning modal networks, take into account the following guidance:

- Outlining the network for each mode helps practitioners see where crossing treatments are needed or where gaps occur. Each network needs its own coherent, connected system.

**Figure 3.14** All travel demand must be focused on arterials *(Source: Nelson\Nygaard)*

**Figure 3.15** Diagonal streets are often the most direct route *(Source: Nelson\Nygaard)*



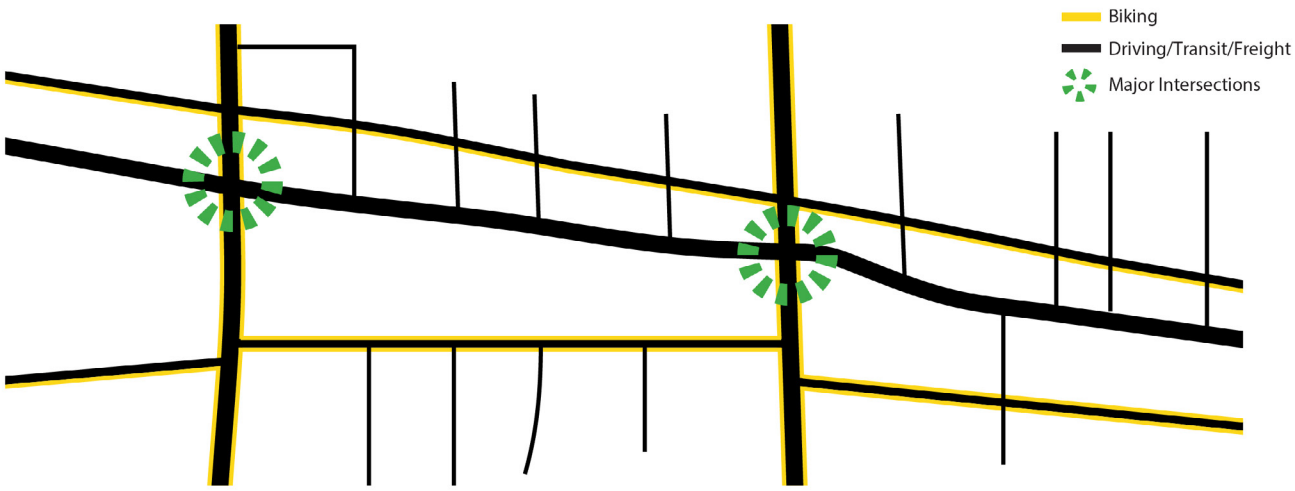




**Figure 3.16** Parallel, connected streets provide an alternate to arterial travel *(Source: Nelson\Nygaard)*

- The modes can use different spaces within the right-of-way. For example, cars can only drive between curbs, but people can walk through parks, plazas, or other pedestrian spaces (Figure 3.17).
- Effective modal networks as a planning tool require extensive input from the community, stakeholders, and public works departments.
- Modal networks can tie to design decisions. For example, the freight network can help the practitioner select the right design vehicle.
- Land use context and roadway operating characteristics determine the type of facility needed for each user, as discussed in Section 3.1.

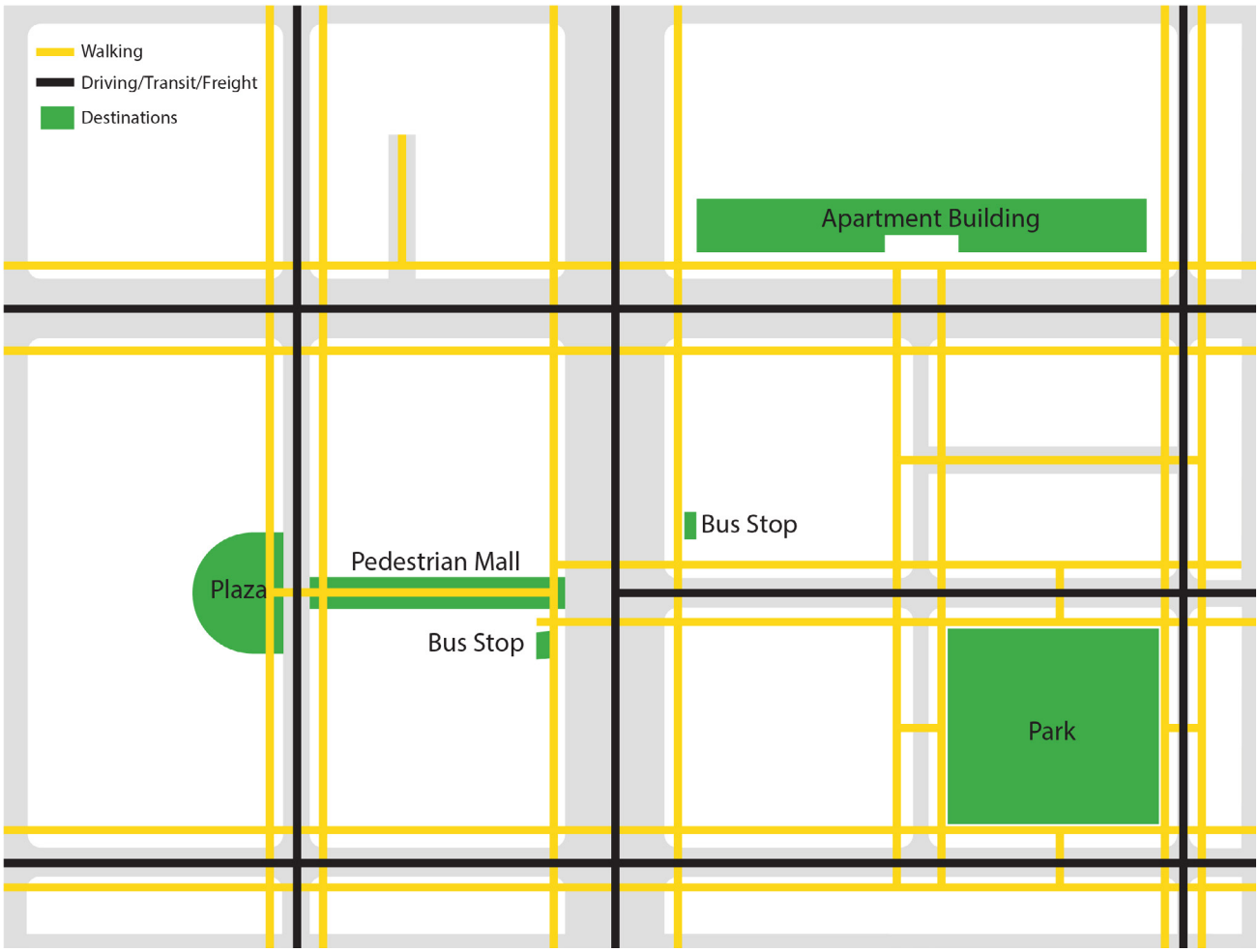



**Figure 3.17** The driving network is different from the walking network *(Source: Nelson\Nygaard)*

# 3.3 Understanding the Project's Street Type

The context within which a street functions determines its design. A street that travels through an industrial area will have different traffic levels, sidewalk needs, and streetscape amenities than a street in a residential neighborhood or a business district. It is important for street practitioners to consider these context factors as well as the role the street plays in the transportation network to effectively accommodate the street's range of users and to support changes in land use or activity over time.

FHWA created the functional classification system as a way of categorizing streets and highways on a continuum based on the level of mobility or access they provide for vehicles. The use of functional classification in an auto-centric system has resulted in high-speed vehicle routes primarily serving vehicle mobility rather than multimodal access and safety needs. In a multimodal environment, streets are used by people walking, taking transit, and riding bicycles to access destinations. (The functional classification system is now undergoing revision as part of NCHRP 15-52, "Developing a Context-Sensitive Functional Classification System for More Flexibility in Geometric Design.")

Communities have begun remaking their arterial roadways into spaces that support safe and attractive mobility for all users. Street types are a classification convention that goes beyond traditional functional classification by considering the street's land use context and tying the type to design guidance.

## 3.3.1 Determining Street Type

Street types allow a community to define the existing and future character and design of a street based on a combination of the street's mobility function and area context. The street type will influence the selection of various design elements including the following:

- Sidewalk width, design, amenities, and pedestrian buffers
- Landscaping
- On-street parking provision and design
- Loading and goods movement
- Bicycle facility types
- Design treatments for public transit
- Driving lane widths

Street types, like all planning tools, require policy support and consensus among different participating agencies and the community to be effective. Adopting street types into design policies, manuals, or other documents may require changes to existing guidance. In some cases, communities might apply street types only to certain areas, such as designated redevelopment or downtown districts.

Street types (sometimes called typologies) are typically drawn from the following two primary definitions:

- **A land use context,** such as residential neighborhoods, mixed-use districts, institutional districts such as college campuses and hospitals, parks or open space, industrial areas, or downtown business districts.
- **A mobility function,** such as a regional thoroughfare, a freight corridor, a collector street balancing access and through-moving travel, or a local street primarily serving access to residential properties.

The land use context and mobility function are joined together to create the street type, with multiple options possible (Figure 3.18). Street typology guidance includes the following:

- Keep street types simple by limiting the number of contexts and functions. The FHWA Functional Classification has been an enduring planning framework partly because of its simplicity, therefore it is ideal if context-sensitive street typologies are similarly limited in number.
- Create street types as part of a jurisdiction's modal, long-range, or district plans
- Link design guidance to each street type. Ensure consistency between street type guidance and ROW design manuals, zoning codes, and other documents that planners and practitioners frequently utilize.

- Use street types to guide capital programming, development review, and modal prioritization.
- Emphasize basic street design components of each street type. Typologies are most effective when not overly prescriptive, instead defining the basic fundamentals of the context-mobility relationships and supporting this with guiding principles on how to address detailed design.

## 3.3.2 Defining Mobility Function

The mobility function is the key characteristic that defines the design of the traveled way, or the area between the two curbs, for mobility and access. Some communities use the FHWA Functional Classifications (arterial, collector, local) and some use names that they feel better reflect those streets' role in the network. There is also often an overlay that defines some special network characteristic (such as a street that is a high-capacity transit route or an emergency response route) that can take priority in design decisions.

The mobility function might consider elements such as the expected mix of modes, the volume of people movement, the general lengths of trips handled by the corridor, access control requirements, etc.

## 3.3.3 Defining Area Context

Context describes the intended character of each street in terms of building form and land use. Context drives the

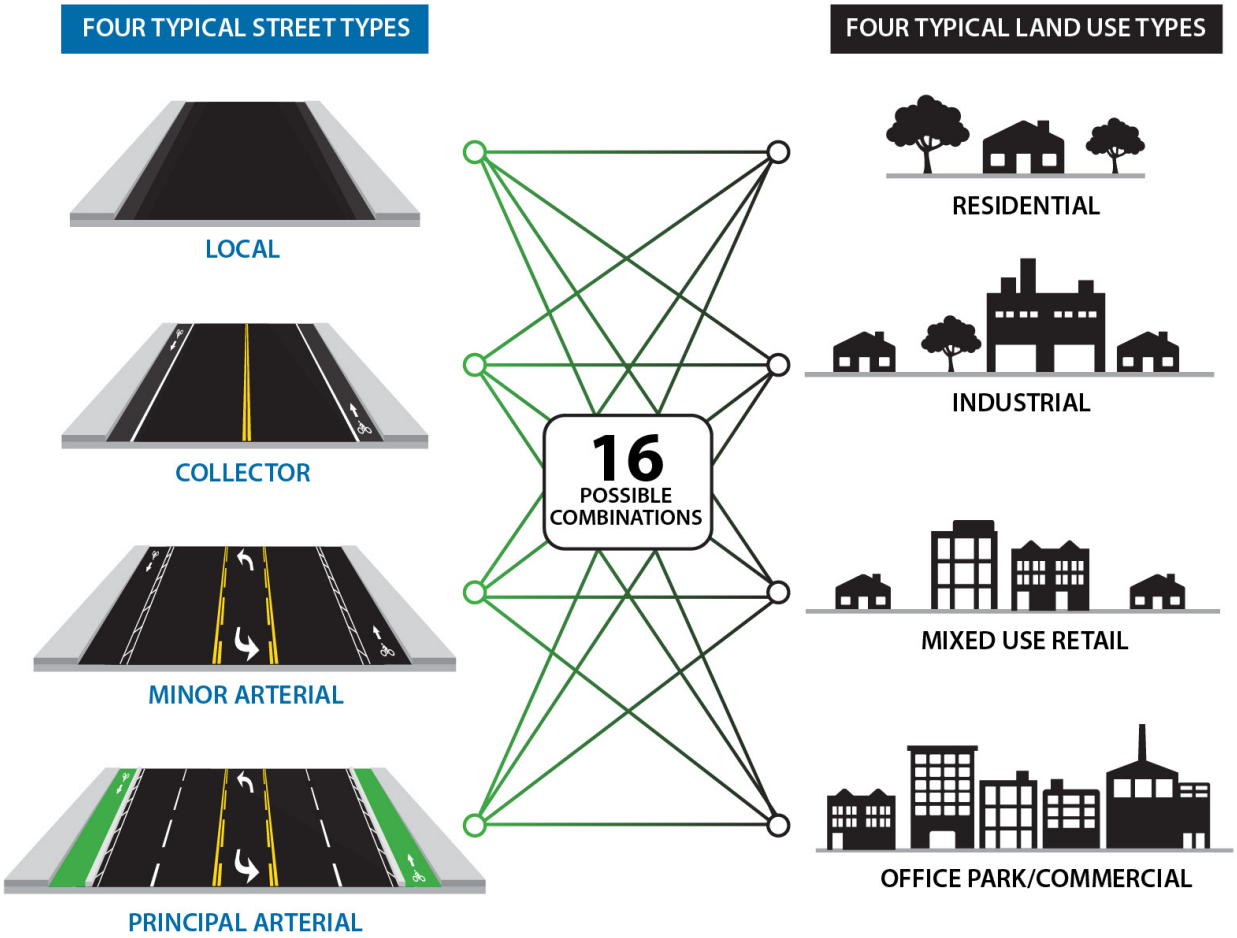



**Figure 3.18** Street types include both mobility and land use components *(Source: Nelson\Nygaard)*

design of the space between the building and the edge of the curb (Figure 3.19). Sometimes special overlays such as historic districts, are also added.

Evaluate typical land uses and create land use contexts, formally organizing these through comprehensive plans, zoning ordinances, or other land regulations.

## 3.3.4 Relationship to Functional Classification

The practice of classifying streets has traditionally entailed using the FHWA Functional Classification. This is an ordering system that defines "the part that any particular road or street should play in serving the flow of trips through a highway network."[1] Functional classification plots streets on their ability to 1) move vehicular traffic, and 2) provide access to adjacent properties (direct land access). The three primary classifications in this system are arterials that prioritize traffic mobility, collectors that link local traffic patterns with arterials, and local streets focused on access.

**The *Recommended Practice* (see Table 4.3) provides a cross reference between functional classification and appropriate thoroughfare design type. Table 6.4 provides design dimensions for each of these thoroughfare types for walkable areas.**

The use of this system has become prevalent, even on streets that are not part of the National Highway System. Using functional classification as the basis for planning policies and roadway design has the following two primary drawbacks:

- It is not multimodal and considers only one type of traffic: motorized vehicles.
- Functional classification is intended to categorize the facilities used by automobiles in terms of their ability to get motorists from point to point. Many streets, especially in cities and more mature suburbs, predated the advent of the functional classification system and do not easily fit the descriptions of the classes.

Because of its cornerstone role in the federal highway planning process, the federal functional classification system has been embedded into the policy framework

**Figure 3.19** All three streets have the same curb-to-curb widths but very different land use contexts *(Source: Nelson\Nygaard)*

surrounding streets. Certain classifications make streets eligible for federal highway funding assistance, which makes using the system a practical reality for most communities. Yet when partner agencies such as state departments of transportation have roadway design policies and manuals that define links between classification and specific designs, this can create

[1] Federal Highway Administration. "Functional Classification Guidelines: Section II - Concepts, Definitions, and System Characteristics." HYPERLINK "http://www.fhwa.dot.gov/planning/processes/statewide/related/functional_classification/fc02.cfm" \l "tcofc" http://www.fhwa.dot.gov/planning/processes/statewide/related/functional_classification/fc02.cfm#tcofc.

difficulties by requiring that any variation from the standards must seek administrative exceptions.

Community street types provide a different way of organizing street design principles, while still allowing communities to retain the conventional functional classification names for transportation system planning and funding purposes, especially for principal arterials. Applying local principles through a context-sensitive street type is a way for a community to reflect its particular characteristics and needs in the street design process.

Create a comparison table or other document correlating functional classifications to adopted street types (Figure 3.20). Some types may fit under multiple classifications.

| FEDERAL CLASSIFICATION | LOCALLY SELECTED STREET TYPOLOGY | | | |
|---|---|---|---|---|
| | TYPE 1 | TYPE 2 | TYPE 3 | TYPE 4 |
| Principal Arterial | X | | | |
| Arterial | | X | X | |
| Collector | | | X | X |
| Local | | | | X |

**Figure 3.20** Relate locally-selected types to federal classifications *(Source: Nelson\Nygaard)*

# 3.4 Analysis Tools

The project development process includes extensive collection and analysis of data. This section goes over approaches and tools that can support design of multimodal thoroughfares. This is not an exhaustive list of tools, but instead focuses on less commonly used methods. Typical tools include analysis of arterial and intersection Level of Service, average speed, travel time, and queue lengths.

## 3.4.1 Direction, Observation, Iteration

Multimodal thoroughfare design can follow a three-step process:

1. **Get Direction:** from policy, the community, elected officials, etc.
2. **Observe and Evaluate Existing Conditions**
3. **Test and Refine the Design:** A preliminary design can be tested and refined through an iterative process. The idea is that all projects and initiatives serve a common goal, a full understanding of the context of the project is developed, and the process allows for refinements and adjustments.

## 3.4.2 Mapping and Diagramming All Modes

To truly create a multimodal thoroughfare, assemble and assess information pertaining to all the modes. While the information sets may vary, and data may be best viewed at different scales, it is important to illustrate the design and operation for all modes equitably. Such a modal diagram reveals modal interactions, networks, and conflict points.

Existing conditions analysis may include examination of all modes through mapping and evaluation, with an eye toward identifying excess pavement or underused sections of the right-of-way. Map transit routes, sidewalks, crosswalks, bike routes, freight routes, and auto networks.

Develop multi-layer maps and diagrams that show all modes, not just auto traffic. These can be used for analysis of traffic volumes, speed, congestion, crashes, routes, parking, origin-and-destination patterns, desire lines, etc.

## 3.4.3 Tracking Surveys

The pedestrian network is more fluid than the other modes. Pedestrians tend to take the straightest line possible between their origin and destination, but infrastructure does not always accommodate that link.

A tracking survey is a method to document movement and understand how pedestrians are using a space and where they need to cross the street. They can be used to track people, bicyclists or vehicles. They are typically used at complex intersections or midblock locations, but can also be applied to public spaces like plazas.

Pedestrian tracking surveys visually document in a non-judgmental way exactly where people cross the street (e.g., within the crosswalk, away from the crosswalk, at a diagonal, midblock). Counters are stationed at intersection corners and mark down on an aerial exactly where people cross the street. Tracking takes place over a long enough period of time to gather a reasonably sized sample. Tracking surveys also provide data on pedestrian counts, and supplement traditional traffic volumes. Data can be used to inform designs **(Figure 3.21)**.

## 3.4.4 Desire Lines

Quantitatively calculating demand for walking facilities is difficult. Sometimes, however, demand for a walking route has been clearly marked by the passage of many feet. These "desire lines" show where enough people have walked to wear a path into the grass **(Figure 3.22)**. Documenting desire lines can be simply done in the field.

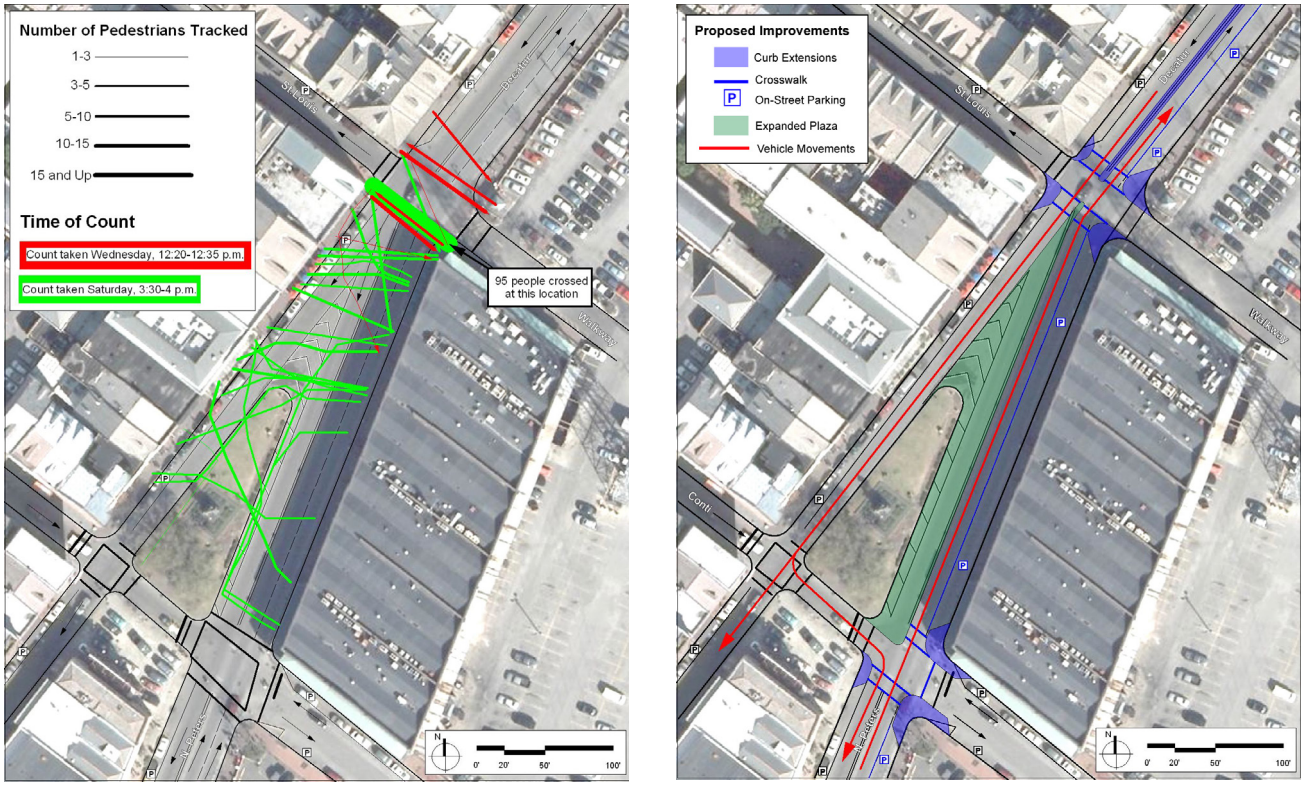



**Figure 3.21** Tracking surveys (left) reveal desire lines and inform designs (right) *(Source: Nelson\Nygaard)*

**Figure 3.22** Desire lines show where people want to walk or cross *(Source: Nelson\Nygaard)*

## 3.4.5 Rethinking LOS

Conventional Level of Service has historically been a measure of the congestion and delay experienced by motorists. During a design project, it is common practice for practitioners to evaluate impacts by measuring changes to intersection and arterial LOS calculated through travel demand models or traffic analysis programs. Its use as a primary measure of a project's performance results in projects that prioritize the needs of motorists over other road users. Recognition of these outcomes has led to communities and agencies building on or even identifying alternatives to the conventional automobile-based LOS as a sole measure of effectiveness.

Contextualize and provide broader, more multimodal alternatives to vehicle LOS metrics. These might include the following:

- Examine delay for all modes. LOS A for one user means another user might fall to LOS E or F. (Figure 3.23).

**Figure 3.23** Level of service means different things by user perspective *(Source: Nelson\Nygaard)*

- Recognize that peak periods will have congestion. Many cities will allow LOS E or F during peak times, understanding that off-peak periods operate with less congestion.
- Report LOS outputs for both peak and off-peak so people can see the difference.
- Frame LOS as one of many outputs within the project's performance measures. LOS of E or even F may be acceptable if a project scores high on all other measures.
- Integrate new analysis tools that measure safety and comfort. For example, the Pedestrian Environmental Quality Index (PEQI)[1] analyzes the safety and quality of the walking environment, and Level of Traffic Stress (LTS) classifies street segments in terms of high and low stress to assist in network evaluation and facility selection.[2]

## 3.4.6 Pedestrian Delay LOS

Typically, LOS analysis is applied to vehicle traffic. Planners use the Highway Capacity Manual to calculate average delay at intersections and average travel speed along arterials. Planning for all users requires thinking about how LOS principles apply to other modes. LOS is based on reducing delay, with any wait longer than 60 seconds receiving the poorest rating of "F."

Apply the same thinking to the pedestrian network. For example, a common challenge is providing safe crossings at midblock pedestrian generators like bus stops. Although every intersection with sidewalks has legal crosswalks connecting the sidewalks even though they are not marked, most motorists are not aware of this and do not yield to pedestrians. When proposals for marked, protected crossings are raised, a common rebuttal is that pedestrians can walk to the nearest signalized location to cross. In the example below, the nearest signalized location is a five-minute walk out of the way **(Figures 3.23 and 3.24)**. If LOS standards were applied, this would equate to an LOS F for delay. Include delay to pedestrians in analysis of signal timings and crossing locations. Pedestrians should not be expected to go more than 300 feet out of their way to take advantage of a controlled intersection.[3] See also Section 4.3.2.

## 3.4.7 Communicating Usage by Lane

Traffic volumes are typically reported as either average daily traffic (ADT) or peak hour volumes. Yet ADT and peak traffic do not account for the size of the road. An effective communication tool for how much of the roadway is actually being utilized by vehicle traffic is to display ADT per lane.

[1] Batteate, Christina, "Walkability & Pedestrian Safety in Boyle Heights: Using the Pedestrian Environmental Quality Index (PEQI)." https://nacto.org/wp-content/uploads/2015/04/Pedestrian-Environmental-Quality-Index-Part-I.pdf.
[2] Mekuria, Maaza C., Peter G. Furth, and Hilary Nixon. "Low-Stress Bicycling and Network Connectivity." Mineta Transportation Institute. 2012. http://transweb.sjsu.edu/PDFs/research/1005-low-stress-bicycling-network-connectivity.pdf.
[3] Institute of Transportation Engineers. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice,* 2010.

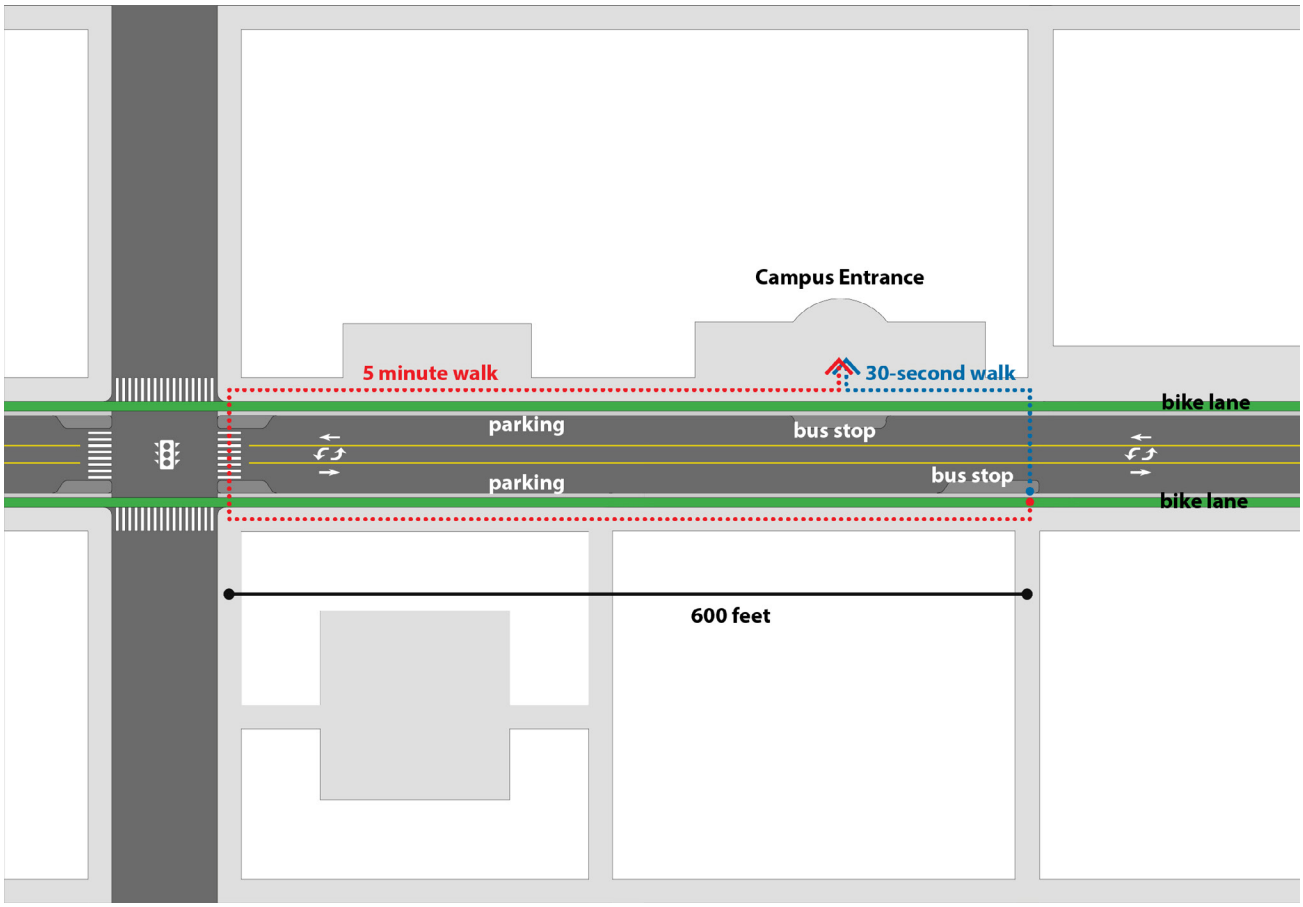



**Figure 3.24** Think about delay for all modes in LOS calculations *(Source: Nelson\Nygaard)*

In general, on a signalized roadway, traffic capacities range from 800–1,000 vehicles per lane per hour. The practitioner trying to make a street more multimodal may need to communicate how shifting capacity from vehicles to other modes will affect the experience for motorists. In many cases, there may not be time or resources to lay down traffic counters, thus another approach is to take peak hour volumes and split the total by number of through travel lanes (unless lane utilization data is available). This is a theoretical exercise—clearly volumes in actuality are not split exactly evenly between lanes, as seen in Figure 3.25. Yet, the visualization of such information has a powerful effect in terms of understanding whether countermeasures such as road diets are viable.

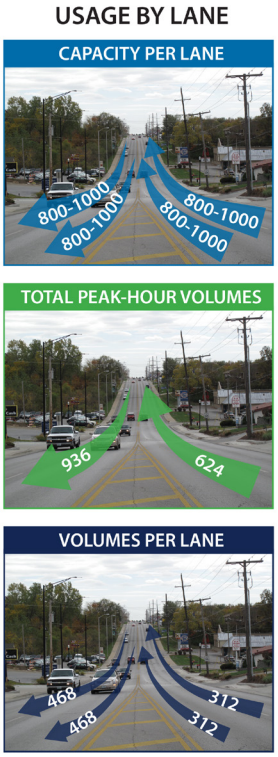



**Figure 3.25** Look at usage by lane, rather than volumes alone *(Source: Nelson\Nygaard)*

## 3.4.8 Understanding Usage by Time of Day

Typical traffic analyses are based on traffic volumes during the peak hour. Designs that accommodate little

delay during the peak results in a street that is overbuilt relative to demand during off-peak periods (Figure 3.26). This can result in speeding during off-peak hours and an opportunity cost for the street to include other uses.

Rather than basing design decisions solely on traffic volumes during the most congested peak conditions, consider how the street will be used for the vast majority of the day's hours.

For communities that are willing to accept greater congestion during the peak period (including potential diversion to alternate routes), alternative approaches are available. If data is available, practitioners can calculate averages based on both commute and midday or other peak periods, or a combination of peak and off-peak periods.

## 3.4.9 Traffic Projections

During corridor projects, stakeholders and the public often want to know how changes to the right-of-way—especially changes that reduce vehicle capacity—will affect traffic operations. Communities often have city-specific or regional travel demand forecasts that take existing vehicle volumes and land uses, make assumptions about future land uses, and project out future vehicle volumes using a growth rate.

The traffic projections process brings several challenges to implementing multimodal streets. Outcomes from models are given a great deal of weight when evaluating alternatives, and may reduce the

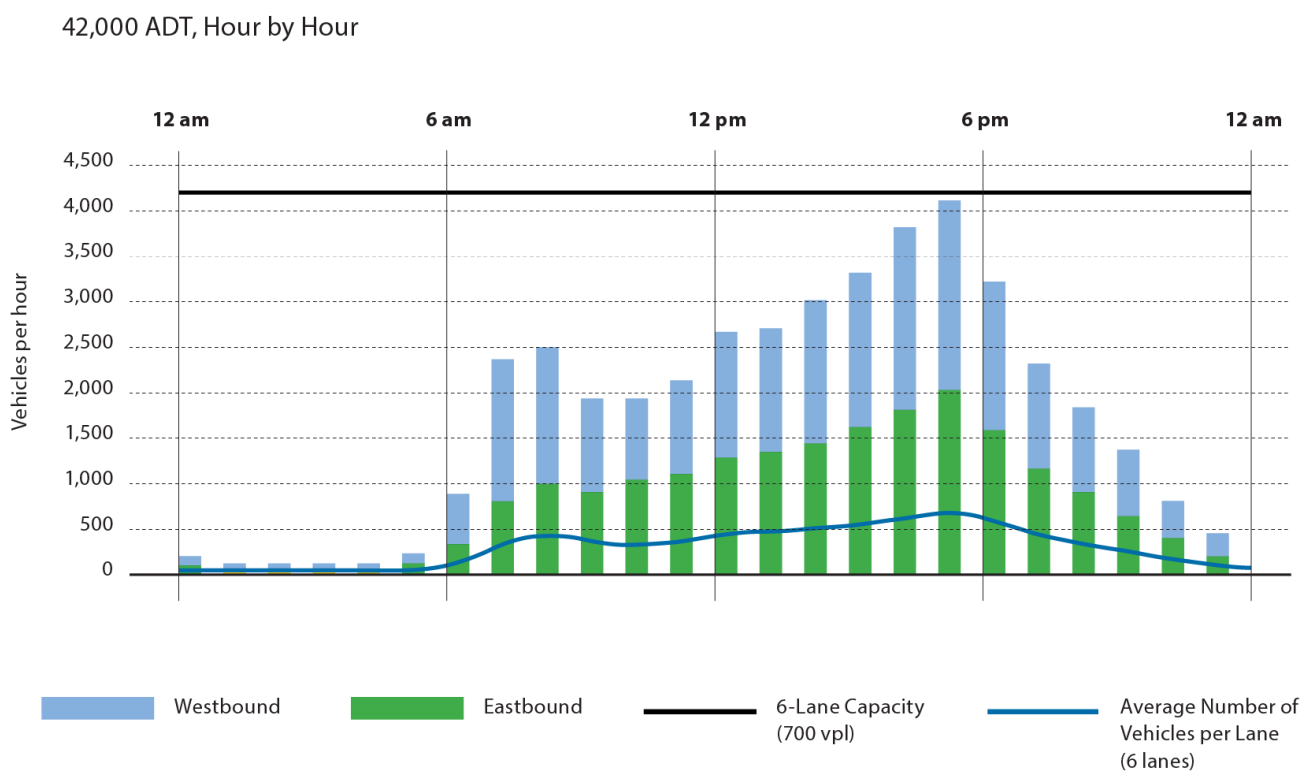



**Figure 3.26** Roadway capacity is often based on peak period conditions, resulting in infrastructure that is underutilized at all other hours *(From* Urban Street Design Guide *by NACTO. Copyright © 2013 National Association of City Transportation Officials. Reproduced by permission of Island Press, Washington, D.C.)*

## TRAFFIC PROJECTIONS

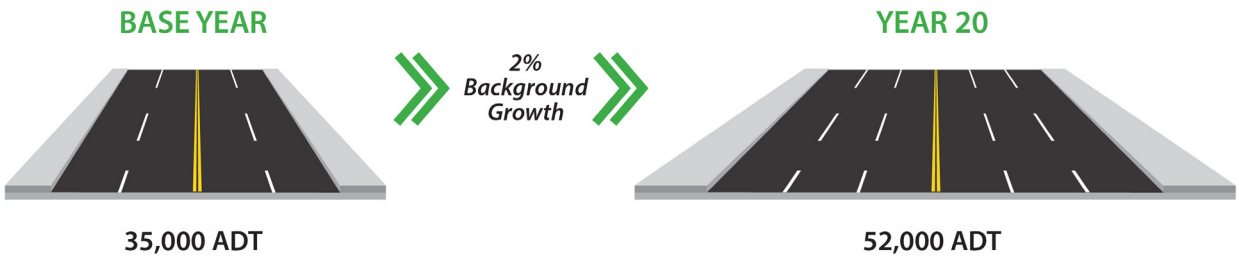



**Figure 3.27** Assumption of background growth automatically requires more vehicle capacity in the long-term *(Source: Nelson\Nygaard)*

viability of those that create the most complete streets. Challenges include the following:

- **Long-term traffic predictions may not be accurate.** Twenty-year projections of traffic volume and delay look far into the future and may not always come true. It may be better to think about them as order-of-magnitude estimates and not use them for precise analyses or detailed design or operations decision-making.[1] Even short-term projections may also be considered approximations, adequate for guidance, but only accurate within a range of values. Any predictive exercise, no matter how sophisticated, has inherent limitations.
- **Linear growth rate is unsustainable.** Many traffic models use an annual background growth rate, such as 2 percent or 3 percent, which is applied to existing traffic volumes. This type of linear growth would result in the continued need to add capacity. An assumed growth rate of 2 percent per year may sound modest, but will result in a doubling of traffic in just 35 years (Figure 3.27). Perhaps not surprisingly, a recent study found that "the likely inaccuracy in the 20-year forecast of major road projects is +/- 30 percent at minimum."[2]
- **Trip generation may not reflect community land uses.** Models often use future land use patterns to help determine traffic levels. Assumptions about trip generation from those land uses is often based on test sites taken from single land use areas that have suburban patterns of development (such as auto-dominated site designs and large, free parking lots). They do not include any assumption about travel via walking, bicycling, or transit. Thus the projections of future trips may be unnecessarily high and not matched to the actual travel patterns in the community.
- **Projections can be taken as prophecy.** A wealth of detailed analysis go into traffic projections, thus their outputs can often feel like a set, prescribed future. Rather than proactively designing streets that shift people away from driving, these projections can set up a mentality in which practitioners and the public feel forced to preserve or even add capacity for future traffic.

Guidance to evaluate traffic projections in a more multimodal way includes the following:

- **Evaluate more modest future scenarios.** Many projects use very long-term projections (20 years) as a basis for planning. While it is sound planning to look ahead, very long horizons magnify the potential for inaccuracy. In a world where technological and resulting cultural change is occurring at a rapid pace, it may be more prudent to focus on shorter horizons with a greater likelihood of accuracy.
- **Project volumes based on actual trends.** In built-out areas, compare forecast traffic volumes to historic counts on some sample corridors as a cross-check for reasonableness. Many communities have also found that their VMT is declining. Use actual trends for future forecasting, rather than an automatic growth assumption (Figure 3.28).
- **Adjust trip generation factors.** Adjustments to trip generation factors based on varying land use contexts (for example, mixed-use and transit-

[1] "Estimating traffic volumes for a 20-year design period may not be appropriate for many rehabilitation projects. These projects may be developed on the basis of a shorter design period (5 to 10 years) because of the uncertainties of predicting traffic and funding constraints." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. (2011): 2-53.

[2] David T. Hartgen," Hubris or humility? Accuracy issues for the next 50 years of travel demand modeling," *Transportation* 40, No. 6 (2013): 1133-1167, doi: 10.1007/s11116-013-9497-y.

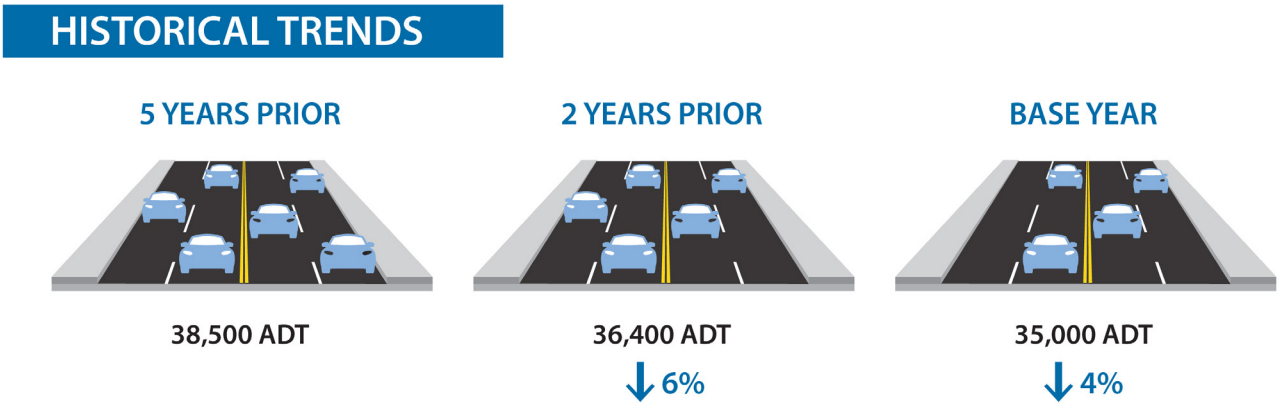



**Figure 3.28** Base projections off historical trends *(Source: Nelson\Nygaard)*

oriented developments versus typical suburban contexts) may be used where appropriate in lieu of rigid adherence to those found in widely used suburban trip generation samples.

- **Set policy decisions that actively shape the future.** Use mode targets or other goals that set a community's vision. Make investments today that can increase a corridor's passenger capacity by shifting travel to other modes and setting up the street for future success.

## 3.4.10 Multimodal Trip Generation

The ITE *Trip Generation Manual* and *Handbook* have been historically based on data collected at suburban locations with little to no transit service, pedestrian amenities, or demand management programs. The latest edition released in late 2017 also contains data collected at infill, mixed- and multi-use, and other types of sites that generate less vehicle trips than typical suburban sites. The handbook advises users to apply local data trends if available or to adjust the trip generation rates based on local transportation option availability (Figure 3.29).

## 3.4.11 VMT/ Account for externalities

Vehicles provide essential mobility and economic benefits, and are an indispensable element of the transportation system. Yet rates of driving are also associated with negative impacts on communities including greenhouse gas emissions, crashes, and public health impacts. Vehicle

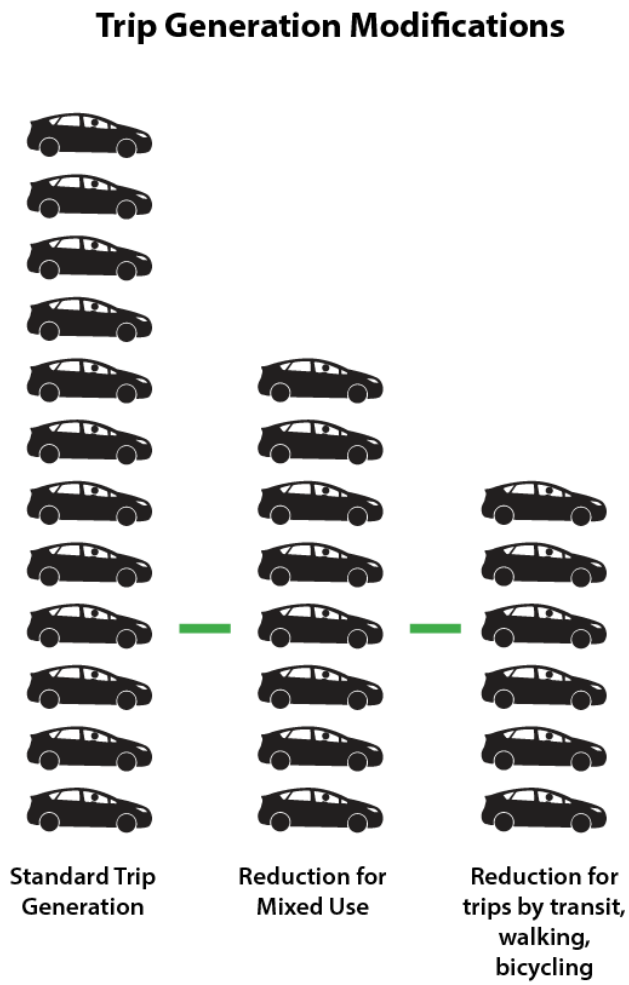
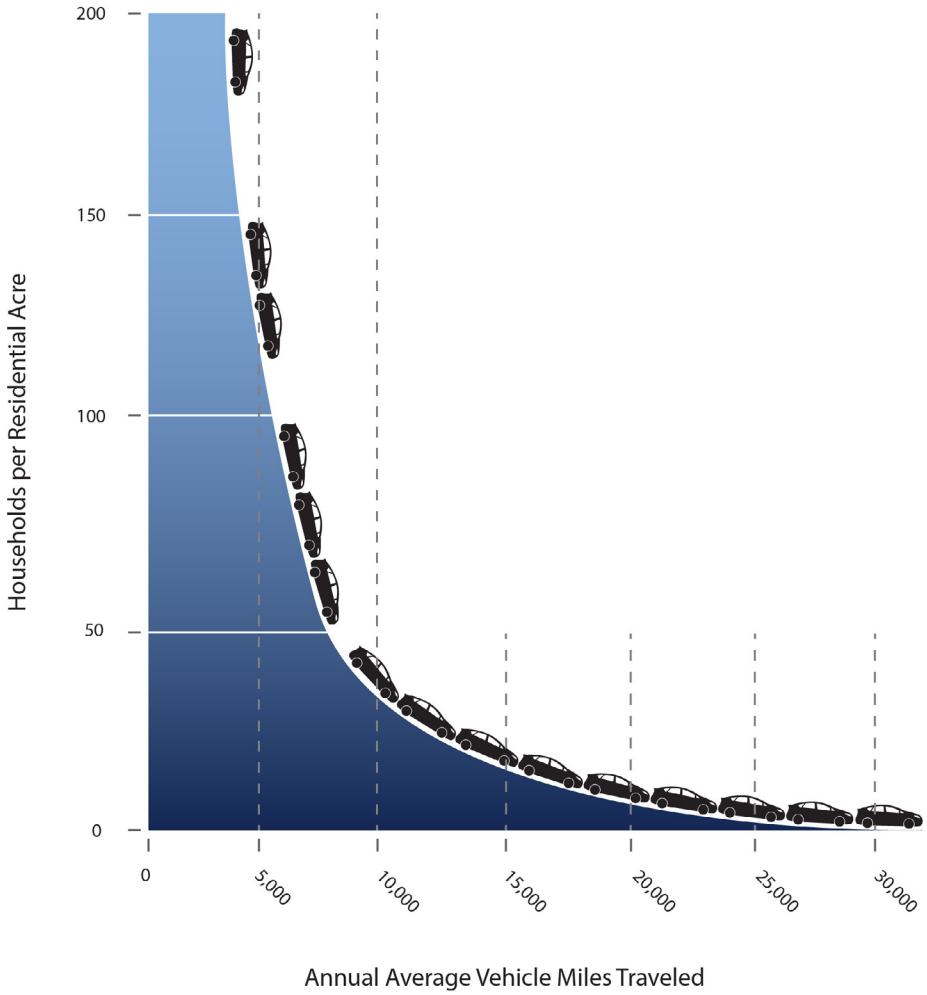



**Figure 3.29** Demand management and multimodal mode splits reduce vehicle-generated trips *(Source: Nelson\Nygaard)*

**Figure 3.30**
Relationship of VMT to land use density[1]




traffic also incurs maintenance, enforcement, emergency response, and medical costs. Due to these negative impacts many communities have begun to take steps to encourage the use of other modes for some trips.

For these reasons, vehicle miles travelled (VMT) is emerging as a standard for analysis of transportation impacts. In California, VMT will soon replace intersection LOS as a basis for mitigation of traffic impacts. VMT drops as land uses densify and multimodal trips become more feasible (Figure 3.30).

## 3.4.12 Pilot Projects and Experimentation

Experimentation with new and different ways of using streets can lead to innovations in street operation, or can assist in piloting a design. Experiments or pilot projects may also be used as a way of responding to the community's desire for enhanced livability and active use of public right-of-way. Pilots can be implemented through the FHWA, for example, which encourages innovation through its experimentation program. Experiments or pilots can fall into one or more of the following categories:

- Temporal—Opening up streets for walking, bicycling, farmer's markets, or other events (Figure 3.31).
- Spatial—Creating plazas, adding parklets, or changing the layout of the street.
- Operational—Different forms of pavement markings, traffic control, materials, lighting, and other street design elements can be applied through experimentation. For example, pedestrian-activated flashing yellow warning beacons, which facilitate

[1] Holtzclaw, J., et al., "Location Efficiency: Neighborhood and Socioeconomic Characteristics Determine Auto Ownership and Use—Studies in Chicago, Los Angeles and San Francisco," *Transportation Planning and Technology,* Vol. 25 (2002): 1-27.

**Figure 3.31** Events opening up the street to community usage have become popular in cities across the country *(Source: Nelson\Nygaard)*

street crossings, were used experimentally before being granted interim approval for use.

- Educational—Using pilots to help people understand how a design works.

Pilots and experiments can provide excellent publicity for the project and create political will for project approval. They use non-permanent materials to test a particular design for a short amount of time. These include the public engagement practice of using temporary demonstrations as a tool to familiarize the public with design concepts (Figure 3.32, Figure 3.33).

The main benefits of pilots include the ability to carry out the following:

- Test and adjust designs prior to construction
- Train staff and others on the intricacies of multimodal thoroughfare design
- Serve as before-and-after studies
- Reduce the need for lengthy and expensive analyses
- Inform the public of changes, and ensuing benefits or challenges
- Create or bolster political will for a project
- Potentially shorten the capital planning, design, and construction process
- Measure impacts that can be used by other practitioners

Ensure that any temporary projects are ADA-compliant, providing accessibility for individuals with disabilities, and that construction impacts on pedestrians, bicyclists, and others are taken into account and mitigated.

**Figure 3.32** Traffic cones used to test street design alternatives in Miami, FL, where a median (left) and curb extension (right) were piloted *(Source: Nelson\Nygaard)*

**Figure 3.33** Road diet piloted and built in St. Louis, MO *(Source: Nelson\Nygaard)*

# Pedestrian Mobility & Safety

4

**"Pedestrians are the lifeblood of our urban areas, especially in the downtown and other retail areas. In general, the most successful shopping areas are those that provide the most comfort and pleasure for pedestrians."**

— AASHTO Green Book, 2011 (p. 2–78)

**"In 2015, 5,376 pedestrians were killed in traffic crashes in the United States … almost 129,000 pedestrians were treated in emergency departments for non-fatal crash-related injuries in 2015."**

— Centers for Disease Control and Prevention, 2017[1]

[1] Centers for Disease Control and Prevention, "Pedestrian Safety." August 9, 2017. https://www.cdc.gov/motorvehiclesafety/pedestrian_safety/index.html.

# 4.1
# Typical Challenges

People walking activate street space, reduce congestion, and boost healthy outcomes—pedestrians on the street are the ultimate goal of a multimodal thoroughfare. Yet during the past 50 years, many streets have become wider, faster, and more complex, making streets challenging to travel at the human-scale, as reflected in Figure 4.1. Multimodal thoroughfares seek to create a balanced use of space. This chapter introduces design practices that create places where people want to walk. Typical challenges the practitioner faces include the following:

- Safety: Crashes involving pedestrians (with the practitioner goal of eliminating those crashes)
- Connectivity: Long signal spacing results in low density of connections and people are forced to either walk out of direction or cross at uncontrolled locations
- Crossing distance: Intersections with multiple turn lanes lengthen the pedestrian crossing
- Crossing time: Intersections with multiple signal phases result in long wait times for the pedestrian signal
- Sidewalk quality: Sidewalks with missing curb ramps, narrow sidewalks, driveways with significant cross-slopes, sidewalks in poor condition, and/or obstructions in the sidewalk
- Demonstrating demand: Parts of the community wants multimodal usage of a corridor, but the practitioner faces opposition from other constituents because "no one is walking today" indicating no demand for pedestrian activity
- Land use and community design: Wide setbacks, large surface parking lots, and narrow sidewalks make walking along the street unpleasant and accessing destinations difficult

**Figure 4.1** Arterials with numerous travel lanes emphasize vehicle movement but also serve pedestrians (taking transit, in this case). Making streets like these safe for all modes is a common challenge across the country. *(Source: Nelson\Nygaard)*

# 4.2 Increase Safety and Pedestrian Activity Along the Street

## 4.2.1 Allocate Space Using Zone System

Figuring out where the bicycle lane can be placed or how wide a sidewalk can be involves critical thinking, community input, and engineering judgment. The zone system is an organizational framework that helps to determine where to place street elements in the right-of-way.

The zone system helps practitioners clearly envision the different parts of the street and their functions. For example, considering the curb area as its own zone allows for a more nuanced discussion of the elements that can be in and around the curb (e.g., parklets, bicycle corrals, bulbouts, loading zones, etc.).

Generally, there are at least three zones in most streets: an area for moving vehicles (these might be cars, buses, trucks, or bicycles), an area for stationary objects (parked cars, trees, benches, light posts, etc.), and an area for walking that is free of obstructions. Some communities further subdivide or add (zones for retail or café dining) to make the zones more responsive to their local needs. Naming conventions vary based on community, but an example is provided in Figure 4.2.

### Pedestrian Realm

Sidewalks are a critical component of multimodal thoroughfares, creating a space for pedestrians to navigate the network safely. Several detailed and effective resources provide guidance that is widely accepted for

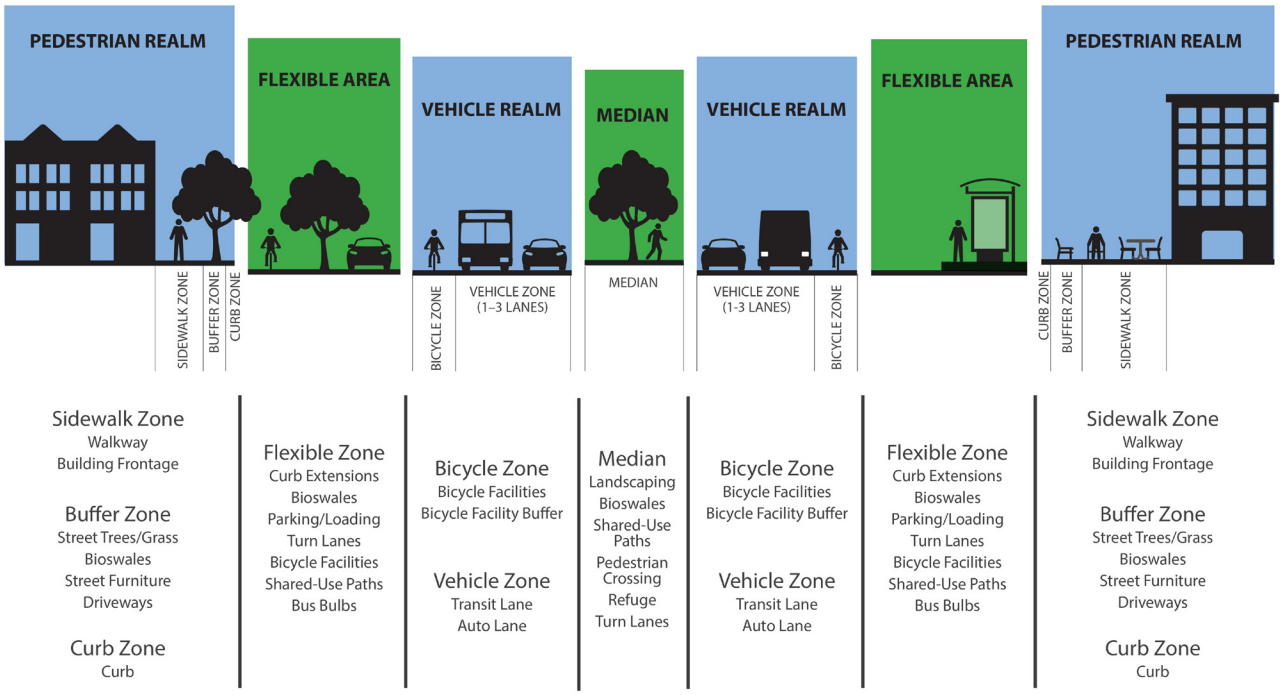



**Figure 4.2** Zones of the street help in thinking through placement of street elements *(Source: Nelson\Nygaard)*

sidewalk designs. Practitioners looking for guidance on the development and design of sidewalk projects should consult the AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities* and the U.S. Access Board's *2011 Notice of Proposed Rulemaking on Draft Proposed Rights of Way Guidelines* (PROWAG). The minimum clear through zone for pedestrians (not including space for street furnishings and the curb) should measure five feet in residential areas and six feet in commercial areas per the *Recommended Practice*.[1]

While sidewalks create a space for pedestrians to navigate a roadway network, sidewalks alone do not make walking feel safe and comfortable. Many people already walk out of need; the goal of multimodal thoroughfares is to also encourage walking by choice. Elements between the sidewalk and traveled way such as parked cars, landscaping, and street furniture have been shown to reduce motorist speeds and encourage pedestrian activity.[2,3,4,5,6] See Section 5.3 for a review of strategies for managing speeds and fostering pedestrian friendly streets.

## Safety in Numbers

"Safety in Numbers" is a term given to the phenomenon that when a group of people engage in a common activity, that activity becomes safer. Initial research from 2003 found that if bicycling or walking rates doubled, the injury rate only increased by about 32 percent.[7] A comparison of pedestrian commuter and fatality rates showed that cities where more people walked to work (as a proxy for walking rates in general) generally had lower pedestrian fatality rates.[8] These trends are reflected in Figure 4.3.

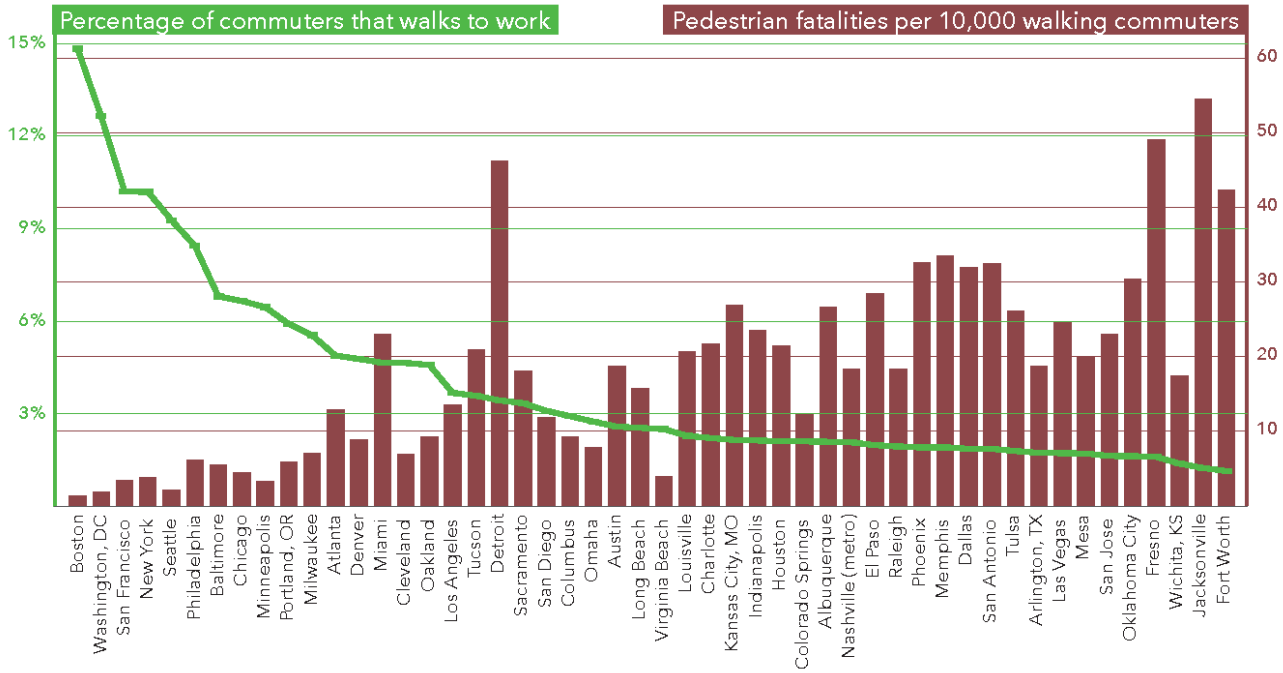



**Figure 4.3** As rates of pedestrians and bicyclists increase, it becomes safer to participate in those modes *(Source: Alliance for Biking and Walking[9])*

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1 Institute of Transportation Engineers. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice,* 2010.
2 City of Boston Transportation Department. *Boston Complete Streets Design Guidelines,* 2013.
3 City of Chicago Dept. of Transportation. *Complete Streets Chicago,* 2012.
4 Los Angeles County Department of Public Health. *Model Design Manual for Living Streets,* 2011.
5 National Association of City Transportation Officials. *Urban Street Design Guide,* 2013.
6 Welle, B., et al. *Cities Safer by Design: Urban Design Recommendations for Healthier Cities, Fewer Traffic Fatalities,* World Resources Institute, 2015.
7 P.L. Jacobsen, "Safety in numbers: more walkers and bicyclists, safer walking and bicycling," *Injury Prevention* 9, No. 3 (2003): 205-209, doi: 10.1136/ip.9.3.205.
8 Dorothy L. Robinson, "Safety in numbers in Australia: more walkers and bicyclists, safer walking and bicycling," *Health Promotion Journal of Australia* 16 No. 1 (2005): 47-51.
9 Alliance for Bicycling and Walking. *Bicycling & Walking in the United States,* 2016.

Specific to bicycling, research from Australia shows that "...if cycling doubles, the risk per kilometer falls by about 34 percent; conversely, if cycling halves, the risk per kilometer will be about 52 percent higher."[1] A comparison of bicycle rates and risks in the United States since 1977 had similar findings.[2]

Therefore, the absolute number of injuries to people walking or bicycling may rise, but not as fast as the number of people walking or bicycling. As such, the injury *rate* will lower. Explaining this to a questioning public and local decision-makers requires an understanding that the overall health of a community is also better in communities with higher rates of walking and bicycling than communities that are car dependent. Lowering the absolute number of injuries to people walking and bicycling may require additional engineering, education, or enforcement efforts.

## 4.2.2 Add Lighting

Often overlooked, lighting is a key feature that is needed at the scale of all users, including pedestrians and bicyclists. Studies consistently show a disproportionate number of pedestrian and bicyclists injuries and deaths occur during periods of low light or darkness. For example, most pedestrian deaths occur in urban areas, at non-intersection locations, and at night.[3] Effective lighting strategies to consider include:

- Scale: While vehicle-scaled lighting such as standard "cobra" lighting works well on highways, on multimodal thoroughfares cobra-head lighting does not work well to illuminate sidewalks. Pedestrian-scale lighting is placed on shorter poles than cobra heads and is oriented toward sidewalks and crosswalks.[4]
- Energy use: Switching to a different light source such as LED can reduce ongoing energy costs and maintenance needs, since LED lights last longer than traditional lights.
- Conflict points: Intersections, crosswalks, transit stops, and other potential conflict points need lighting to create a safe environment for all users.
- Shared-Use Paths: Paths are sometimes set back from the roadway. Lighting is needed both for visibility as well as security.

## 4.2.3 Connect Space with Community Design

Mixed land uses and transportation facilities alone are not enough to support walking. Retail areas with wide parking lots adjacent to the sidewalk are not inviting. Wide sidewalks with nowhere to sit do not invite walking for leisure.

Community design knits together the space between the curbs, the sidewalk, and the land uses behind the sidewalk. Communities that build and design to a pedestrian scale can ensure a context that fosters walking. Thoroughfares should be designed to serve the context of adjacent land uses to meet mobility, connectivity, accessibility, safety, and placemaking functions of public right-of-way.[5] Incorporating community design into corridor planning means consideration of the following:

- Street network—block length, intersection density (see Section 3.2)
- Building massing—height and relationship to street width
- Site design—placement of the building setback
- Frontage zone—interaction between the building and sidewalk via windows, doors, grates
- Landscaping and streetscape—trees, benches, public art
- Security—lighting, activity levels during evening and morning hours

## 4.2.4 Driveway Design and Consolidation

Driveways provide access and egress to parcels along a corridor. Yet on suburban arterials, frequent driveways pose several safety challenges:

- Motorists trying to spot the desired opening slow down or suddenly stop

[1] Alliance for Biking and Walking. *Bicycling and Walking in the United States 2016 Benchmarking Report,* 2016.
[2] Andersen, Michael and Tanya Snyder, "Don't Believe the Headlines: Bike Boom Has Been Fantastic for Bike Safety," Streetsblog USA, October 28, 2014.http://usa.streetsblog.org/2014/10/28/despite-ghsa-claims-the-bike-boom-has-been-fantastic-for-bike-safety/
[3] National Highway Traffic Safety Administration. "Traffic Safety Facts 2015 Data—Pedestrians." Washington, DC, 2017. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812375.
[4] Zegeer, Charles V., Dan Nabors, and Peter Lagerway. "Pedestrian Safety Guide and Countermeasure Selection System." Federal Highway Administration. 2013. http://www.pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=8.
[5] Institute of Transportation Engineers. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice,* 2010.

- Each driveway creates a conflict point between motorists and pedestrians
- Pedestrian comfort and safety is degraded and in some cases, travel for people with disabilities is inhibited
- Frequent driveways make the addition of protected cycling facilities difficult as driveways present conflict points

Although cities and states have access management standards, during a corridor design project the practitioner will likely find that many driveways along the corridor do not meet the standards. This happens because the standards were likely put into place after the curb cuts were created. In many cases, one parcel might have two driveways, or very wide driveways, causing nearly the entire block to be a curb cut. In these cases, driveways can be consolidated to try to meet access management standards.

In general, reducing the total number of driveways may reduce conflict points and create a more welcoming pedestrian atmosphere. The project process may reveal opportunities to consolidate and/or eliminate driveways. Consolidation can also occur during redevelopment, which would require a staged implementation process that occurs when individual parcels seek new use permits. This concept is reflected in Figure 4.4.

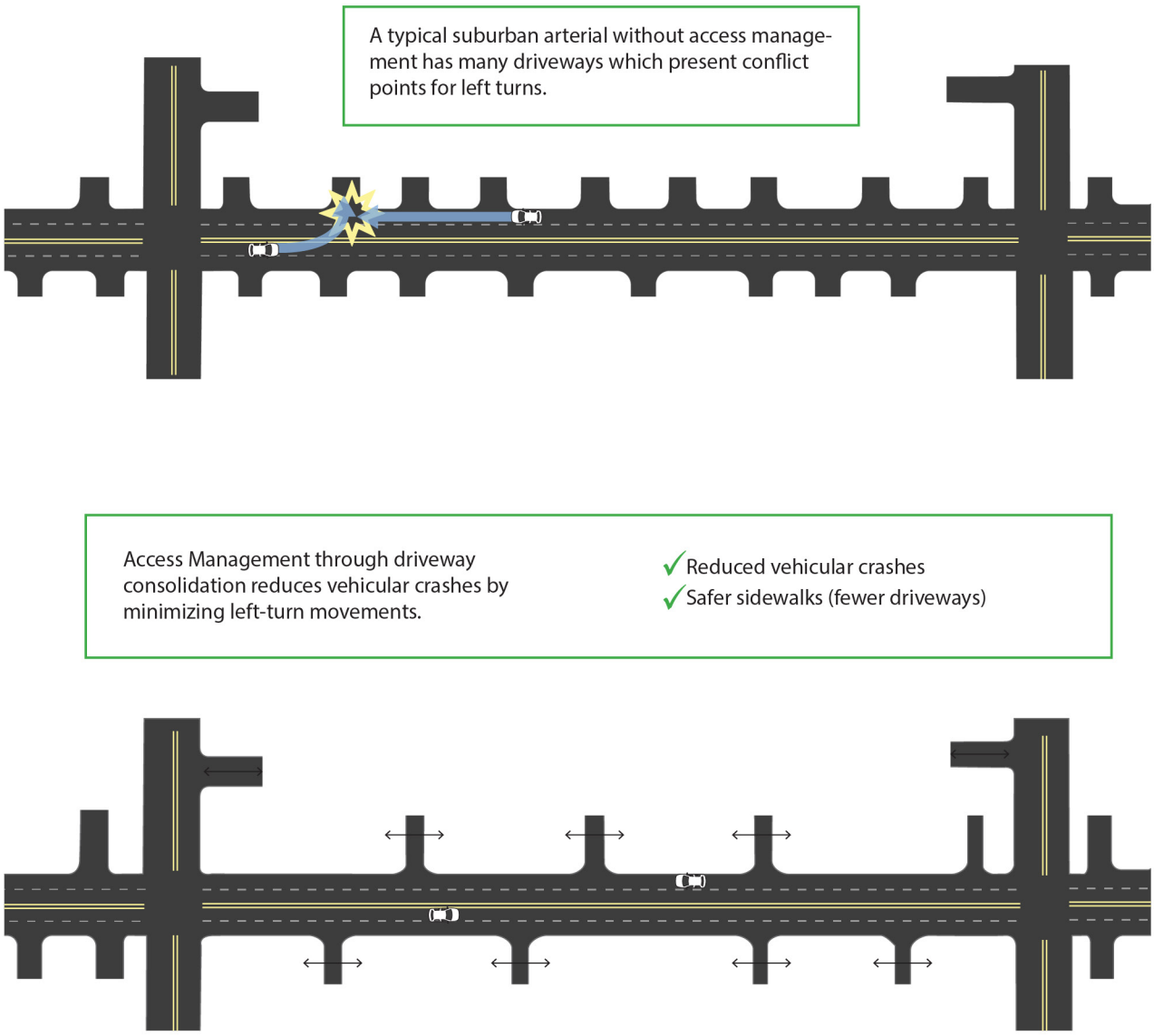



**Figure 4.4** Impacts of Driveway Consolidation *(Source: Nelson\Nygaard)*

| | Min. Distance from Signalized Intersection | Min. Distance from Unsignalized Intersection | Min. Driveway Width | Max Driveway Width |
|---|---|---|---|---|
| Commercial Driveways | 100′ | 100′ | 20′ | 24′ |
| Residential Driveways | 40′ | 20′ | 10′ | 12′ |

**Figure 4.5** Example standard for driveway spacing and design *(Source: Boston Transportation Department[1])*

Driveways widths range from eight-foot wide ramps leading to one-car garages to curb cuts running nearly the entire block. Gas stations and sites with drive-throughs often have very wide driveways. Keeping driveways narrow lowers motorist turning speed, which in turn reduces the chance of crashes between motorists and pedestrians using the sidewalk across a driveways.

Guidance for multimodal driveway design includes the following:

- Design driveways so the sidewalk is dominant (at sidewalk level, using sidewalk materials) and has good sight lines. A driveway should be designed to favor those walking or bicycling along the road (across the driveway).[2]
- Design the driveway so it meets the street at a right angle
- Keep commercial driveway widths to no more than 24 feet (Figure 4.5)
- Remove driveways closer than 100 feet to intersections over time (Figure 4.5)
- Consolidate driveways wherever possible, providing access to parcels from access streets
- Design for 10 mph turning speeds or less[3]
- Use stop/yield signs for exiting traffic, particularly if sight distance is limited to prevent conflicts with pedestrians or other vehicles
- To further improve visibility, avoid locating curbside parking spaces within 30 feet of a driveway[4]
- Use steep graded approach ramps to slow turning traffic and clarify vulnerable user priority at conflict points
- Warning beeps and flashing lights to alert pedestrians and bicyclists of exiting vehicles may also be used at driveways to/from garages

## 4.2.5 Add Bicycling Facilities

Bicycling is an increasing component of multimodal thoroughfares. Bicycle facilities may be placed at sidewalk level, between sidewalk and pavement level, against the curb, or to the left of a parking lane. Bicycling facilities can actually benefit pedestrians by providing more distance between the walking area and the vehicle traveled way. See Section 5.3.3 for information on separated bicycle facilities.

Practitioners looking for guidance for the development and design of bicycle facilities should consult the ITE *Protected Bikeways Practitioner's Guide* and FHWA *Separated Bike Lane Planning and Design Guide,* which provides design guidance, detailed information associated with case studies, information regarding the planning process for bicycle facilities, and recommended project evaluation criteria. Additionally, the NACTO *Urban Bikeway Design Guide* and the MassDOT *Separated Bike Lane Planning and Design Guide* provide a comprehensive overview of bicycling facilities.

## 4.2.6 Enhance Transit Stops

Increasing the space for transit riders benefits all who walk along the street. Extending the sidewalk to create bus bulbs provides transit riders with more space to wait for buses (Figure 4.6). Adding amenities like shelter and seating further add to a comfortable transit experience.

By dedicating space for transit riders, sidewalk space is freed up for general pedestrian travel. Additionally, bus bulbs help speed transit operations, as bus operators can

[1] City of Boston Transportation Department. *Boston Complete Streets Design Guidelines,* 2013.
[2] Poorly designed driveways can also contribute to congestion, as noted by AASHTO: "Conflicts and congestion occur at interfaces between public highways and private traffic-generating facilities when the functional transitions are inadequate. Examples are commercial driveways that connect directly from a relatively high-speed arterial to a parking aisle." American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed., 2011: 1-2.
[3] Federal Highway Administration. *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts,* 2016.
[4] National Association of City Transportation Officials. *Urban Bikeway Design Guide,* 2nd ed. 2014.

**Figure 4.6** Bus bulbs provide space for transit riders to wait *(Source: Nelson\Nygaard)*

stop in traffic (often referred to as an "in-lane stop") and do not have to wait for a gap to re-enter traffic.

Bus bulbs shorten the crossing distance for all users. If transit stops are located mid-block, AASHTO notes that mid-block pedestrian crossings may need to be provided.

**The *Recommended Practice* (see pp. 163–164) provides a comprehensive list of considerations for bus stop placement.**

# 4.3 Crossing Location, Treatment, and Design

Street crossings are often the most challenging element of pedestrian design. Typical challenges include the following:

- Existing crosswalks are located ¼ mile apart or further, often times located only at signalized intersections
- Block spacing is shorter than signal spacing. Since blocks are natural crossing points, people cross between signals. Although in most states, every intersection is legally a crosswalk, whether marked or not, not all motorists are aware of this law.
- No marked crossings at trip generators like bus stops and shopping malls
- Resistance to adding marked crosswalks due to concerns of installation cost, liability, and maintenance
- Resistance to adding traffic-controlled crosswalks due to concerns over meeting MUTCD warrants

A pedestrian crossing is the path along which a pedestrian wishes to (or does) travel. This concept is related to pedestrian networks and desire lines (see Sections 3.2.3 and 3.4.4). A crosswalk is defined as the extension of the sidewalk across an intersection (whether marked or not). Ideally, crosswalks are matched to crossing locations to provide the most convenient, direct, and comfortable walking environment. Crosswalks can take many forms including the following:

**Figure 4.7** Where motorists need access, pedestrians need access; safe crossings are needed at trip generators like retail *(Source: Nelson\Nygaard)*

- Unmarked crosswalks are legal crosswalks without any traffic control markings

## ADA Compliance

**Cities are legally bound to meet certain standards to be ADA compliant. Title II of the ADA requires public entities to ensure that all their programs, activities, and services—including their public rights-of-way—are accessible to and useable by individuals with disabilities. Key requirements include the following:**

- **Curb ramps located at all crosswalk locations, whether they are at intersections (marked or unmarked) or midblock locations**
- **Curb ramps designed with specific dimension as identified in the 2010 ADA Standards for Accessible Design**
- **If the agency is a recipient of federal financial assistance from US DOT, curb ramps must include detectable warning surfaces in compliance with the 2006 DOT Standards**
- **Locations for crossing the street should be legible for those with visual disabilities using design features such as truncated domes and crossing edges**

**To meet accessibility requirements, practitioners should reference PROWAG. Though not yet required, these guidelines are considered by FHWA as the best practices for the design and construction of sidewalks, pedestrian facilities, and other elements in the public rights-of-way.**

- Marked crosswalks are legal crosswalks with markings
- Uncontrolled crosswalks are legal crosswalks without stop signs, signals, or other traffic controls
- Controlled crosswalks are legal crosswalks with traffic control

A crosswalk can be a combination of the above terms; for example, a community may have many unmarked, uncontrolled crosswalks.

When creating ways to cross the street, the practitioner may think through three things:

- Location: Where to place the crosswalk (ideally, lining it up with crossing locations)
- Treatment: Level of protection of the crosswalk—unmarked, marked, signalized, etc.
- Design: The striping type, materials, and visual elements of the crosswalk

**Figure 4.8** Marked, uncontrolled crosswalk 250 feet from signalized intersection to facilitate transit passenger movement at light rail station *(Source: Nelson\Nygaard)*

## 4.3.1 Location

Legally, pedestrians can cross at any marked or unmarked crosswalk. Unmarked crosswalks exist at any intersection with sidewalks, but many motorists are not aware of this law.[1] Marking crossings helps to establish visually that pedestrians will be present. Also, the pedestrian network is often more fine-grained than the motor vehicle network, thus crossings may be needed between intersections (see Section 3.2.3). Crossings are needed at desire lines connecting trip generators, such as at transit stops, shopping centers, and building entrances.[2]

The spacing of crossings varies by context. The block network makes for a natural start for figuring out crossing points, and block size varies from 200 feet to 600 feet or more. In communities with very long blocks, desire lines may necessitate midblock crossings Research has shown that pedestrians are unlikely to walk more than 300 feet out of their way to access a marked crosswalk.[3] MUTCD does not dictate spacing for location of uncontrolled crossings.[4] This gives practitioners the flexibility to locate crossings where there is need. For example, crossings at both ends of a light rail station (Figure 4.8) are spaced 250 feet apart and facilitate getting people to and from the station.

## 4.3.2 Treatment

Treatments may vary but must be determined by considering vehicle speed, volume, and roadway configurations. Narrower streets with low volume may not need any formal crosswalks; unmarked, uncontrolled crosswalks may feel safe for all users. Wider, high speed, and high volume roads may require more involved treatments to minimize conflicts between pedestrians and vehicles. These treatments may include medians, overhead signs, improved lighting, and traffic control devices. MUTCD guidance for low-speed streets (35 mph and under) follow FHWA's "Safety Effects of Marked versus Unmarked Crosswalks" for the treatment of marked, uncontrolled crosswalks. (Figure 4.9) summarizes what this guidance means for crossing treatments under different conditions.

Crossings that require more than enhancements need traffic control, creating marked, controlled crosswalks. MUTCD

[1] Fehlig Mitman, Meghan, et al. *Driver/Pedestrian Behavior at Marked and Unmarked Crosswalks in the Tahoe Basin,* California Partners for Advanced Transit and Highways. 2010.

[2] The City of Boston recommends that pedestrian crossings be located wherever there is a concentration of pedestrian origins and destinations across from each other, regardless of whether a formal street or intersection is present. Source: City of Boston Transportation Department. *Boston Complete Streets Design Guidelines,* 2013.

[3] Fitzpatrick, Katy, Brooke Ullman, and Nada Trout. "On-Street Pedestrian Surveys of Pedestrian Crossing Treatments." Transportation Research Board. 2003.

[4] Federal Highway Administration. "3B.18: Crosswalk Markings," in *Manual of Uniform Traffic Control Devices,* 2009 Edition with Revisions No. 1 and 2 Incorporated. 2012.

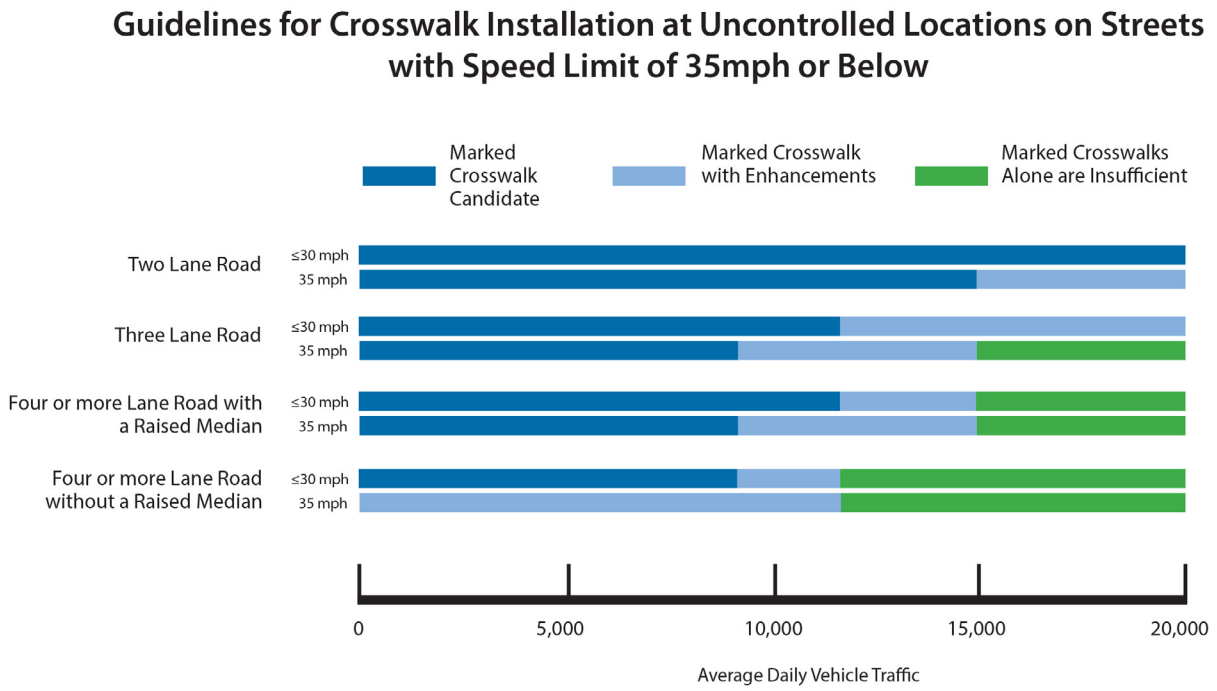



**Figure 4.9** Guidelines for crosswalk installation at uncontrolled locations on streets with speed limit of 35 mph or below *(Source: Nelson\Nygaard)*[1]

provides warrants for location of pedestrian signals (which could be pedestrian-specific, such as flashing beacons, or full signals). These factors include the following:

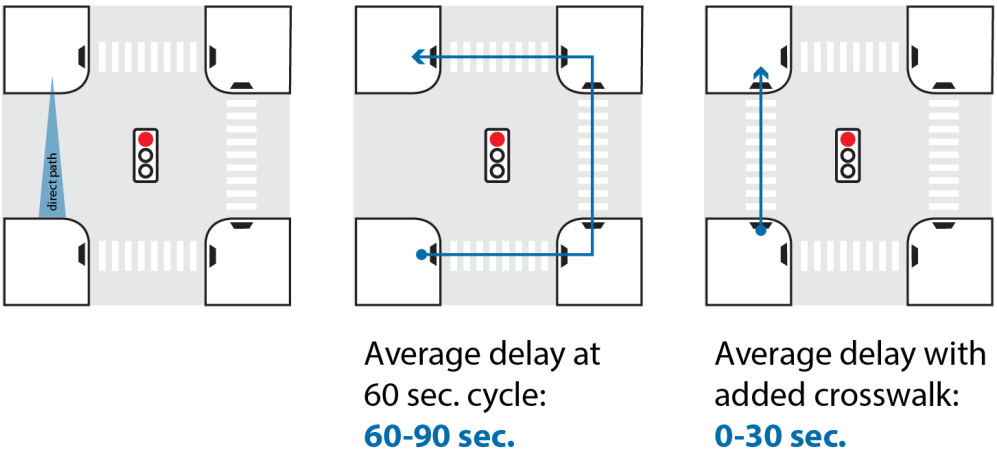
- Pedestrian volumes
- Crash history
- School location
- Proximity to closest traffic control (no closer than 300 feet)[2]

This standard creates several issues for pedestrian mobility and safety:

- **Warrants are too high.** TCRP Report 112: Improving Pedestrian Safety at Unsignalized Intersections, conducted a workshop with practitioners.
  - "The engineers who expressed concern about the MUTCD pedestrian warrant unanimously agreed that the required pedestrian volumes were too high to adequately address many pedestrian crossing issues in their jurisdiction. To address their pedestrian issues, many engineers either installed crossing treatments that are less restrictive than traffic signals, modified the existing MUTCD pedestrian warrant, or used a supplementary engineering analysis to justify a traffic signal installation."[3]
- **Jurisdictions rigidly adhere to the 300 foot rule.** The 300 foot standard applies to controlled, marked crosswalk location, but some jurisdictions interpret this to apply to all crosswalks, whether controlled or uncontrolled.[4] Many cities have blocks that measure less than 300 feet. As these communities seek to add direct and frequent crossings, the 300 -oot standard inhibits them from installing controlled crossings at every block. The MUTCD standard also stipulates that controlled crosswalks should not be less than 300 feet from the nearest traffic control "unless the proposed traffic control signal will not restrict the

[1] Based on data from source: Federal Highway Administration. "Safety effects of marked versus unmarked crosswalks." 2005.
[2] Federal Highway Administration. "4C: Traffic Control Signal Needs Studies," in *Manual of Uniform Traffic Control Devices,* 2009 Edition with Revisions No. 1 and 2 Incorporated. 2012.
[3] Fitzpatrick, Kay, et. al., *TCRP Report 112/NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings,* Federal Transit Administration, Transportation Research Board. Washington, DC, 2006. https://nacto.org/wp-content/uploads/2010/08/NCHRP-562-Improving-Pedestrian-Safety-at-Unsignalized-Crossings.pdf.
[4] For example, see source: City and County of Denver. "Uncontrolled Pedestrian Crossing Guidelines." 2016. https://www.denvergov.org/content/dam/denvergov/Portals/Transportation-Mobility/documents/CCD-uncontrolled-pedestrian-crossing-guidelines-2016.pdf.

**Figure 4.10** Crosswalks on all intersection legs versus missing leg *(Source: Nelson\Nygaard)*




progressive movement of traffic."[1] There is flexibility for engineering judgment built into the standard, but this detail is often overlooked.

- **Crashes focus on vehicles.** The warrant assessing crashes only looks at vehicle crashes, without including those involving pedestrians.

TCRP Report 112 describes the following useful tools and suggestions for making crosswalk placement more in line with community needs:

- **Middle ground between controlled and uncontrolled crosswalks.** Communities have created installation criteria for devices that are not signals, nor are they static signs. These include in-roadway warning lights and flashing beacons.
- **Modifications to warrants.** Some communities interviewed reduced the warrants based on factors such as vulnerable users, transit ridership, or type of street (i.e. wider streets are harder to cross without control). Another community used warrants that are 80% of the values included in MUTCD.
- **Incorporate roadway characteristics.** Vehicle speed, width of roadway, and volumes could all be incorporated into pedestrian signal warrants.

## 4.3.3 Design

### Alignment

Design crosswalks with the straightest and most direct path. Direct crosswalks reduce crossing time for pedestrians. Align crosswalks with sidewalks and wheelchair ramps.

### Crosswalk Striping On All Legs

In general, try to stripe crosswalks on all legs. A single missing leg at a standard four-way intersection can be highly problematic for pedestrians, as it can require crossing three approaches tripling exposure to vehicle conflicts, and if the intersection is signalized, this can greatly increase crossing times and lead to non-compliance.[2]

Striping crosswalks on all legs of an intersection provides a path that is more clearly visible to motorists, enhancing safety and minimizing potential conflicts and delay at intersections, as seen in Figure 4.10.

In some cases, high turning volumes may suggest removal of a crosswalk leg. This approach could be taken in exceptional situations and for intersections where the policy is clearly to prioritize vehicle throughput. Another option would be the use of signal phasing that protects the crosswalk with its own phase, typically concurrent with a parallel vehicular movement. If an otherwise legal crosswalk (created by an extension of a sidewalk) is closed, such closure must be communicated to pedestrians with visual disabilities.

### Materials

Make crosswalks visible to pedestrians and motorists. In many locales two lateral lines perpendicular to the roadway identify a crosswalk, but current best practice is to employ zebra, ladder, or continental crossing stripes due to their enhanced visibility.

[1] Federal Highway Administration. "3C: Roundabout Markings," in *Manual of Uniform Traffic Control Devices,* 2009 Edition with Revisions No. 1 and 2 Incorporated. 2012.

[2] NACTO recommends marked crosswalks on all legs of all intersections except on streets with low traffic volumes (< 3,000 vehicles per day), low speeds (<20 mph), and with no more than one or two lanes. Source: National Association of City Transportation Officials, *Urban Street Design Guide,* 2013.

Visibility is a key element of roadway design. Markings should tend toward high-visibility, regardless of underlying material, as required by MUTCD.[1] The most obvious example of this is high-visibility crosswalks; however, lane markings and other striping elements can also be high-visibility.

Though required, often municipalities do not use such materials at crossings, often for decorative purposes, as seen in Figure 4.11. Such materials, while decorative, can create hazardous conditions, by making pedestrian crossings, and as a result, pedestrians, less visible, especially during evening hours.

Use high-visibility materials. High-visibility materials are those that can be seen by all users at all speeds in most weather conditions. Examples of high-visibility materials are seen in Figure 4.11 and Figure 4.12.

**Figure 4.11** Decorative brick crosswalks can be difficult to see *(Source: Nelson\Nygaard)*

**Figure 4.12** High visibility crosswalks offer good visibility for motorists *(Source: Nelson\Nygaard)*

## Highway Ramps

Where a ramp to or from a highway meets a street, there is potential for conflict between motorists and people walking on the sidewalk, bicyclists, and other roadway users.

The cloverleaf design of highway ramps mean that motorists are often traveling at speeds that are higher than desired on the local street. Many entrance and exit ramps are designed to facilitate merging at higher speeds, negatively affecting the peripheral view of a motorist. These factors, while efficient at moving vehicles, create serious conflict points between motorists and vulnerable users on the road.

To reduce speed and increase visibility, pedestrian crossings can be squared off at highway ramps, as represented in Figure 4.13.

Other solutions to facilitate a safer junction between a highway ramp and street include the following:

- Curving the ramp so it meets the street at a right angle
- Placing crosswalks perpendicular to the ramp
- Signalization
- Placing a series of horizontal curves along an exit ramp to incrementally slow motorists
- Installing traffic calming devices on exit ramps
- Utilizing longer ramps and deceleration lanes to reduce speeds

For additional materials on designing for vulnerable users at interchanges, ITE's *Design Guidelines to Accommodate Pedestrians and Bicycles at Interchanges* provides in-depth guidance.

## Bridges and Tunnels

A pedestrian bridge or tunnel (overpass or underpass) is a physical structure built for the express purpose of getting people on foot or bicycle over or under a roadway or other barrier (train tracks, canals, etc.).

[1] Federal Highway Administration. "3G: Colored Pavements," in *Manual of Uniform Traffic Control Devices,* 2009 Edition with Revisions No. 1 and 2 Incorporated. 2012.

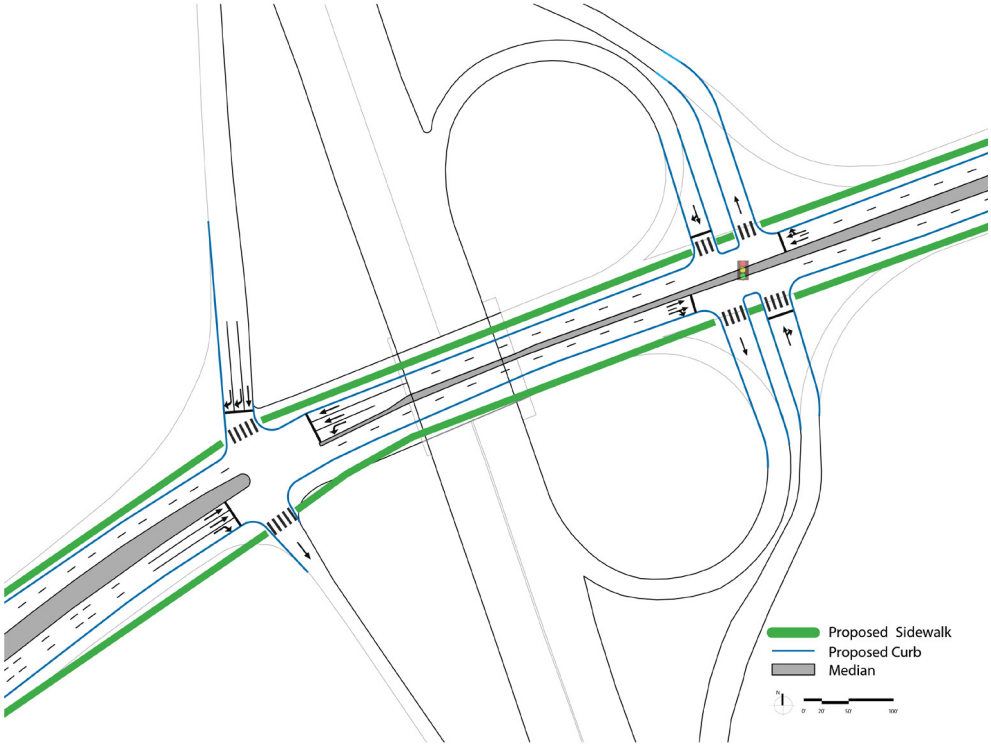



**Figure 4.13** Highway ramps can be designed to meet local streets at right angles *(Source: Nelson\Nygaard)*

A pedestrian bridge/tunnel will be little used where the time to go up or down and across is greater than that of crossing at-grade.[1,2] This leads to the main argument against pedestrian bridges/tunnels—that people will not use them.

In some cases, grade-separated crossings may be useful and/or are the only option for crossing highways or other major barriers. Tunnels can work well for bicyclists, as they require less grade change and bicyclists can use the downhill momentum to ease the climb back up, as seen in Figure 4.14.

If a pedestrian bridge or tunnel is necessary, practitioners may consider the following:

- To accommodate people with disabilities, ramps and/or elevators must be installed and maintained
- In tunnels, ensure good visibility, lighting and sight lines for security
- Integrate pedestrian bridges and tunnels into the surrounding infrastructure such as transit stations and shopping centers
- If adjacent to a hill, use the natural grades to eliminate the need for ramps

**Figure 4.14** Bridge and tunnel crossings for bicyclists and pedestrians *(Source: Nelson\Nygaard)*

[1] Räsänen, Mikko et al. "Pedestrian self-reports of factors influencing the use of pedestrian bridges." *Accident Analysis and Prevention,* September 2007.
[2] AASHTO also notes that pedestrians are generally averse to bridges and tunnels: "Pedestrians also have a basic resistance to changes in grade or elevation when crossing roadways and tend to avoid using special underpass or overpass pedestrian facilities." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. (2011): 2-78.

# 4.4 Intersection Design

## 4.4.1 Compact Intersections

Compact intersections are preferred for establishing a multimodal environment. A compact intersection has a small roadway footprint, fosters eye contact, reduces crossing distances, and reduces speeds. Where compactness is not achievable due to geometry, number of streets, turning requirements, etc., it might be feasible to break up intersections into "mini-intersections" using small roundabouts.

Techniques to create compact intersections include the following:

- Designing for the largest vehicle that regularly executes the subject movement—FHWA recommends that practitioners use the smallest practical design vehicle[1]
- Calculating turning radius using effective rather than actual radius (see Section 5.3.9)
- Setting back stop lines to allow wider turns from approaching legs
- Adding pedestrian refuge islands
- Constructing curb extensions where on-street parking is present or in cases where a turn lane is discontinued across an intersection

Approaches to creating compact intersections can be thought of an moving curbs closer together, adding raised areas within the intersection, or a combination (Figure 4.15).

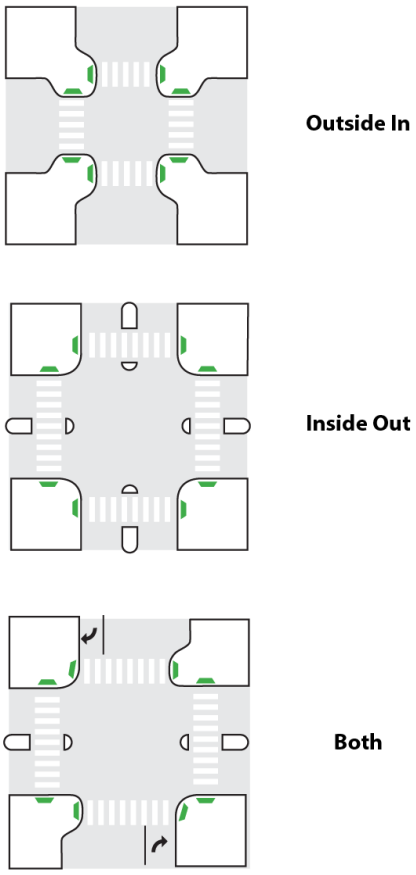



**Figure 4.15** Strategies for creating compact intersections *(Source: Nelson\Nygaard)*

### Facilitate Eye Contact

Eye contact in the context of transportation planning refers to visual dialogue between people. Fostering eye contact between street users is achieved by creating compact street designs and slowing speeds at intersections and other conflict points.

At lower speeds, increased eye contact can mitigate crashes. A motorist can make eye contact with other users (motorists or otherwise) and decrease the potential for crashes.[2]

### Minimize Exposure

Exposure risk is the amount of time that a person is exposed to potential conflicts. Examples include the amount of time

[1] Federal Highway Administration. *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts,* 2016.
[2] Guéguen, Nicolas et al. "A pedestrian's stare and drivers' stopping behavior: A field experiment at the pedestrian crossing." *Safety Science.* June 2015.

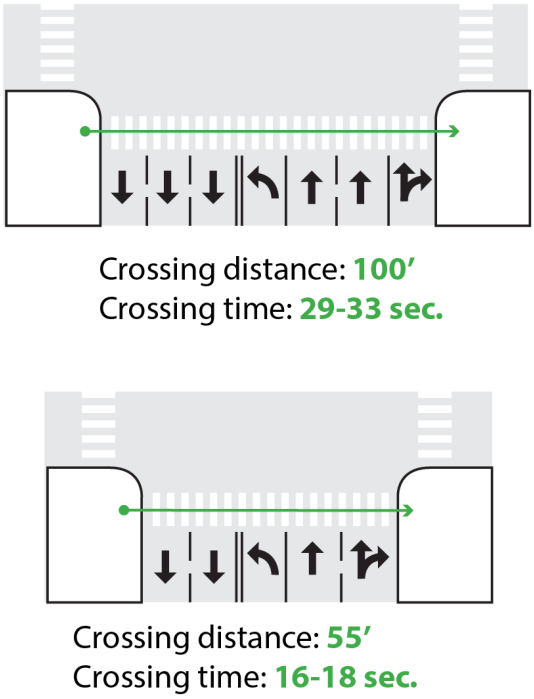



**Figure 4.16** Smaller intersections result in less exposure, less crossing time, and less clearance time *(Source: Nelson\Nygaard)*

that it takes a person to cross the street, or the amount of time it takes to drive through an intersection. Minimizing exposure risk generally increases safety as it reduces the amount of time users are exposed to a possible crash. This concept is presented visually in Figure 4.16.

Compact intersections, short crossing distances, and intuitive design all reduce exposure. Shorter crossings have the added traffic benefit of less clearance time needed during the flashing don't walk phase.[1]

## Minimize / Remove Turn Lanes

Right- and left-turn lanes are used to facilitate traffic flow and provide storage for vehicles queued to turn. They also create larger intersections and may add to overall signal cycle length if turning movements have dedicated phases.

### Right-Turn Lanes

Right-turn lanes that cut into the curb line are generally not recommended in well-networked urban environments (general purpose lanes that become right turn lanes or right turn lanes that replace on-street parking near the intersection may be considered).

If traffic volumes demonstrate need for a dedicated right turn lane, add a channelizing island so pedestrians can cross the turn lane separately from the through lanes.

Slip lanes with "pork chop" shaped islands, as shown in Figure 4.17, are angled so that motorists approach the crosswalk straight on, enhancing visibility. Use the design angle of 55-60 degrees and a design speed of 14-18 mph.[2] In addition, the use of stop controls and a raised crosswalk on the right-turn slip lane are preferred in order to manage speeds and limit conflicts between pedestrians and motorists.

If traffic analysis deems that existing right turn lanes are not needed, they can be used as transit queue jumps.

### Left-Turn Lanes

Dedicated left turn lanes benefit motorists by removing left-turn vehicles from through traffic. Protected left turn signal phasing can facilitate turns when gaps in oncoming traffic are infrequent. Left turn lanes also widen intersection crossings. The addition of left turn signal phases can increase the overall delay at a signal for all users. Try to avoid double left turn lanes, which result in even larger intersections, and seek ways to channel traffic to other streets in the network.[3]

## Add Curb Extensions

Curb extensions can be used in tandem with on-street parking to narrow a crossing, either at the intersection or midblock. They serve to increase safety in a variety of ways.

Benefits:

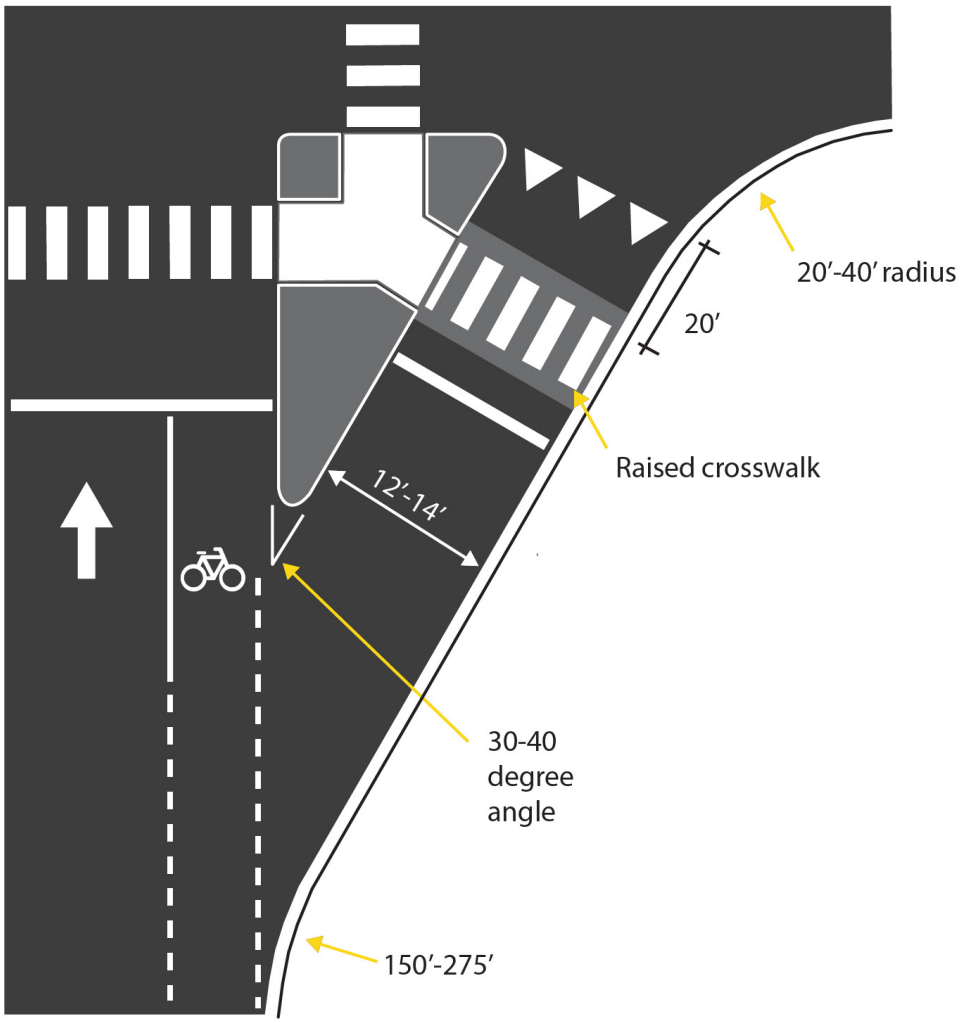
- Lowers turning speeds
- Shortens pedestrian crossing distance

[1] AASHTO recommends use of "simple designs that minimize crossing widths and minimize the use of more complex elements such as channelization and separate turning lanes." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 2-79.

[2] Federal Highway Administration. "Road Design: Well Designed Right-Turn Slip Lanes." http://safety.fhwa.dot.gov/saferjourney1/library/countermeasures/15.htm.

[3] The *Highway Capacity Manual* lists thresholds for dual left turn lanes as 300 vehicles turning left during the peak hour.

**Figure 4.17** Channelized right turn lane design with marked bicycle facilities *(Source: Nelson\Nygaard)*




- Shorter pedestrian walk time needed, which can reduce signal cycle times
- Increases visibility for people waiting to cross the street
- Enforces no parking near intersection ordinances by design
- Can provide additional space for bus passengers waiting
- Can provide space for utility poles, trashcans, newspaper boxes, etc.
- Adds space at corners to allow for installation of two ADA ramps, which better direct people in line with crosswalks rather than one per corner

Considerations:

- Reduced effective turning radius (concern for freight)
- May interrupt water flow to drains
- Generally, not possible when on-street parking is not present

In winter environments, ensure that the curb return can accommodate snowplows, and include vertical elements that will be visible during snow cover. Along bicycle corridors, pull back curb extensions a foot or two from the bicycle lane.

Generally, curb extensions may be included wherever on-street parking is present. Exceptions might include the following:

- Curb lanes are used for mobility purposes, such as peak-only travel
- The receiving street for right turning vehicles is too narrow for the design vehicle to make right turns
- Moving drainage may present a cost challenge

## Add Pedestrian Refuge Islands

A pedestrian refuge is a section of median at a crossing location that is sufficiently large (six feet or wider) for pedestrians to wait. It can stand alone or be part of a longer median. When located at an intersection, the refuge extends beyond the crosswalk to enforce slower turning speeds, as

**Figure 4.18** Pedestrian refuge islands with median tips can reduce turning speed and ensure that motorists turning left meet the crosswalk at a right angle *(Source: Nelson\Nygaard)*

shown in Figure 4.18. The crosswalk is cut into the median at street level, with tactile warning strips.

Refuge islands have the following four primary benefits:

- Facilitate crossing movement by providing a space for pedestrians to wait who cannot make the crossing in one phase. It is more convenient for pedestrians to cross the street in one stage (with signals timed accordingly), but some pedestrians will begin their crossing toward the end of the flashing don't walk, phase or have mobility limitations, and will be unable to complete the crossing.
- Median tips (extension of the refuge beyond the crosswalk) reduce left turn speeds
- Add a friction element to the street to reduce motorist speeds
- Provide space for landscaping or other amenities

When no left turns are possible, refuge islands can take the place of the TWLTL and measure 10'–12' wide (or the width of the TWLTL). Bracket the crosswalk with the island to provide visual and physical separation of traffic. Add bollards to enhance separation. An example, refuge island, is shown in Figure 4.19.

**Figure 4.19** Refuge islands can include landscaping and seating *(Source: Nelson\Nygaard)*

### Use Small Corner Radii

See Section 5.3.9.

## 4.4.2 Enhance Visibility

Ninety-degree angles at intersections provide the best visibility. At skewed intersections, some corners end up acute, which results in difficulty for large vehicles making tight turns, limits space for directional curb ramps, creates longer pedestrian crossings, and reduces visibility to the right. Other approaches are obtuse creating skewed curb ramps, and other design challenges. Try to square off skewed intersections so that they are at least at 75 degrees.

### Sight Triangles

Sight triangles are a concept meant to enhance safety through good visibility at intersections. They are calculated based on design speed and the type of traffic control used at the intersection. Sight triangles are "specified areas along intersection approach legs and

across their included corners, which should be clear of obstructions that might block a motorist's view of potentially conflicting vehicles."[1]

The need for sight triangles is clear in suburban contexts (where buildings are set back from the street) and along higher speed streets. In urban or transitioning contexts (buildings directly behind the sidewalk, or planned to be) with speeds below 30 mph, sight triangles can be disruptive to the urban fabric because a building on a corner would need to be removed in order to obtain the desired sight triangle. Furthermore, in urban areas the demand for on-street parking may limit the ability to provide sight-triangles that meet AASHTO criteria. It is therefore important to understand when their use is called for, as summarized below:

- Traffic Signal Control—No Sight Triangle Calculation Required
- All-Way Stop Control—No Sight Triangle Calculation Required
- Side-Street Stop Control (main movement not stop controlled)—Calculation Required

If the land use policy at an intersection calls for buildings to be built to the back of the sidewalk in the future (even if the current buildings are set further back), this may be taken into account in determining the speed design and sidewalk standards. In Figure 4.20 below, a motorist stopped on a side street looking for gaps in 30 mph main street traffic is likely to have difficulty seeing far enough along the main street due to the presence of a building. Two simple steps of reducing the vehicle speeds on the main street to 25 mph and adding a landscaped buffer between the sidewalk and the street will clear the building from the sight triangle creating a safer condition.

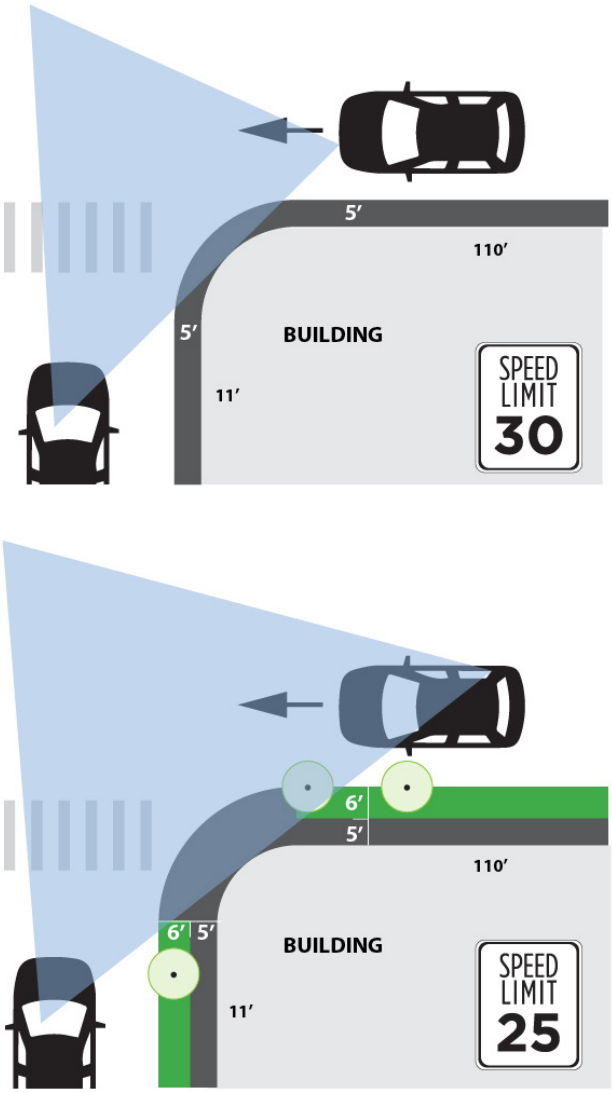



**Figure 4.20** The figure shows a building sitting within a sight triangle because of 30 mph speeds and small sidewalks. The motorist would likely need to pull into the crosswalk, or potentially even into traffic to see to the right. Below, the slight speed reduction to 25 mph and buffering of the sidewalks allows the sight triangle to reach the oncoming car. *(Source: Nelson\Nygaard)*

[1] American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 9-29.

# 4.5 Intersection Control

## 4.5.1 Pedestrian Signals

### Recall vs. Actuated Signals

Signals that are programmed for "pedestrian recall," or those that do not require pedestrians to push a button to request to cross the street, are generally preferred in walkable districts. Consistency in these signals throughout the district helps avoid confusion for pedestrians where push button calls may or may not be required to obtain a walk signal.

Conventional practice employs actuated pedestrian signals to minimize pedestrian or cross-traffic interference with the flow of traffic in the dominant direction. This makes sense in rural areas with low pedestrian demand, but on multimodal streets where pedestrians are desired, this practice makes pedestrians a secondary user.

Signals set to pedestrian recall should generally be the rule in areas of pedestrian activity. It is recommended that pedestrian recall signals are equipped with "accessible pedestrian signals" to ensure ADA and MUTCD compliance, though the walk signal will be called regardless of pressing the actuator.

Signals can also be synchronized to encourage motorists to adhere to the speed limit. This is critical during off-peak hours.

### Leading Pedestrian Intervals (LPI) and Leading Bicycle Intervals (LBI)

Leading intervals provide a head start for pedestrians and bicyclists, making them more visible in the crosswalk or bicycle lane and helping to cue turning motorists to yield, as represented visually in Figure 4.21. LPIs have been shown to reduce pedestrian-vehicle crashes by as much as 60 percent when implemented at intersections.[1]

LPIs and LBIs do not add time to the overall signal cycle, but "borrow" time from the green time allocated to vehicles in a cycle. An LPI should be at least 3 seconds in duration and should be timed to allow pedestrians to cross at least one lane of traffic. [2] Additionally, when LPI's are used, they may also be paired with right turn on red restrictions.

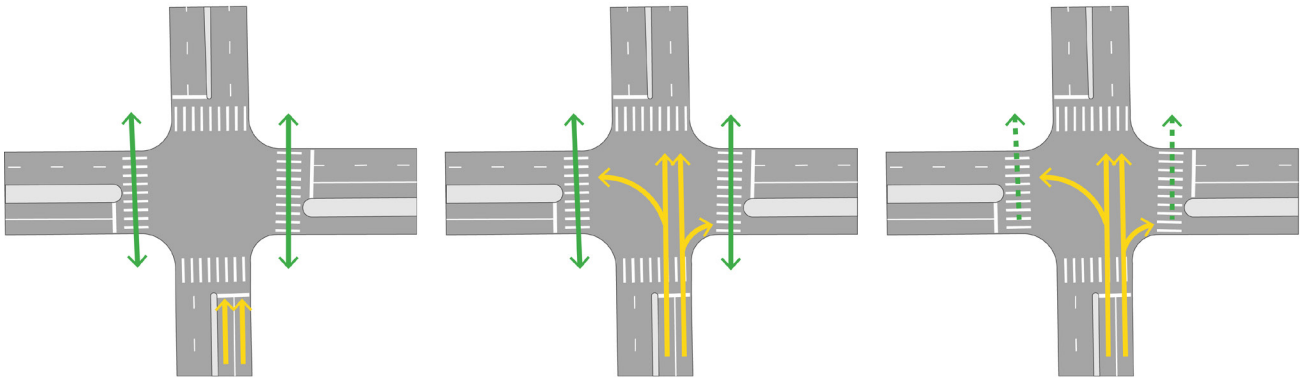


**Figure 4.21** Leading Pedestrian Intervals allow pedestrians to establish themselves in the crosswalk *(Source: Nelson\Nygaard)*

[1] Fayish, Aaron C., and Frank Gross. "Safety effectiveness of leading pedestrian intervals evaluated by a before-after study with comparison groups." *Transportation Research Record,* No. 2198, 2010: 15-22.

[2] Federal Highway Administration. "Manual of Uniform Traffic Control Devices." 2009 Edition with Revisions No. 1 and 2 Incorporated. 2012, 499.

Include accessible pedestrian signals meeting ADA and MUTCD requirements at LPIs and LBIs.

## Scrambles (All-Pedestrian Phase)

Scrambles or all-way pedestrian phases can benefit pedestrians when the prevalent desire line is to cross diagonally. This happens where there is a large pedestrian generator at one corner, where two commercial streets meet, or at T-intersections. Standard crossings allow pedestrians to move simultaneously with cars in the same direction. This can create conflicts with turning vehicles. At a scramble, pedestrians are allowed to cross in all directions during a dedicated pedestrian-only phase. Scramble intersections typically include both signage, as seen in Figure 4.22, and special striping indicating this crossing pattern.

Scrambles temporally separate vehicle and pedestrian movement. They can, however, increase instances of pedestrians crossing against signals as people will simply cross with traffic. Scrambles also add a signal phase to an intersection, which can increase the overall cycle time.

**Figure 4.22** Pedestrian scrambles facilitate diagonal crossings *(Source: Nelson\Nygaard)*

## Pedestrian-Activated Flashing Yellow Lights

In places where pedestrians need to cross but there is no support for adding vehicle signals, pedestrian-activated flashing yellow lights provide an option to increase pedestrian visibility. Flashing yellow beacons (varying in diameter of 8 to 12 inches), and flashing yellow LED's bordering a warning sign as seen in Figure 4.23, are currently MUTCD approved interventions.

**Figure 4.23** Pedestrian-activated flashing yellow LED's used to improve visibility of midblock crossing warning signs *(Source: Nelson\Nygaard)*

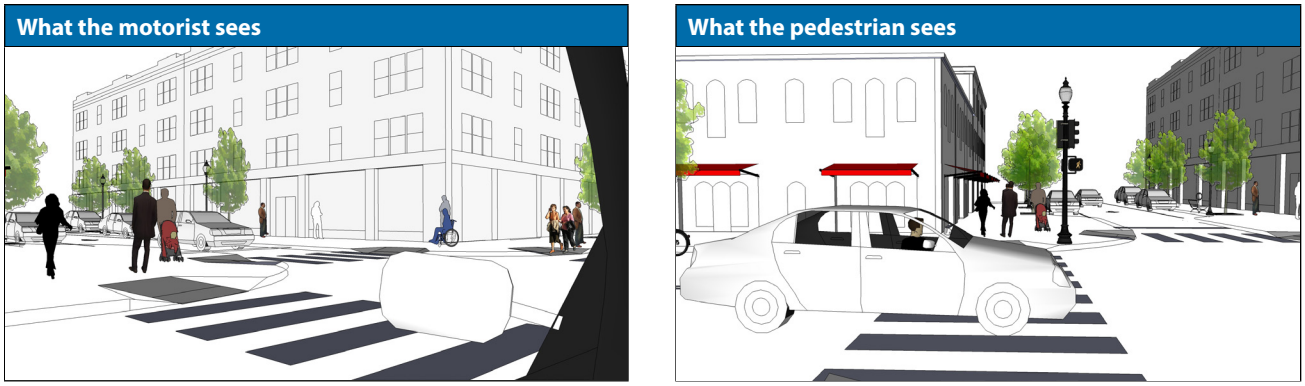



**Figure 4.24** When right turn on red is allowed, motorists approach an intersection looking to the left for a gap in oncoming traffic (left). During this same phase, the WALK signal crossing in front of the motorist is on, but the car may be blocking the crosswalk to look for an opportunity to turn right (right). *(Source: Nelson\Nygaard)*

## 4.5.2 Adding Signals

See 5.3.5 and 4.3.2.

## 4.5.3 Right Turns on Red

Right turns on red are legal in most locations. Allowing right turns on red is the rule rather than the exception in North America, as it increases throughput for vehicles. This policy creates safety issues because motorists looking left for oncoming traffic may fail to see pedestrians or bicyclists entering an intersection to their right, resulting in pedestrian-vehicle crashes, as illustrated in Figure 4.24.

In locations with high levels of non-motorized activity, consider restricting right turns on red.[1,2] Because right turns on red are generally legal unless signed otherwise, restrictions require signage and enforcement.

[1] Institute of Transportation Engineers. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice*, 2010.
[2] Los Angeles County recommends the elimination of right turns on red when there are restricted sight lines or an "unusual" number of vehicle-pedestrian conflicts. (Source: Los Angeles County Department of Public Health. "Model Design Manual for Living Streets." 2011.) AASHTO also supports the right-turn-on-red prohibitions to reduce pedestrian-vehicular conflicts and improve operations in urban contexts. American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 2-80.

# Speed Management

5

# 5.1 Typical Challenges

Speed, in the context of transportation, means the rate at which a person (in a car, on foot, or on a bike or bus) travels along a street, expressed in miles per hour. To control speed, practitioners set speed limits for motorists (the user with the ability to travel the fastest). Speeding occurs when motorists are traveling faster than this desired speed. On multimodal thoroughfares, often times a major challenge for practitioners lies in reducing motorist speeds to ensure both safety as well as comfort for people walking or on bicycles. Speed management approaches also aim to reduce harm to motorists by reducing crashes between vehicles.

Speeding continues to be a major factor in traffic injuries and fatalities. NHTSA reports that during the past two decades, speeding has consistently been a key factor in one-third of vehicle fatalities, killing 9,557 people in 2015.[1] A safety study by the NTSB found that, despite the known safety problems caused by speeding, the topic is not emphasized enough in Federal and state policy (speed limit setting and automated enforcement, for example[2]).

Infrastructure design also has a role in reducing speeding, with benefits to overall safety as well as comfort. On multimodal streets, vulnerable users can be protected from injury by keeping motorist speeds low. Vehicle speed also has a major impact on a street's ability to attract non-motorized users, as walking or bicycling next to high-speed motorists is not comfortable for most people.

Typical challenges the practitioner faces related to speeding include the following:

- Safety: Goal to reduce all crash rates and severity, but especially involving vulnerable street users
- Traffic capacity: Streets with extra vehicle capacity may result in speeds higher than desired
- Speed limit lowering: Reducing speed limits is a policy tool, but must be matched with changes to infrastructure and enforcement to be effective
- Traffic control: Adding traffic control can reduce speeding but may be viewed as adding delay

[1] National Highway Traffic Safety Administration, "Speeding." https://www.nhtsa.gov/risky-driving/speeding.
[2] National Transportation Safety Board, "Reducing Speeding-Related Crashes Involving Passenger Vehicles: Safety Study NTSB/SS-17/01," (2017).

# 5.2 Why Speed Matters

A fundamental goal of transportation departments is to foster the safety of street users. Crashes, in the context of street design, are incidents involving one or more users, which result in death, injury or property damage. As vehicle speeds increase, two outcomes also increase: the likelihood of crashing and the severity of injuries resulting from the crash.[1, 2] Vulnerable users are especially prone to injury or death in a crash, due to the difference in mass between street users (Figure 5.1).

The following two key factors that slow operating speed are:

1. Complexity: the addition of parked cars, pedestrian refuge islands, trees, narrow lane widths, curves in alignment, pavement changes, and other street elements slows motorists.
2. Congestion: More vehicles constrain operations and slow all motorists.

Approaches like intuitive design (see Section 2.1.3) and additions of multimodal elements all work to keep driving speeds at a rate desirable to multimodal conditions. A list of design interventions that can reduce speeding are discussion in Section 5.3.

## 5.2.1 Crash Outcomes

As speed increases, three main outcomes occur:

- Reaction time and braking distance increase
- Peripheral vision decreases
- Traffic noise increases

### Reaction Time and Braking Distance

Higher speeds increase both reaction time and braking distance required to come to a complete stop. If a crash occurs that involves a vulnerable user, the speed differential between the two opposing bodies are more likely to result in severe injuries, as seen in Figure 5.2.

Safety increases when speed differential is minimized. For example, freeways are extremely safe because motorists move at similar speeds, access is limited, and transitions to slower speeds are handled via ramps to surface streets in an organized fashion (where slower users on foot and bicycle are kept on a different network). Low-speed streets (due to low volumes or congestion) can be similarly safe because all users, from

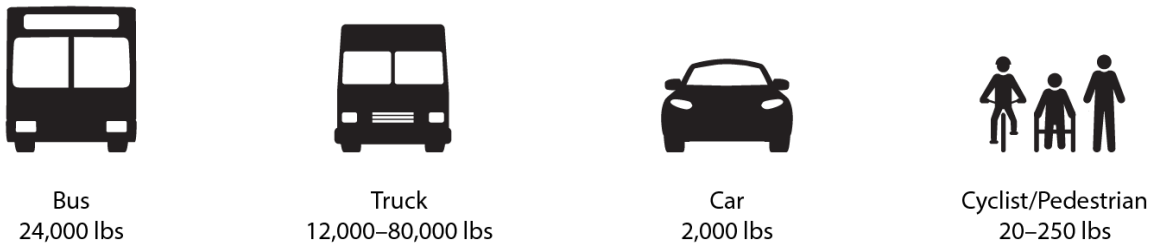
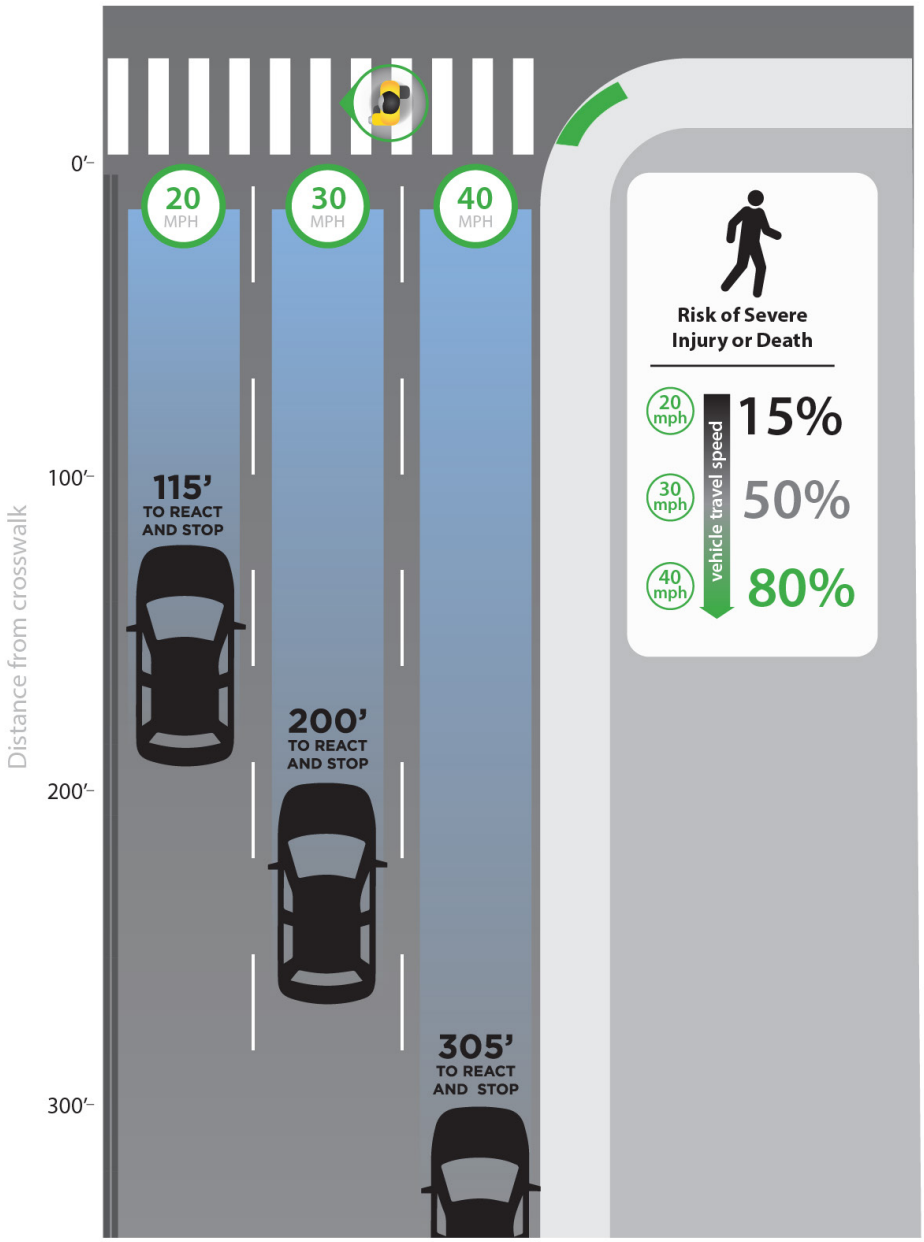



**Figure 5.1** Typical users of the street vary in size *(Source: Nelson\Nygaard)*

[1] Department of City & Metropolitan Planning, University of Utah, and School of Public Health and Community Development, Maseno University. "Pedestrian Safety Review: Risk Factors and Countermeasures." June 2012

[2] National Transportation Safety Board, "Reducing Speeding-Related Crashes Involving Passenger Vehicles: Safety Study NTSB/SS-17/01," 2017

**Figure 5.2** Speed increases a motorist's need for time to react and space to stop, and increases the risk of injury or death for pedestrians *(Source: Nelson\Nygaard)*[1]




motorists to bicyclists to walkers, are traveling at similar speeds. A crash between a vehicle driven at a low speed and a fixed object will typically result in minimal damage because of the lower speed impact.

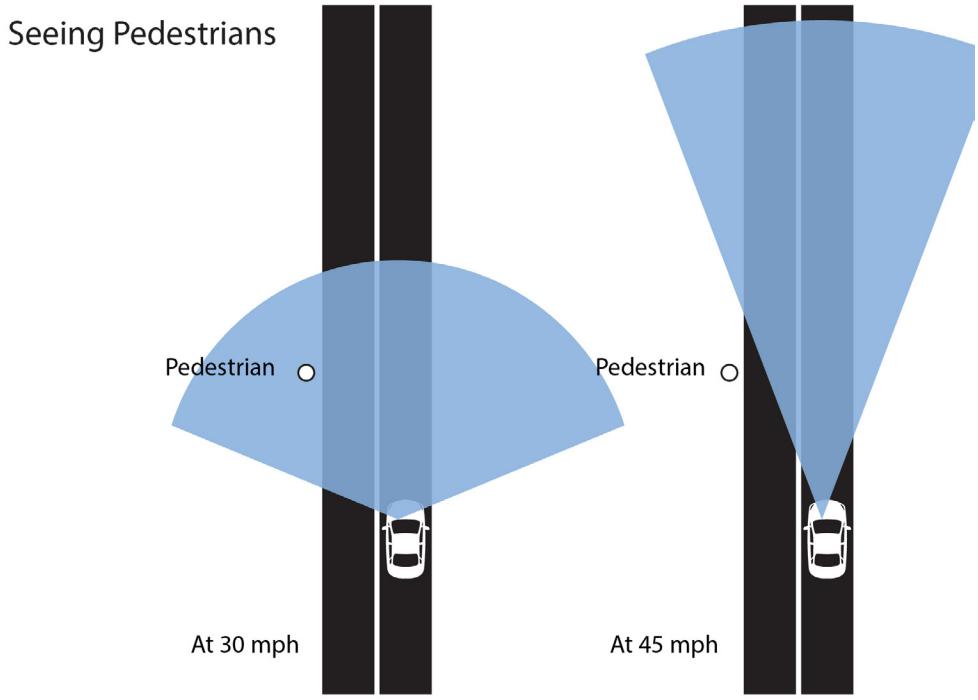
## Peripheral Vision

As motorist speed increases, the cone of vision narrows so that the motorist can focus on items farther away. When stationary, the cone of vision approaches 180 degrees. When moving, the cone of vision decreases with increasing speeds. The relationship is a function of speed, as visualized in Figure 5.3.[2, 3]

Given the limits of the vision cone, it is unrealistic to expect motorists to be able to be aware of all their surroundings when traveling at higher speeds. Design objectives that prioritize lower speeds for motorists on

[1] Graphic is based on data from the AAA Foundation for Traffic Safety.
[2] Bartmann, Astrid, Will Spijkers and Manfred Hess. "Street Environment, Driving Speed and Field of Vision." In Vision in Vehicles III. 1991.
[3] Leaf, W. A., and David F. Preusser. "Literature review on vehicle travel speeds and pedestrian injuries." Washington, D.C.: National Highway Traffic Safety Administration, 1999

**Figure 5.3** At slower speed rates (left), motorists have a wider peripheral vision cone, allowing them to more clearly see pedestrians *(Source: Nelson\Nygaard)*[1]




streets where pedestrians and bicyclists are present may enhance visibility.

### Traffic Noise

An often-overlooked impact of speed is noise. The noise generated from fast-moving motorists makes walking and bicycling feel unsafe, especially if there is no space between cars and non-motorized users. Noise emanates from a combination of sounds from the engines, exhausts, tires, and turbulence.

Traffic noise levels are affected by the following factors:

- Vehicle speed (faster is louder)
- Vehicle volume (higher is louder)
- Inclines (steeper is louder as engines labor more)
- Declines (especially with truck engine braking)
- Roadway surface (smoother is quieter)
- Physical separation from the road (noise walls, distance)
- weather (winter is louder as there is less vegetation to absorb noise)

Traffic noise on a city street is generally 70–85 decibels. Motorcycle noise is often 100 decibels; to put those numbers in perspective, hearing loss can occur with sustained exposure to sounds of 90–95 decibels. Researchers are beginning to understand the impacts of traffic noise on general health and welfare. Traffic noise negatively affects cardiovascular disease, cognitive impairment, sleep disturbance and tinnitus.[2, 3] Electric vehicles have little engine or exhaust noise, but still emit tire noise and are not yet widely in use.

Traffic noise can be mitigated using the following strategies:

- Include decibel levels as a project metrics and establish quieter roads as a performance objective. See FHWA's *Measurement of Highway Related Noise Manual.*[4]
- Facilitate travel by quieter vehicles such as bicycles, pedicabs, bicycle delivery carts, and electric vehicles.

## 5.2.2 Crash Analysis

Crash data can be an invaluable tool to pinpoint safety problems and determine solutions. Crash data can provide information about contributing factors leading to a crash, crash time of day, environmental conditions (such as weather), and other data. This information can be used to highlight a pattern of behaviors or conditions

[1] Based on data from source: Lindeke, Bill. "The Critical Ten." *streets.mn*, April 2, 2015. https://streets.mn/2015/04/02/the-critical-ten/.
[2] World Health Organization. "Burden of disease from environmental noise." 2011.
[3] H. Ising et al., "Health effects of traffic noise," *International Archives of Occupational and Environmental Health* 47 No. 2 (1980): 179-190.
[4] Federal Highway Administration. "Measurement of Highway-Related Noise." http://www.fhwa.dot.gov/environment/noise/measurement/mhrn05.cfm.

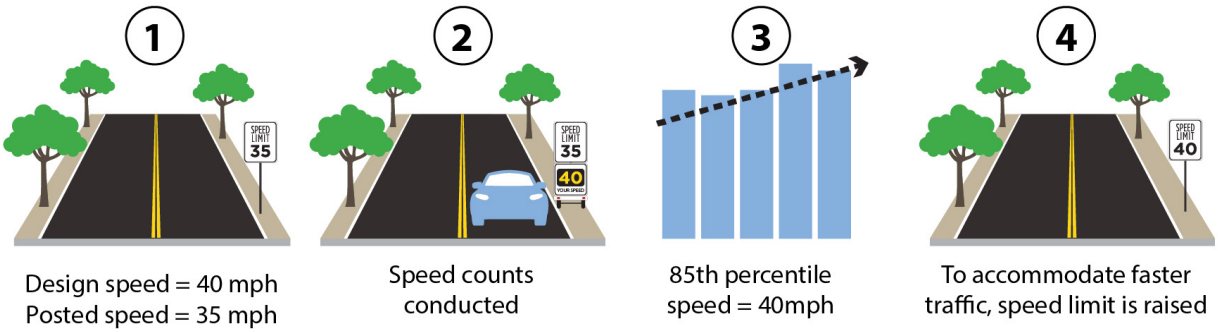



**Figure 5.4** Use of 85th percentile to determine posted speed results in higher speed limits over time[1] *(Source: Nelson\Nygaard)*

that threaten safety, and help the practitioner come up with countermeasures.

Common challenges encountered when using crash data include the following:

- Crashes are typically reported as absolute numbers (for three to five-year periods) without any normalization for volumes.
- Crash report records may not be fully complete with all attribute fields filled out. Missing information such as factors leading to the crash make the data less useful in developing solutions.
- Crash reports do not list missing infrastructure as a contributing factor—including missing bike lanes, sidewalks, crossings, etc.—to help agencies identify problematic locations.
- Crashes are often only reported in three main categories: fatality, injury, and property damage. Within the "injury" category, the severity of the injury is not always reported.
- Property damage only crashes are typically not reported to police (or police do not fill out crash reports) in many states.
- Crashes that do not involve a motor vehicle or do not involve injury or major property damage may not be reported.
- Near misses are not reported as they do not result in a crash.

The following guidance helps make the best use of crash data in the multimodal design process:

- Analyze separately property damage only crashes from killed or serious injury crashes in order to determine if the data speaks to need for capacity driven projects or safety driven projects—this allows for a more context based safety assessment of tradeoffs between travel modes.
- Work with law enforcement to automate crash reporting (e.g., via tablets), revamp the report template as needed, and to underscore the importance of complete crash information. The FHWA *Model Minimum Uniform Crash Criteria Guidelines* provides a basis for a comprehensive crash reporting template to ensure data provided can inform infrastructure improvements.
- Ensure that crash reports include bicycle-pedestrian and bicycle-bicycle crash fields.
- During project development, a mapping exercise (online or on paper) can be used to ask the public to record dangerous locations to inform design.
- Work with hospitals to augment law enforcement data and capture non-motor-vehicle related crashes.

## 5.2.3 Design, Operating, and Target Speed

Motorists make decisions on how fast to drive based partially on posted speed limit signs and partially based on physical cues in the environment (e.g., trees, parked cars, etc.). If higher speeds feel natural and instinctive, people are likely to drive at those speeds, due to the intuitive nature of such designs (see Section 2.1.3).

Current policy allows speed limits to be adjusted based on operating speed, gathered by observing actual speeds and selecting the 85th percentile. The road's design speed is based on 100th percentile speeds and is higher than the posted speed. There is no evidence that the 85th percentile speed corresponds to a speed with low crash rates.[1] Over time, using the 85th percentile to determine posted speed can lead to continual increases in the speed limit (Figure 5.4).

[1] National Transportation Safety Board. "Reducing Speeding-Related Crashes Involving Passenger Vehicles: Safety Study NTSB/SS-17/01." 2017

Using street design as a language for communicating desired operating speed means designing toward a designated *target speed*, or the speed at which the community desires motorists to travel.[1] Street design features may be incorporated to establish an inferred speed, or the speed that most motorists sense as correct, that matches the target speed.

Operating speeds on roadways are successfully managed when design speed, target speed, speed limit, and inferred speed converge. Practitioners may use USLIMTS2, an online tool provided by FHWA, to help set context-sensitive speed limits. USLIMITS2 includes crash statistics and other roadway factors to validate speed limits.[2]

**The *Recommended Practice* (see pg. 108) presents a detailed comparison of design speed and target speed, as well as identifying factors that dictate target speed.**

[1] AASHTO recommends target speeds on urban arterial streets of 20 to 45 mph. Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, 6th ed. (2011): 2-57.

[2] Federal Highway Administration. "USLIMITS2." Accessed September 23, 2017. safety.fhwa.dot.gov. https://safety.fhwa.dot.gov/uslimits/.

# 5.3 Interventions to Manage Vehicle Speeds

This section describes countermeasures that may be applied to projects where reduced speeds are a priority. They each add an element of either complexity or congestion to the street.

In addition to the nine countermeasures discussed in this section, a whole body of literature exists on traffic calming. This report does not cover traffic calming in detail, but many excellent resources exist that further describe the practice. Suggested literature includes:

- FHWA's *Traffic Calming ePrimer* (2017)
- FHWA's *Road Diet Informational Guide* (2014)
- FHWA's *The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior* (2001)
- ITE's *Traffic Calming State of the Practice* (1999)

## 5.3.1 Road Diets

Many communities have found they are able to convert a vehicle travel lane into a different use, such as converting a four-lane undivided street into a three-lane street, with two moving lanes and a center median/turn lane (Figure 5.5). The right-of-way can be reallocated for other uses, such as bicycle lanes or pedestrian facilities.

FHWA's *Road Diet Informational Guide* details considerations for the design of these facilities.[1] The guide encourages practitioners to be sensitive to the lower-speed operating conditions desirable for pedestrians and bicyclists, as well as the presence of truck traffic, which may necessitate the use of freight-specific design criteria. Typical ranges of dimensions for the design of specific geometric elements for road diet projects are detailed in the sections on geometric design and freight networks. The *Road Diet Informational Guide* notes that road diets have been applied to streets exhibiting volumes up to 25,000 ADT.

Road diets reduce speeds by adding complexity and congestion. The motorists who were using four lanes of traffic would use two instead, adding more vehicles per lane. Road diets add complexity through the addition of bicycle facilities, landscaping, or parking. Often times road diets result in greater lateral separation between pedestrian and vehicle traffic, which may make walking more comfortable.

Road diets also have effects on crash reduction. Converting a four lane street to a three lane street removes left turns from the main flow of traffic and has been shown to reduce the number of rear-end collisions, for example, since left turning motorists can wait to turn in the center lane.[2]

## 5.3.2 Change Use of the Curb Zone

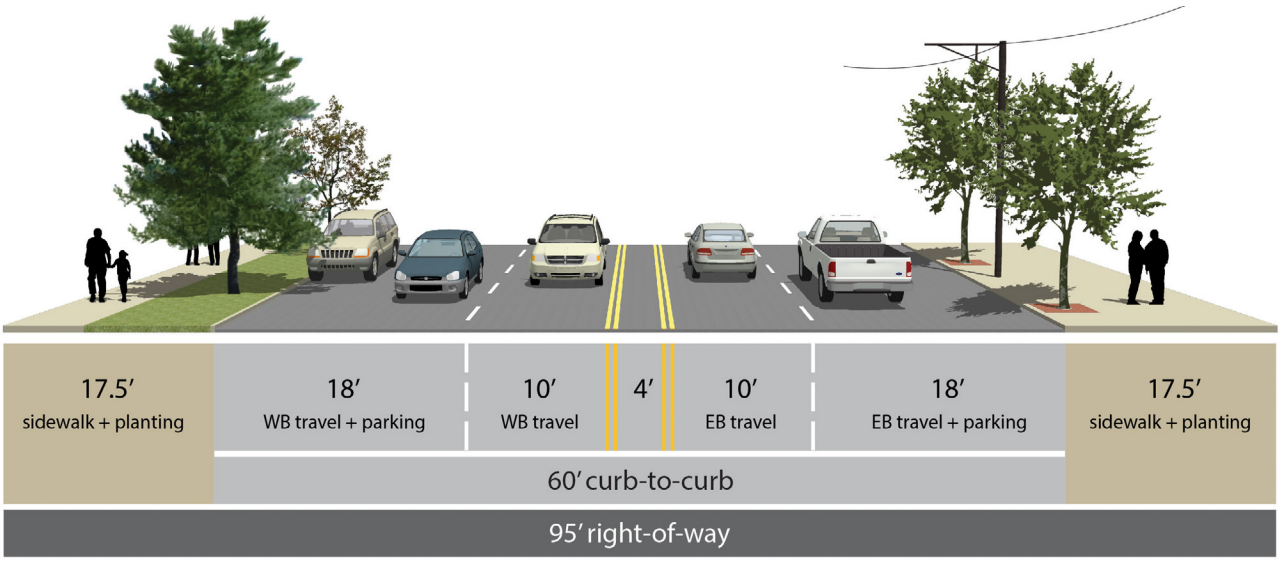
### On-Street Parking and Loading

On-street parking buffers pedestrians from moving traffic and can support retail businesses.[3] On-street parking and loading includes both the designing for and permitting of vehicle and truck parking at the curb. Vehicles may be parked parallel to the roadway, perpendicular, or at an angle. Parking may be permitted at all times or at some times (e.g., off-peak only).

On-street parking and loading provides the following benefits:

- Accommodation for freight deliveries
- Buffers the sidewalk and pedestrians from traffic
- Access to adjacent businesses, especially for people with disabilities

[1] Federal Highway Administration. *Road Diet Informational Guide,* 2014.
[2] Federal Highway Administration. *Evaluation of Lane Reduction 'Road Diet' Measures and Their Effects on Crashes and Injuries,* 2010.
[3] Maintaining on-street parking should be prioritized where pedestrian activity is to be supported. "Eliminating curb parking can affect pedestrian safety and comfort, and reduce the livability of both commercial and residential districts." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 7-47.



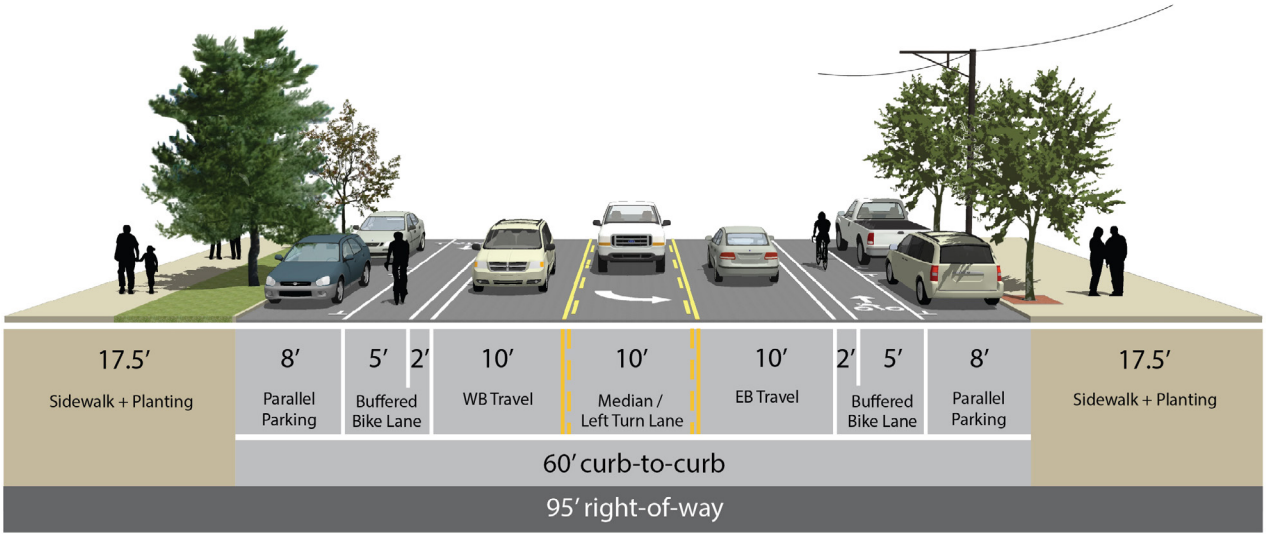




**Figure 5.5** Road diets allow right-of-way to be allocated for uses other than vehicle throughput, improving safety for all road users by adding complexity to reduce speeds. Example of before (top) and after (bottom) design. *(Source: Nelson\Nygaard)*

- More efficient than a series of driveways
- Provides opportunities for curb extensions at intersections
- Adds complexity to street and may reduce vehicle speeds

On-street parking considerations include the following:

- Occupies valuable space on corridors with many modal demands
- Can require construction of bus bulbs at transit stops to facilitate level boarding
- Privatizes public right-of-way if not properly managed

See the *Recommended Practice* for parking dimension details.[1]

## Angle Parking

On wide streets, angle parking can be used to provide more spaces than parallel parking and simultaneously narrow the traveled way. Back-in parking can offer the following benefits:[2]

- Improving sightlines and visibility for motorists pulling out of spaces
- Reducing conflicts with other motorists as well as bicyclists
- Positioning both children getting in and out of back seats and motorists and passengers loading or

[1] RP, pp. 147.
[2] American Association of State Highway Transportation Officials. "A Policy on Geometric Design of Highways and Streets." In *Green Book*, 6th ed. (2011): 4-72.

**Figure 5.6** A striped bicycle lane on an arterial is not pleasant for the average bicyclist *(Source: Nelson\Nygaard)*

unloading the trunk next to or directly on the sidewalk, rather than in the street

### New Uses of the Curbside Zone

A variety of new uses for curb space have emerged in recent years. These include a variety of mobility and non-mobility-related treatments ranging from parklets, or small platform-based installations for seating and art, to bikeshare stations, on-street reserved spaces for carshare vehicles, and "bioswale" landscaping designed to treat stormwater.

Many of these newer uses rely on public-private partnerships. For example, parklets generally require permits to use curbside parking spaces for other purposes. In these cases, roles and responsibilities including responsibility for maintenance of different elements must be clearly defined. This could involve private businesses, other public agencies, or community organizations.

## 5.3.3 Add Separated Bicycle Facilities

On suburban arterials, a bicycle lane alone may not be sufficient to attract riders, especially when designed with minimal considerations for hurdles such as gutter space as seen in Figure 5.6. Fully separated facilities with vertical separation (such as a median or bollards) or a separate off-street path are often needed on arterial roadways (Figure 5.7).

**Figure 5.7** On arterials, separated cycling facilities may be more comfortable for users *(Source: Nelson\Nygaard)*

Bicycle facilities could include one or two-way facilities, with separation from traffic taking the form of bollards, raised concrete, or on-street parking.

## 5.3.4 Signal Timing & Synchronization

Traffic signal timing involves allocating signal green time among all users and travel movements. Synchronization or coordination of traffic signals can be used to move vehicles more smoothly (few stops and delays) and/or to encourage desired driving speeds.[1]

[1] "Signals should be coordinated for progressive movement at the intended operating speed in the direction of the predominant flow of traffic on the arterial street…." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 7-44.

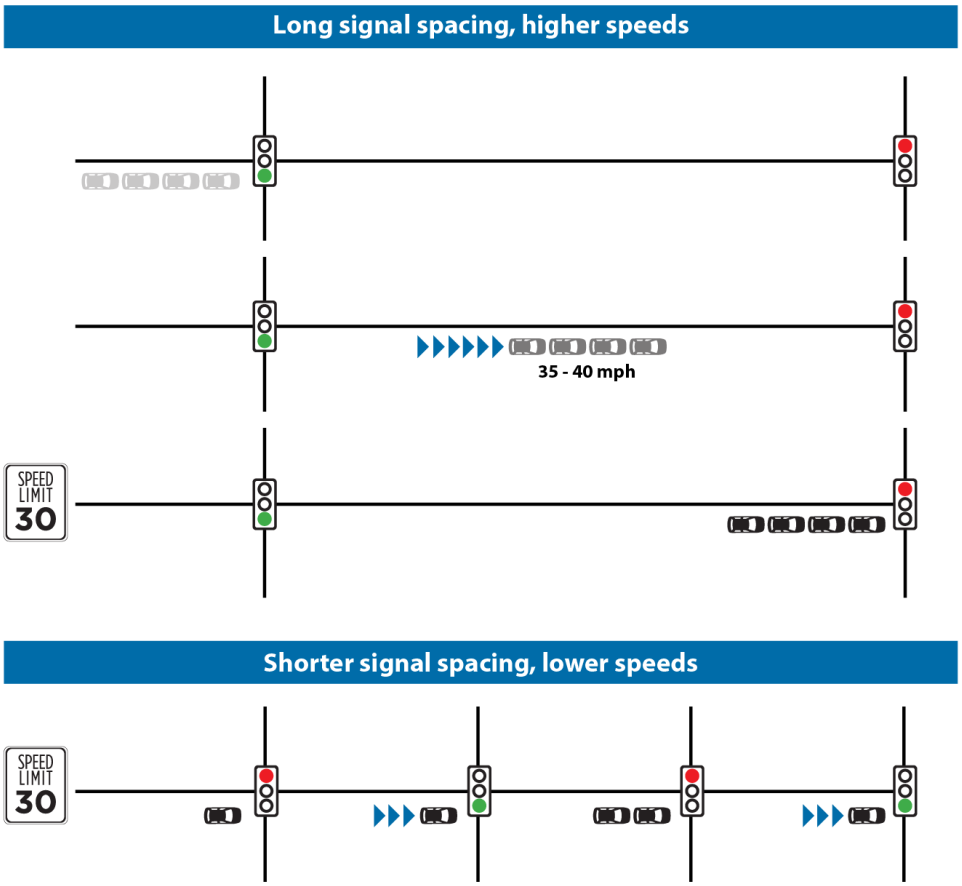



**Figure 5.8** Long signal spacing leads to speeding while more signals coordinated well reduces that effect *(Source: Nelson\Nygaard)*

Traffic signal synchronization may be used to coordinate signals for traffic to progress without undue delay at a specified speed, typically near or just below the target speed or speed limit. Motorists are more likely to conform to the progression speed if the proper signage (e.g., "Signals set for XX mph") is used. Synchronization works best if a "green band" or "green wave" can accommodate most of a traffic "platoon" during one green phase. Signals can be timed to prioritize different modes; for example, signals timed for progression at 10 to 15 miles per hour favor bicyclists on a street with limited vehicular traffic. Signal synchronization for relatively low speeds can also be used to calm traffic, particularly where signals are closely spaced, reducing the amount of distance to accelerate, travel at speed, and decelerate before having to stop at a red light.

Signals can be timed differently for peak versus off-peak travel times. During peaks, signals can favor the dominant traffic direction, while during off-peak times signals can be balanced for each approach. This may help reduce speeding during off-peak times.

## 5.3.5 Adding Signals

Signals are the tools that help move traffic through intersections. In many communities, arterial signal spacing is a half-mile or more, which does not correlate well to a pedestrian-scaled network. On a low-speed street, signals are not as necessary to manage speeds, but on arterials and collectors signals can allow for cross-flow, keep vehicle traffic moving at safe speeds, and allow for access to destinations. MUTCD provides recommendations on signal spacing, but also states that locations that do not meet warrants could still include signals with application of engineering judgment.[1]

More signals, when well-timed, do not necessarily lead to more delay, and can actually help achieve the target speed (Figure 5.8).

[1] Federal Highway Administration. "4C: Traffic Control Signal Needs Studies," in *Manual of Uniform Traffic Control Devices,* 2009 Edition with Revisions No. 1 and 2 Incorporated. 2012.

## 5.3.6 Reduce Lane Width

Analysis of a street's layout might reveal space that could be allocated from motorist uses to other elements. A road diet (Section 5.3.1) or cycle track (Section 5.3.3) might be infeasible; however, narrowing vehicle lanes might allow for the inclusion of on-street parking, wider sidewalks, stormwater treatments, or bicycle lanes without causing any safety effects for motorist traffic.

Lane width is the dimension of a travel lane, as measured from the center of the lane marking to the face of the curb. In general, travel lanes on walkable streets should measure from 10–11 feet. The wider dimension should be used for lanes that are frequently used by transit or freight.[1] Lane dimensions should total no more than 12 feet.[2] Lanes may be narrower than 10 feet on lower-speed local residential streets.[3]

An example of allocation of lane space to new users is illustrated in **Figure 5.9**.

## 5.3.7 Add Median Islands

Median islands or pedestrian refuges, as seen in **Figure 5.10**, can serve the dual purpose of reducing speeds and facilitating street crossings. Pedestrian refuges can occur at intersections or midblock locations, and should measure 120 square feet with minimum dimensions of six feet wide and 20 feet long.[4] They should also include a raised nose that extends beyond the crosswalk to both clearly delineate the pedestrian area and to reduce turning speeds.[5,6,7]

Pedestrian refuge islands reduce crashes and delays for people trying to cross the street by allowing people to cross one direction of traffic at a time. They have been shown to have a significant safety benefit for pedestrians.[8] Islands also reduce vehicle speed by adding complexity.[9]

## 5.3.8 Transitions

As context and mobility functions change, street type designations may change accordingly. The transitions between street types can include design cues reinforcing the street's desired character relative to its changing context. For example, state highways that function as main streets on entering a commercial district might introduce more urban elements (narrower lanes, curb and gutter edges, pedestrian lighting, gateway treatments, etc.) to cue motorists to the transition from a higher-speed mobility corridor to a lower-speed, walkable commercial district.

Examples of places where transitions commonly take place include campus edges, bridges over highways, and interchanges where highways meet community streets.

Consider access management using medians as a key supporting element in transitions, with the intent of limiting conflict along portions of a street corridor where user perception may need to adapt to different context or design features.

## 5.3.9 Reduce Turning Speed

Turning speed is a factor in street design because almost all turns involve a conflict point. For example, a motorist turning left yields to oncoming traffic, a motorist turning into a driveway yields to people walking on the sidewalk or riding in the bicycle lane, and a motorist turning in a slip lane yields to cross traffic then merges into traffic.

Turning speeds are directly linked to effective turning radius, or the actual path a vehicle follows through an intersection; thus, intersection design can influence turning speeds. Because intersections are where many modal conflicts and safety issues occur, keep turning speeds at a minimum.

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1 RP, pp. 137.

2 "Under interrupted-flow operating conditions at low speeds (70 km/h [45 mph] or less), narrower lane widths are normally adequate and have some advantages. For example, reduced lane widths allow more lanes to be provided in areas with restrictive right-of-way and allow shorter pedestrian crossing times because of reduced crossing distances. Arterials with reduced lane widths are also more economical to construct." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 7-29.

3 "Lane widths may vary from 3.0 to 3.6 m [10 to 12 feet]. Lane widths of 3.0 m [10 feet] may be used in more constrained areas where truck and bus volumes are relatively low and speeds are less than 60 km/h [35 mph]." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 7-29.

4 Institute of Transportation Engineers, *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice,* 2010.

5 City of Chicago Dept. of Transportation. *Complete Streets Chicago,* 2012.

6 Los Angeles County Department of Public Health. *Model Design Manual for Living Streets,* 2011.

7 National Association of City Transportation Officials, *Urban Street Design Guide,* 2013.

8 Federal Highway Administration. "Safety Effects of Marked vs Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines." 2000. https://safety.fhwa.dot.gov/ped_bike/docs/cros.pdf.

9 King, Mike. "Pedestrian Safety through a Raised Median and Redesigned Intersections," TRR 1445, TRB, Washington, DC, 2004.

**Figure 5.9** Reducing lane width can reallocate space for other uses *(Source: Nelson\Nygaard)*

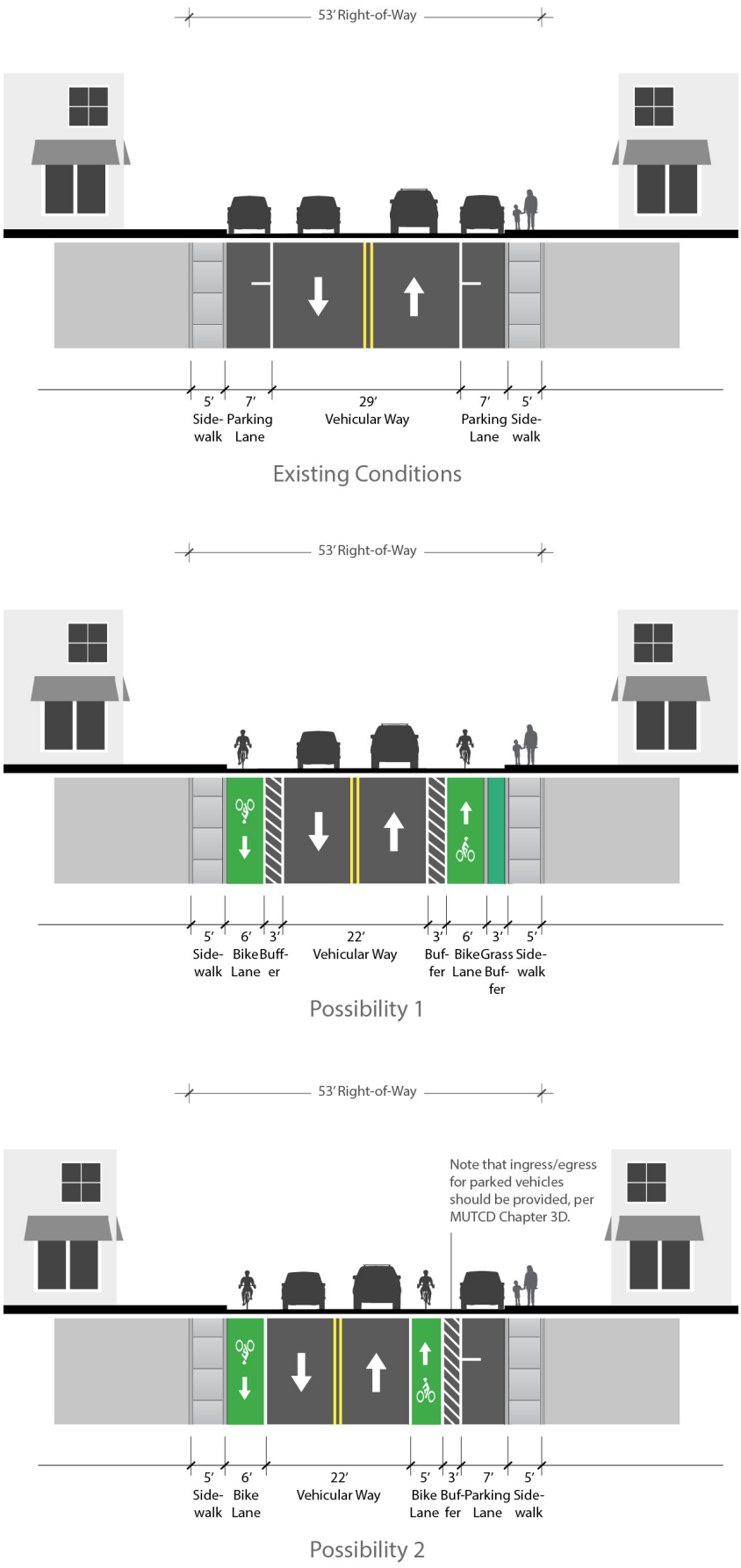

**Figure 5.10** Examples of median islands facilitating pedestrian movement used as a calming traffic tool *(Source: Nelson\Nygaard)*

## Design and Control Vehicle

A design vehicle represents the largest typical roadway vehicle, while a control vehicle represents the largest occasional roadway user, including fire engines. Design vehicles can be assumed for general design purposes, while control vehicles are safely accommodated, with methods described below.

Conventional practice relies on the design vehicle to establish turning radii. The larger the design vehicle, the wider the turning radius. This facilitates truck movements but expands the size of intersections, lengthens pedestrian crossings, and creates a turn that passenger vehicles and smaller freight vehicles can navigate at higher speeds than the design vehicle.[1]

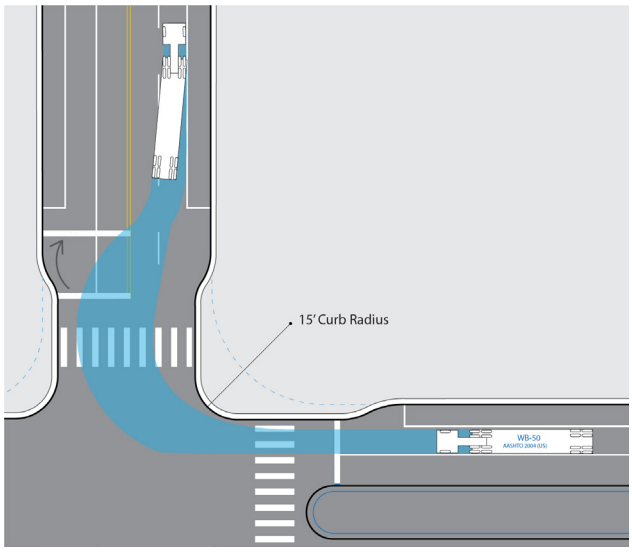


**Figure 5.11** Intersections where large vehicles make frequent right turns can have setback stop lines to facilitate right turns but still have relatively short corner curb radius *(Source: Nelson\Nygaard)*

Use the largest frequent (10 percent or more of ADT) truck as the design vehicle. Match corner design to places where trucks must frequently turn in the network. On many streets, the DL-23 (size of a UPS or FedEx box truck) is the largest frequent vehicle, although this should be verified with local field observations whenever possible.

The control vehicle is the largest infrequent user of the street. Roads can be designed to allow control vehicles to encroach on other lanes (including opposite direction lane encroachment) to make turns in emergency situations (Figure 5.11). Desired turning speed is low for these vehicles. For all streets, use fire and emergency-size vehicles as the control vehicle default.

## Corner Design

Vehicle speed and intersection complexity affect safety. An intersection corner radius has an effect on vehicle speeds in intersections (Figure 5.12), thus corner design is an especially important speed management topic for

[1] AASHTO notes that "(a)n intersection designed to accommodate trucks with no encroachment into adjacent lanes needs large corner radii, wide turning roadways, and greater distances for pedestrians to cross. Motorists can often negotiate these turns at speeds that are too fast to adequately detect and stop for pedestrians crossing the roadway." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 9-6.

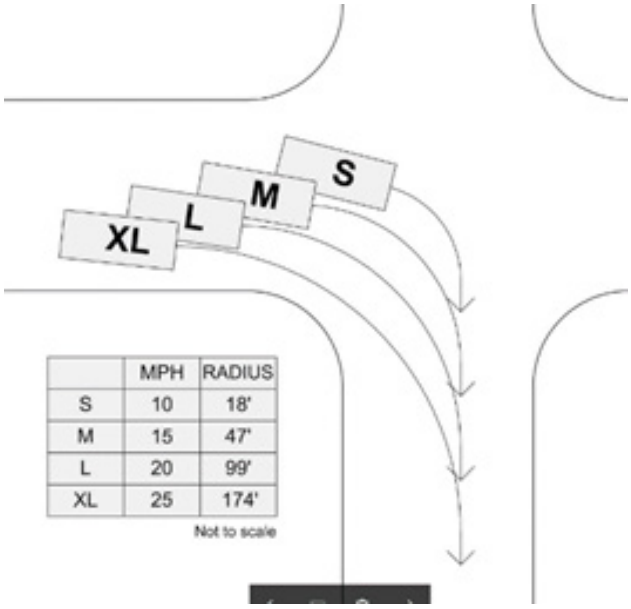


**Figure 5.12** How effective turning radius affects turning speed *(Source: Nelson\Nygaard)*

practitioners of multimodal thoroughfares.[1] The size (and turning radius) of the corner for the purpose of speed management depends on the design vehicle turn radius.

## Compact Intersections

See Section 4.4.1.

## Curb Extensions

See Section 4.4.1.

## Effective and Actual Turning Radius

The corner radius is that of the actual corner. It is also referred to as the corner or curb return radius. The effective turning radius is calculated using the widest turn possible. For example, a truck will turn from the lane closest to the curb (not including the parking or bicycle lane) and into the farthest lane from the curb (up to the center line or median), as seen in Figure 5.13, Figure 5.14, and Figure 5.15.

[1] As AASHTO notes, "Design of intersection elements for one group of users often has consequences for other users. An intersection designed to accommodate trucks with no encroachment into adjacent lanes needs large corner radii, wide turning roadways, and greater distances for pedestrians to cross. Motorists can often negotiate these turns at speeds that are too fast to adequately detect and stop for pedestrians crossing the roadway." Source: American Association of State Highway Transportation Officials, *A Policy on Geometric Design of Highways and Streets,* 6th ed. 2011: 9-6.

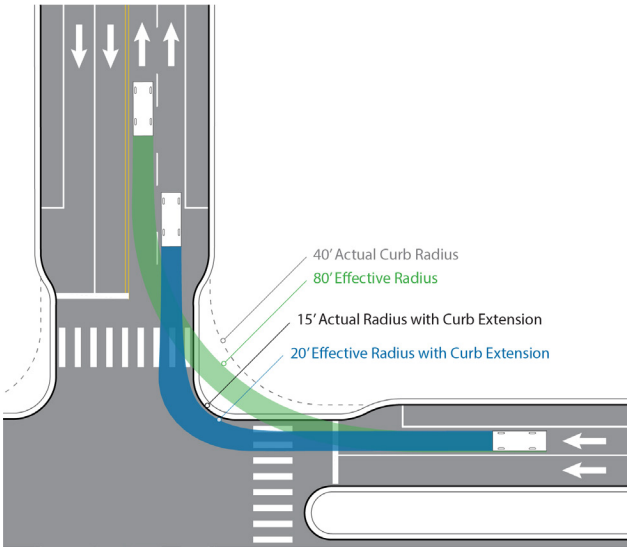


**Figure 5.13** Actual and effective turning radius *(Source: Nelson\Nygaard)*

**Figure 5.14** Truck using all lanes to make right turn *(Source: Nelson\Nygaard)*

**Figure 5.15** Recessed stop line used to facilitate a bus making a right turn *(Source: Nelson\Nygaard)*

Whether the actual and effective turning radius is the same depends on the design of the intersection. If the travel lane is not immediately adjacent to the curb due to parking or a bicycle lane, then the two radii are not the same.

Calculate the effective turning radius, regardless of the actual corner radius. The effective radius of an intersection can be enlarged by eliminating parking or other facilities near the intersection.

Design features such as setback stop lines help facilitate frequent right turns **(Figure 5.15)**.

While corner radii should be based on the turning radius of the design and control vehicles, corner radii of 15 feet or less and an effective radius of no more than 35 feet are generally desirable, if feasible.[1,2,3]

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[1] National Association of City Transportation Officials. *Urban Street Design Guide,* 2013.
[2] City of Boston Transportation Department. *Boston Complete Streets Design Guidelines,* 2013.
[3] Federal Highway Administration. *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts,* 2016.

# Case Studies

# 6

## Introduction

**The following case studies are context-sensitive thoroughfare projects that have been implemented across the US in a variety of locations, including small and large cities, towns, and suburbs. These transformative street projects were selected because they use a wide range of strategies that are described in this book to support walkable, mixed-use places. The case studies offer real-world design, implementation, and results of context-sensitive solutions.**

# Cincinatti, Ohio

## Madison Road & Geier Esplanade/Oakley Square

| | |
|---|---|
| **Project Date** | Began 2006. Completed 2010. |
| **Uses/Modes** | Heavily used by motorists. Two bus routes travel the corridor. The square has many businesses that receive truck deliveries. |
| **Section Length** | 0.25 miles |
| **Street Classification** | Major arterial |
| **Traffic Counts** | 22,800 vehicles per day entering the square prior to the construction.<br>23,700 vehicles per day entering the square after construction. |
| **Safety** | Operating speeds dropped from 35 mph to 25 mph. Crashes decreased 44%, including 70% in the Madison/Markbreit/Allston intersection at the northeast end of the square. |
| **Intersections** | Reconfiguration of the Madison/Markbreit/Allston intersection, including road realignment. Some of the crossing distances were reduced. |
| **Block Size/ Street Spacing** | 300′ to 450′ |
| **Right of Way Characteristics** | Two 10′ lanes of traffic in each direction, with on-street parking. Before, the square had three 11′ lanes going northeast, and two 11′ lanes with diagonal parking going southwest. The right of way is 160′ wide, including the central green space and sidewalks. |
| **Cost/Funding** | $3 million, including $1.5 million for roadway and public space improvements, and $1.5 million for water main replacement. City of Cincinnati Transportation and Engineering funds, community development block grants, and other sources. |
| **Additional Notable Features** | The central public space, Geier Esplanade, was doubled in size. After the square was improved, curb extensions and crosswalks were installed in two additional segments of Madison Road leading northeast. |

## Objectives

### Overview

A road diet doubled the size of an esplanade park at the center of a "streetcar suburb" neighborhood in Cincinnati, revitalizing business and social activity and reducing automobile and pedestrian crashes.

### Community Goals

1. Improve pedestrian safety at a dangerous intersection.
2. Restore usefulness of a public space.
3. Economic revitalization of neighborhood center.

### Project Champions

- Oakley Community Council
- City of Cincinnati

## Design

A road diet and traffic calming measures were installed on Madison Road in Oakley Square, the center of an old "streetcar suburb" built in the early 20th Century about five miles from downtown Cincinnati. Madison Road is a major thoroughfare leading from central to northeast Cincinnati.

The heart of Oakley Square is a mixed-use district along Madison Road with a 350-foot-long linear park, Geier Esplanade, in the center of the roadway. The esplanade had shrunken over the years to create more space for through traffic. Changes to accommodate cars and widen the road did not support the original main street environment. The city sought to restore and enhance the business district, which serves as not only a transportation junction but also the economic and social heart of the neighborhood.

Pedestrian safety was an issue, especially at a six-point intersection at the northeast end of the square. The intersection had large turn lanes and confusing signage that made it inhospitable to pedestrians, according to

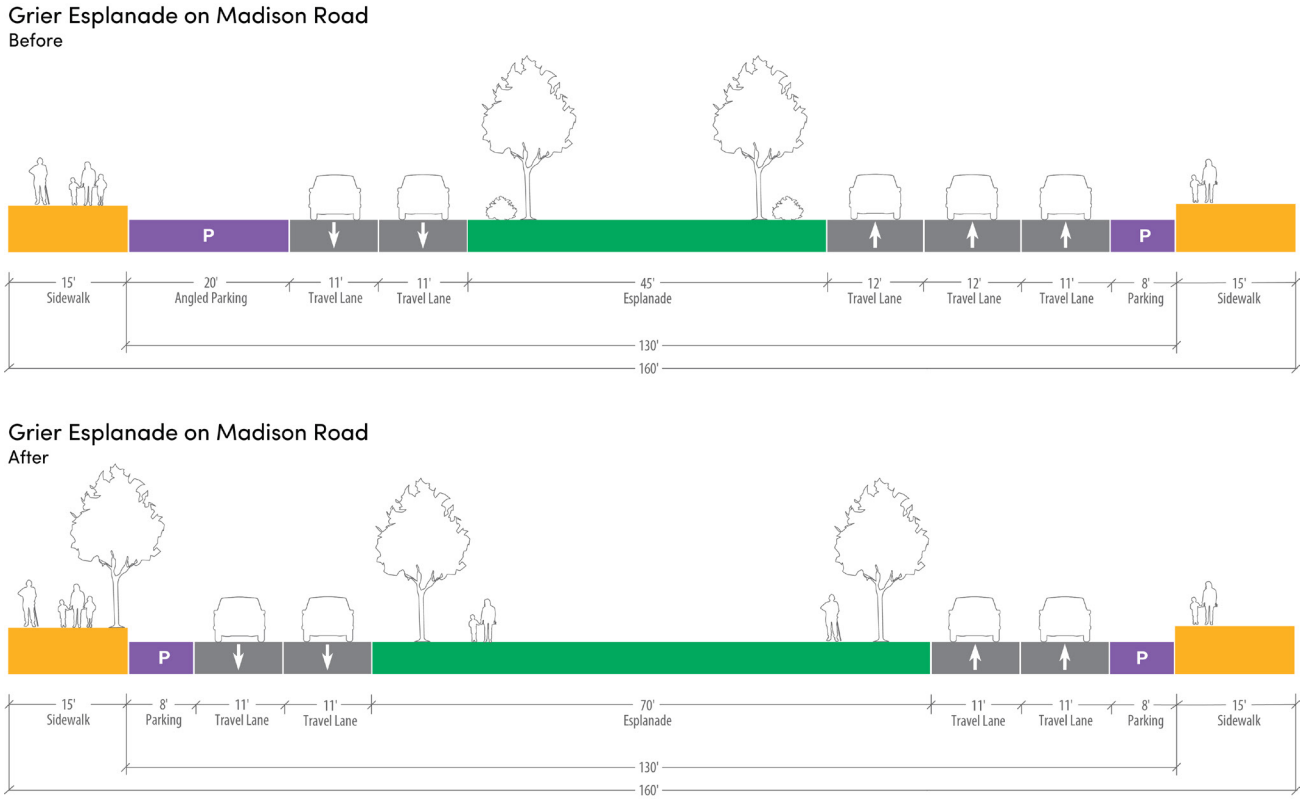



**Figure 6.1** Street design of Grier Esplanade on Madison Road before (top) and after (bottom) reconstruction *(Source: CNU)*

Bryan Williams, an engineer with the city's Department of Transportation and Engineering. Streets were realigned, the intersection was simplified, traffic signals were upgraded, and new crosswalks were created. Some of the larger pedestrian crossing distances were reduced with the new design. Small public spaces were created with leftover space in and around the intersection.

Along with that project, the city decided to redesign the entire square. The esplanade was doubled in size to increase its usefulness as a city park. Almost a half-acre of impervious asphalt and concrete was converted to green space and pervious pavement. A low protective wall was built around the new public space to separate users, especially children, from the traffic.

New public amenities have been provided, such as new and wider sidewalks through the entire business district and space for outdoor dining.

One travel lane was eliminated and the width of travel lanes was reduced in the square, taking space away from automobiles and giving it to people on foot. After the redesign (Figure 6.1), the esplanade is used more often and local businesses now utilize the sidewalk for outdoor dining and other activities, the city reports.

Other new additions include pedestrian-scale street lighting, street sign and meter posts, 26 street trees, benches, and green stormwater control elements such as permeable surfaces and rain gardens. In addition, Greater Cincinnati Water Works invested in a major new water main.

## Implementation

The project started with the Oakley Square Community Council, which requested funds to look at a confusing intersection at Madison Road, Markbreit Avenue, and Allston Street (Figure 6.2) where numerous crashes had occurred.

That request spurred a more holistic examination and redesign of the infrastructure in this historic neighborhood center.

**Figure 6.2** Madison Road looking south toward Geier Esplanade, prior to the reconstruction *(Source: City of Cincinnati)*

## Results

Prior to the reconstruction of Geier Esplanade, Oakley Square was compromised by automobile traffic, notes Williams.

The project (Figure 6.3) has vastly improved safety along Madison Road by calming traffic, shortening pedestrian crossings and redesigning a dangerous intersection to improve street geometry and traffic patterns. Crashes decreased 44 percent, including 70 percent in the Madison/Markbreit/Allston intersection. Traffic speeds have slowed in the area to 25 mph from about 35 mph, the city transportation department reports.

The square has seen revitalization of businesses since the work, most visibly with the restoration of the façade of the 1941 Twentieth Century Theater, a movie theater turned special events venue. A former funeral home on Geier Esplanade is also being converted to a microbrewery. New residential construction has begun less than a block from the square, Williams says.

## Lessons Learned

It takes some time for freight operators to get used to tighter turning radii and dimensions. Given that truck traffic often travels through the square to make deliveries, turning radii of the Oakley Square redesign were tested for large vehicles. The right turn onto the square at Markbreit Avenue is at a particularly sharp angle. "It's tight for a few of the vehicles, but they can make it," Williams says. Truck drivers had to get used to the newer, tight conditions. One truck hit the new wall of Geier Esplanade. After that, the city installed a heavy post filled with concrete. One truck subsequently hit the post,

**Figure 6.3** Geier Esplanade following the reconstruction *(Source: City of Cincinnati)*

with little damage to the post and more damage to the truck. Truck drivers have apparently learned their lesson. "It hasn't been hit since," Williams says.

A street redesign can also focus on a public space—improving the usefulness of a square. The Geier Esplanade was rescued and restored because of a project that began with pedestrian safety concerns. The public space has helped to restore economy activity in the center.

As new development occurs in the Oakley neighborhood, residents are working on an updated land development code that will encourage mixed-use buildings to define Madison Road and the square.

# Dallas, Texas

## Greenville Avenue

| | |
|---|---|
| **Project Date** | First phase completed 2013. Second phase began 2015, completed in early 2017. |
| **Uses/Modes** | Motorists, pedestrians, bicyclists |
| **Section Length** | 0.75 miles, 16 blocks |
| **Street Classification** | Major collector. The city calls it a "mixed-use complete street." |
| **Traffic Counts** | 16,000 vehicles per day prior to reconstruction. No data after. |
| **Safety** | No data on crashes. Speeds are reduced to 20–25 mph from 35–40 mph. |
| **Intersections** | Bulbouts extend the curb out to the edge of the travel lane. Crosswalks made of concrete pavers that create a different color and texture to encourage cars to slow down. Different color pavers are used in intersections. |
| **Block Size/ Street Spacing** | Average: 250′ |
| **Right of Way Characteristics** | Four 11′ lanes have been reduced to two 11′ travel lanes, one in either direction. A single angle-in parking lane is changed to 10′ parallel parking lanes on both sides. Sidewalks enlarged on both sides. The right of way is 60′ wide, not including 8′ sidewalks within the property line. |
| **Cost/Funding** | $1.3 million for first four blocks, and $3.67 million for the expansion, funded by an infrastructure bond program. |
| **Additional Notable Features** | Street trees were planted about every 30′ in the right of way, where there were few in the past. Trees are planted in curb extensions to further reduce the perceived width of street. Natural xeriscaping planted in the bulbouts. |

## Objectives

### Overview

A road diet was installed on Greenville Avenue in the neighborhood center of Lower Greenville. Streetscape improvements have brought back a family-oriented, main street character to the corridor. Crime has dropped and property values have risen.

### Community Goals

1. Bring back balance of the mix of businesses in the commercial district.
2. Provide a better use of space within the right of way, including more space for people outside of automobiles.
3. Enhance livability and provide more room for sidewalk cafes and bicycle racks.

### Project Champions

- Angela Hunt, a resident and city council member at the time
- Mayor Pro-Tem Pauline Medrano

## Design

Greenville Avenue is the main street of a 1920s "streetcar suburb," Lower Greenville, four miles from downtown Dallas. The context had become automobile-oriented over the years as space was given over to motor vehicles and the design allowed for speeds uncomfortable to pedestrians. Businesses geared to cars, with significant surface parking, had replaced some of the older mixed-use buildings negatively impacting the main street environment.

To improve the character of the street, four lanes were narrowed to two and sidewalks were enlarged. Bulbouts were installed and on-street parking was placed on both sides of the street, helping to protect pedestrians from moving vehicles. Street trees were planted, narrowing the

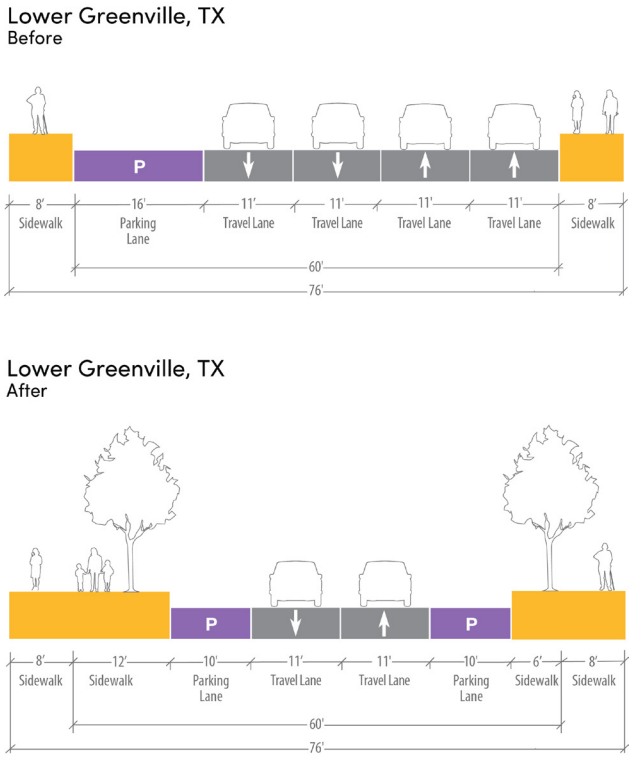



**Figure 6.4** Street design of Greenville Avenue before (top) and after (bottom) reconstruction *(Source: CNU)*

perceived width of the roadway and contributing to a sense of place (Figure 6.4).

Brick pavers were installed in intersections and crosswalks, giving the pavement a different driving feel and highlighting the intersections and pedestrian crossing areas. In addition, the project included street furniture (benches) and bike racks. The benches and old-fashioned lighting, with plenty of streets, creates the feel of small, periodic plazas along the corridor. All of this was intended to reinforce a walkable, main street context and to calm traffic, making the area more comfortable to pedestrians. Café seating has contributed to the stronger sense of place and presence of people—outside of cars—on the street.

Greenville Avenue was a test case and conducted concurrently with the drafting of the city's Complete Streets Design Manual, officially adopted by Council in 2016. The goals of the Complete Streets Design Manual are the following:

- Enhance the public realm rather than serve as mere traffic conduits
- Provide for multiple transportation modes (pedestrian, bicycle, transit, and automobile) and include environmentally sustainable solutions appropriate to context and situation
- Reflect that all streets are not the same
- Use design solutions that are specific to the context
- Support flexibility to accommodate changing needs and allow change to occur incrementally

With Greenville Avenue as a model and the manual as a guide, the city sought to establish a new street design process, policies, and standards that integrated complete streets and stormwater management principles; provide effective and timely opportunities for community stakeholders input on street improvements; and develop a strategy for systematic and phased implementation of complete streets over time.

## Implementation

City Councilmember Angela Hunt and Mayor Pro-Tem Pauline Medrano spearheaded an effort in 2010 to re-envision the neighborhood due to complaints related to the existing land uses, most notably bars and nightclubs (Figure 6.5). A zoning overlay changed the number of late-night establishments in the area. Additionally, in order to change the district character from a nightlife-oriented area to family friendly, Hunt proposed street improvements, including the road diet and change of streetscape.

One day while playing around in Google SketchUp (a design tool for non-practitioners), Hunt created a vision for how the corridor could change. "I looked at what it could be, and it was amazing," she says. "It was this pedestrian-friendly, fun little street that could be attractive to neighborhoods and restaurants." Hunt was able to get money for the street redo from the city's 2006 infrastructure bond package.

The city used a carrot-and-stick approach—change zoning and permits to get control of the late-night bar scene, and at the same time rebuilt the street to make it more pedestrian friendly. The original four-block makeover was recently expanded to 16 blocks, or three-quarters of a mile.

After completion of the first phase in 2013, the lone bus route that travels down the street, DART Route 1, was diverted east one block to Matilda Street. Many deliveries are now accommodated on side streets, rear allies, or rear parking lots.

**Figure 6.5** Greenville Avenue prior to reconstruction *(Source: City of Dallas)*

## Results

The posted speed limit on Lower Greenville Avenue is 30 mph. According to Evan Sheets, project manager with the Dallas CityDesign Studio in the department of Planning and Urban Design, anecdotal observations have shown that the effective design speed within the project area has been reduced to 20–25 mph typical average, from 35–40 mph typical average (Figure 6.6).

Both before and after the improvements, many people have used the Greenville Avenue sidewalks, notably in the evening and night hours. Before improvements, the sidewalks were narrow with little articulation between sidewalk, driveways, parking and travel lanes. Driving lanes on one side of the street were adjacent to the narrow sidewalk, with no separation of people and fast-moving vehicles except a curb.

The widening of sidewalks and more clearly defined travel lanes, streetscapes, and crosswalks has created a much safer pedestrian environment and allowed a wider range of uses that have increased pedestrian volumes in the daytime, afternoon, and evening hours, Sheets says.

Following the street redesign in 2011, Lower Greenville Avenue revitalized with new businesses including two grocery stores, a Walmart Neighborhood Market, a bakery, restaurants, and other firms.

Violent crime dropped nearly 90 percent and all crime dropped 80 percent since the peak—due to factors including more police presence, a different mix of businesses, and more pedestrian activity, according to *Advocate,* a local publication. Property values in the neighborhood—both land and buildings—rose sharply following the completion of the first phase of the project. Values rose citywide during that time, but they went up more in Lower Greenville.

**Figure 6.6** Greenville Avenue's new streetscape *(Source: City of Dallas)*

## Lessons Learned

The success of Greenville Avenue has become a model for how to transform other Dallas neighborhoods and served as a test case for a new city design manual.

The aforementioned carrot and stick approach of streetscape improvements and policy changes have brought about a change in the character of the streetscape. An area known for unruly late-night activity has given way to a much more diverse corridor, with activity 18 hours per day.

# Hamburg, New York

## US Route 62

| | |
|---|---|
| **Project Date** | Began 2007. Completed Summer 2009. |
| **Uses/Modes** | Transportation: Motorists, trucks, pedestrians, and bicyclists.<br>Building: Storefronts and commercial uses, residential, civic. |
| **Section Length** | 1.87 miles |
| **Street Classification** | Rural principal arterial |
| **Traffic Counts** | About 11,000 vehicles per day before and after, including 500–600 heavy trucks per day |
| **Safety** | Injury crashes fell by 60% and serious injuries fell by 90% on the corridor after completion. |
| **Intersections** | Four signalized intersections converted to roundabouts, crosswalks added. Application of bulbouts. Curb return radii unchanged, except as needed for roundabouts. |
| **Block Size/ Street Spacing** | Block range: 450′–1,200′. Mostly connected village context. |
| **Right of Way Characteristics** | Width of ROW ranges from 50′–66′. There are two travel lanes, one in either direction. The project narrowed the travel lanes from 12′ to 10′. Colored 4′ buffers were added for the purpose of slowing traffic. Parking lanes are 7′ wide. |
| **Cost/Funding** | $23 million total cost, including substantial water and sewer upgrades. New York State provided additional $800,000 for façade improvements. |
| **Additional Notable Features** | Benches, picnic tables, bicycle racks, public artwork, planters. New street trees planted. Old-fashioned, pedestrian-scale lampposts installed. |

## Objectives

### Overview

The Village of Hamburg and New York State DOT (NYSDOT) implemented traffic calming on US Route 62, the village Main Street, instead of widening the roadway as originally planned by the NYSDOT. Four traffic roundabouts were installed to replace traffic signals and improve safety of intersections with crash problems. The changes were coordinated with façade improvements and zoning updates to revitalize a village center. Water and sewer lines were upgraded during construction, which accounted for a significant portion of the total cost.

### Community Goals

1. Protect the village character and restore vitality to the business district.
2. Improve safety for motorists, pedestrians, and bicyclists.
3. Manage heavy truck traffic through downtown.

### Project Champions

- The Village of Hamburg
- The Route 62 Committee
- Village Business Advisory Council
- Hamburg Development Corporation
- Hamburg Chamber of Commerce
- Walkability expert Dan Burden

## Design

US Route 62, connecting Niagara Falls with El Paso, traverses a 2,200-mile cross-section of America with scores of cities and towns, including the heart of the Village of Hamburg, New York. On this unique section of the thoroughfare, four roundabouts, each with a prominent light fixture or sculpture, have been built within 1.87 miles. This section of highway traverses an

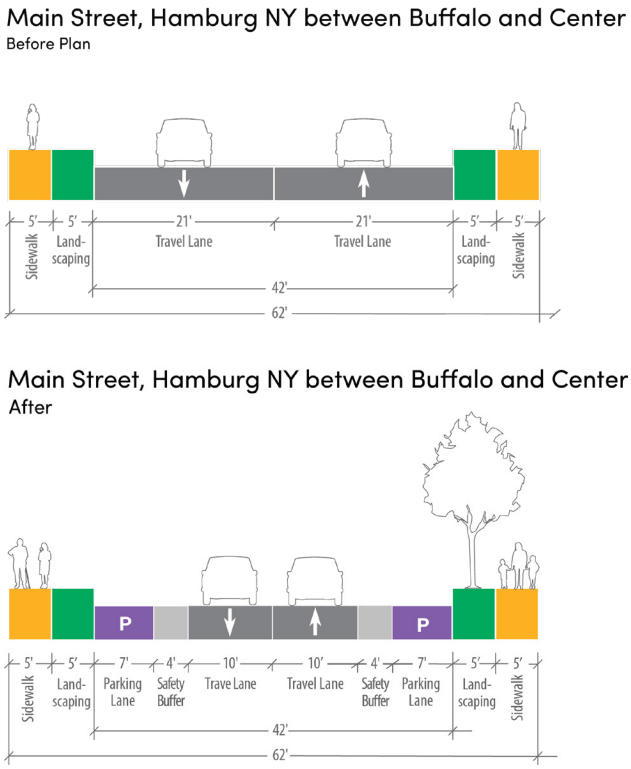



**Figure 6.7** Street design of Main Street in Hamgburg NY between Buffalo and Center before (top) and after (bottom) reconstruction *(Source: CNU)*

historic village center, carrying approximately 11,000 vehicles per day on two lanes, one in each direction.

Colored buffer lanes narrow the travel lanes and separate the moving traffic from parked cars. Mid-block pedestrian crossings, additional on-street parking, and street trees and landscaping complete the transformation. Traffic is calmed through a combination of design changes; such as roundabouts that deflect traffic and employ terminating vistas, the narrower travels lanes that promote more careful driving, and the additional on-street parking and street trees that narrow the perceived width of the thoroughfare (Figure 6.7).

The four-foot-wide buffers are unique. "We didn't even have a name for them when we designed them," says Kenneth Kuminski, engineer for the NYSDOT. Painted a different color to distinguish them from the other pavement, the buffers effectively constrain the proportions of the travel lanes and the parking lanes. "They may have been the most successful aspect of the project," Kuminski says. "They provide space for people to get out of their car, open the car door and get around." Bicyclists also use this space—even though the lanes are less than typical bicycle lanes. The buffer calms traffic by reducing the travel lanes to 10 feet, and allows for 7-foot parking lanes—which are narrower than usual on a principal arterial thoroughfare. The markings encourage vehicles to park close to the curb.

## Implementation

This stretch of US highway would be different had the village not seized control of its own transportation destiny. In the early 2000s, concerned about future congestion, NYSDOT proposed rebuilding Route 62 (Figure 6.8) in the village to accommodate more traffic. The plan called for widening travel lanes from 11 feet to 12 feet and adding a third lane, a turn lane, of 11 feet. No roundabouts were proposed, but crosswalks and other intersection improvements were envisioned. Considerable on-street parking would be have been eliminated, dealing a potential blow to merchants in an already struggling village center. The plan alarmed some residents. "What are you doing with the trees and the people?" asked Lifelong resident Susan Burns, quoted by *The New York Times.* She said she was told by state officials, "We have to get the traffic through."

John S. Thomas, the mayor at the time, met Florida-based walkability expert Dan Burden at a conference, and invited him to Hamburg. Burden told residents that the village wouldn't recover until the main street is redesigned to support street life. He agreed to lead a design charrette to draw an alternative plan, which included the roundabouts and traffic calming measures. Citizens, business leaders, and officials formed the Route 62 Committee to represent the village interests to NYSDOT. The village held a referendum on the two plans, and the traffic-calming alternative won 4-1—an outcome that influenced DOT's decision.

NYSDOT built the traffic-calming alternative, which ultimately transformed the village. By 2010, when Hamburg had been recognized for a prestigious America's Transportation Award in the Northeast Regional Competition, DOT was proud of its accomplishment: "This project has the potential to have far-reaching and positive effects on the quality of life for village residents," the department said.

**Figure 6.8** Main Street looking west, toward a modern roundabout in Hamburg, New York *(Source: Dan Burden)*

## Results

Completed in the summer of 2009, the Route 62 project is widely credited with catalyzing the revitalization of the village—working in concert with other efforts. Concurrently with the reconstruction, New York State Office of Community Renewal provided $800,000 in matching Main Street Program grants for façade improvements—leveraging more than $7 million in private investment in 33 buildings. Aging, deteriorating facades from the 1960s and 1970s have been replaced. The village, meanwhile, tweaked its zoning laws to encourage pedestrian-friendly building frontages in the mixed-use center. Zoning changes allow zero setbacks for buildings on the corridor, encourage a second story on buildings, and require minimum percentage of windows on storefronts (Figure 6.9).

Commercial building permits in the village rose from 16 in 2005 to 96 in 2010. Property values along the corridor more than doubled in this time period, despite the simultaneous steep national recession. The Village of Hamburg had lost population from 1980 to 2010, including a 7 percent loss in the 2000s. During the first half of this decade, the village is growing again, gaining 1.8 percent through 2015, according to census estimates.

The intersections on the route were prone to serious crashes. During the two-year study period prior to the project, two fatal collisions occurred on Route 62 in the village. After the changes, a police analysis revealed that injury crashes are down by 60 percent and serious injuries fell by 90 percent on the corridor. Mid-block as well as intersection crashes have declined.

Although NYSDOT conducted no official speed tests before or after, Burden used a speed gun to observe significant traffic calming. "We were able to drop speeds from 30 mph—and higher for top-end speeds—to a more steady post treatment of 19 mph," he says. Top-end speeds of up

**Figure 6.9** The roundabout at Buffalo and Main Streets, in the heart of the village *(Source: Dan Burden)*

to 40 mph on off-peak hours—speeds most likely to create personal injury crashes—are fully eliminated, he says.

The roundabouts slow traffic, yet allow for efficient movement of freight, because the trucks no longer stop at traffic signals in the village. The thoroughfare daily carries about 500 to 600 heavy trucks a day. The corridor is also a public transit bus route and handles many school buses—four village public schools are sited within a block or two of the highway.

Since the thoroughfare reconstruction, *The New York Times* reports a "burst of civic activity" in Hamburg—with the initiation of a regular farmer's market, movie-in-the-park night, a garden walk, a street music festival, a progressive dinner called Hamburg Bites and other events.

Long-term growth in congestion and delays in the village were a major concern of DOT officials prior to the project. Delay, congestion, and level of service have not been measured since completion, DOT reports. Based on anecdotal evidence, delay and congestion have gone down. "It's more expedient to drive with the roundabouts," says Laura Hackathorn, a Village Trustee. "We used to have to sit at lights all the time—even in off-peak hours."

Hackathorn runs a women's clothing store at the heart of the village, at the junction of Route 62 and State Route 391. Her shop looks out on one of the roundabouts. "Our entire village is transformed," she says. "Not a day goes by in my store I don't hear about how everyone loves our village. This project fulfilled every expectation and then some."

## Lessons Learned

The state did not anticipate the positive economic and social impact of the traffic calming/roundabout alternative. Since the new design was completed, non-automotive traffic

and street life have flourished by all accounts. Nor did the state predict that the widening alternative would damage economic and social life—but that belief drove village support for the alternative. The Hamburg project can be used as a prime case study example by traffic engineers and others to cover transportation, social and economic impacts of thoroughfare design.

Between 2002 and 2009—when the two plans were debated, the village pushed for and DOT agreed to the alternative, and the project was put out to bid and built—there was skepticism about the roundabouts, even among residents.

A 2006 cartoon appeared in the *Hamburg Sun* that showed a fortune teller with a crystal ball consulting with a resident and saying: "I see you traveling a great distance on a useless and thankless journey because you won't be able to find your way out of the new roundabouts." At the time, the public often confused modern roundabouts with larger, higher-speed traffic circles, which can be scary for motorists and pedestrians.

Some concerns remain. The mid-block crossings, some of which are only identified with paint, should be better marked, says Hackathorn. The village requested that DOT provide substantial new landscaping with the reconstruction, and DOT said that it would not be responsible for maintenance. A high level of commitment on the part of citizens to the new town center has solved the issue so far. Village volunteers maintain flowers, shrubs, and do the weeding.

Hamburg continues to win awards and the consensus is that the new design works well. Seven years after the project completion, NYSDOT recently repainted the safety lanes. The revitalized town center is a source of renewed community pride—as confirmed by public surveys. The key lesson, says Hackathorn: "If you build a place for cars, it will be a gathering place for cars. If it's built for people, it will be a gathering place for people."

Kuminski is more succinct: "Bigger is not better," he told the *Times.*

# Lancaster, California

## Lancaster Boulevard

| | |
|---|---|
| **Project Date** | Began 2008. Completed 2009. |
| **Uses/Modes** | Transportation: Motorists, pedestrians, and bicyclists. Trucks for local deliveries.<br>Building: Mixed-use main street with residential and commercial. |
| **Section Length** | 0.8 miles |
| **Street Classification** | Principal arterial |
| **Traffic Counts** | Before: 15,000 vehicles per day. After: 11,350 vehicles per day. |
| **Safety** | Total motor vehicle collisions are down 38%, and injury crashes have fallen by 49%—based on average numbers from 2011 to 2015. Pedestrian-involved collisions fell by 78%. |
| **Intersections** | Traffic signals were replaced with stop signs on the cross streets. Painted crosswalks surround all intersections. Street lamps and bollards are placed next to crosswalks at intersections to keep vehicles from driving into the center flush median. Curb ramps provided at the crosswalks for accessibility. After redesign, the curb return radius remains approximately 15'. |
| **Block Size/Street Spacing** | Block range: 400' |
| **Right of Way Characteristics** | Five travel lanes (two in each direction, plus center turn lane) were converted to two lanes (one in each direction).<br>12' lanes in both directions and 8' parking lanes on both sides.<br>In the center, 32' of diagonal parking with trees, lamps, benches, planters, and kiosks.<br>Sidewalks are 11' wide. |
| **Cost/Funding** | $11.5 million, funded through the local redevelopment agency. |
| **Additional Notable Features** | In the center median, poles support lighting hanging from overhead wires strung in a diamond pattern. Trees are planted along the entire project, on the sidewalks as well as a double row defining the median. For two blocks in the very center of the project, the outside parking lane is eliminated to provide additional sidewalk width for café tables. |

## Objectives

### Overview

The City of Lancaster, California, converted a drab, automobile-oriented arterial at the heart of downtown into a lively, pedestrian-friendly center. The nine-block makeover of Lancaster Boulevard has become a regional amenity and attracted substantial economic development.

### Community Goals

1. Create a community gathering place for festivals, business activity, and social interaction.
2. Boost economic development and restore the economic vibrancy of downtown.
3. Provide shade in desert environment and create an iconic place downtown that improves the city's identity and profile.

### Project Champions

- The City of Lancaster
- Downtown business community
- Scott Ehrlich, Insite Development

## Design

The nine-block makeover of Lancaster Boulevard, the city's historic main street, has become a regional draw and attracted a surge of economic development since opening in 2010. Rebranded the BLVD, this thoroughfare's features are unique among Complete Streets.

Up until the 1950s, Lancaster Boulevard was the main street of a small railroad settlement in the Antelope Valley, in northern Los Angeles County, east of the San Gabriel Mountains. In the last six decades, the town has grown to a sprawling city of 168,000 people, but the street, a principal arterial, suffered from increased and faster-paced traffic—and surface parking lots between buildings created gaps in the urban fabric.

"We knew that in order to revitalize the downtown, we had to reconsider the design of the street," says city planning director Brian Ludicke. "This was a 40 to 50 mile per hour thoroughfare dividing downtown. It was dangerous, noisy, and pedestrians didn't like to cross."

Prior to the reconstruction, Lancaster Boulevard had five lanes of traffic and measured 72 feet from curb-to-curb, carrying 15,000 cars per day. The new design converts the three central lanes to a 32-foot-wide median, or "Ramblas," lined with a double-row of shade trees, inspired by Barcelona, Spain's world-famous Las Ramblas. The center of the BLVD is used for diagonal parking, adding about 100 spaces for downtown shoppers and visitors—while also providing ample room for people to get out of their cars and linger in small public spaces surrounded by rows of trees, lampposts, and large potted plants (Figure 6.10).

On both sides of the Ramblas, one 12-foot travel lane in each direction carries a total of 11,000 vehicles per day. A row of on-street parking separates the moving vehicles from improved sidewalks, street furniture, shopfronts, and buildings.

The speed limit has been reduced to 15 miles per hour from 35 miles per hour, reflecting the slower design speed. Traffic signals were removed along the corridor—replaced with stop signs on the cross streets—and motorists progress slowly, prepared to yield to pedestrians or other motorists backing out of parking spaces. "People stop for pedestrians and let them cross," Ludicke says. "Drivers acknowledge pedestrians and pedestrians acknowledge drivers. People are forced to pay attention, which is why it's a lot safer."

The BLVD is designed for flexibility. For street fairs and markets, the angled parking of the Ramblas is converted to public space. For major festivals and parades, the travel lanes also are closed and made pedestrian only.

In the central block of the BLVD, the outside lanes of street parking have been eliminated to widen the sidewalk for outdoor café seating. "A number of restaurants and businesses have taken advantage of this opportunity for outdoor patios," says Chenin Dow, of the city's Economic Development department. "As the block also features a built-in stage on the southwest corner of Elm and the BLVD, this has become a natural gathering place and center of events."

The Ramblas was meticulously designed to balance the needs of people, parking, trees, lighting, and other street furniture. A six-foot area between each diagonal parking space is reserved for people to move around and for the placement of trees and lampposts. The posts hold overhead wires that cross in a diamond pattern and support the lights. In the center of each block, a mid-block crossing and small public space with seating provides pedestrians with cross-street access and an area to relax. The Ramblas parking is angled at 40 degrees to allow motorists to back safely into the 12-foot travel lane. The Ramblas is built at street grade to allow for parking—but is delineated by pavers and vertical elements. The at-grade design is helpful during festivals.

Although the BLVD is able to store and move many cars, its primary purpose is a public space rather than a transportation corridor. Practitioners realized that the city had no "iconic public space element," says Vinayak Bharne with Moule & Polyzoides, the lead architects. The desert downtown also desperately needed shade. "We realized that whatever we do, the design must provide shade and there must be something dramatic. It must be a big gesture—not something small." That thinking led to inspiration from Barcelona, an approach that resonated with the city.

The most sophisticated aspect of the BLVD is not physical design—rather the city's design of the process aimed at complete urban transformation, Bharne explains. "The real success of the transformation was based on an exceedingly intelligent downtown vision, a very tight

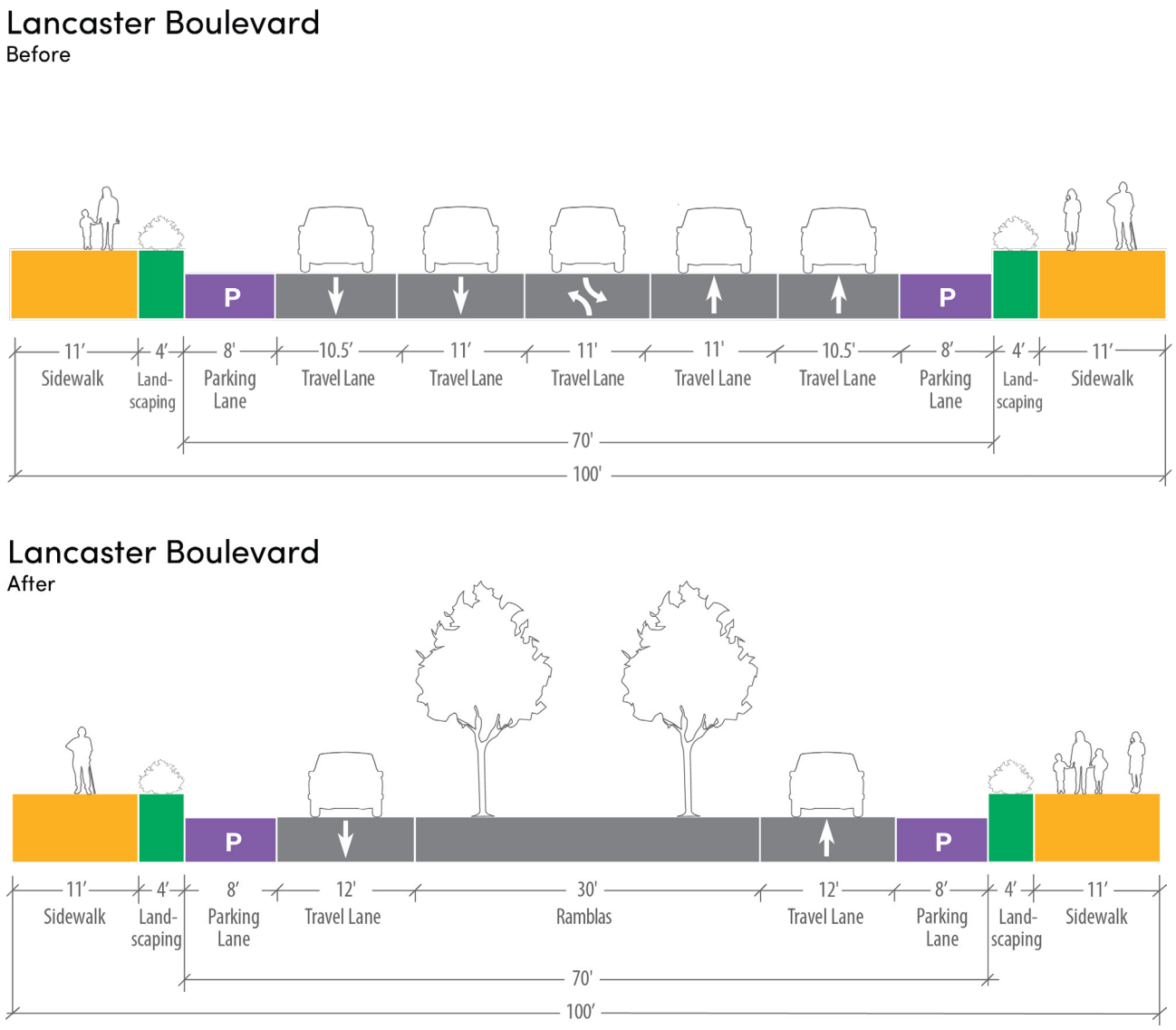



**Figure 6.10** Street design of Lancaster Boulevard before (top) and after (bottom) reconstruction *(Source: CNU)*

budget that the practitioners respected, and a streamlined, synergistic process with the Council and the community to make sure that the boulevard was completed 100 percent on time," he says.

Transit stops serving multiple routes are located at the east and west ends of the BLVD, but Antelope Valley Transit buses are routed around the central portion of the BLVD on parallel downtown streets. Trucks are allowed on the BLVD for local deliveries, but are not prioritized. Businesses generally have rear access from cross streets and/or alleys. The BLVD is posted as a bicycle route and the speed allows bicyclists to mingle with traffic.

## Implementation

The city struck on the idea of transforming the main street (Figure 6.11) through a downtown vision plan, completed in 2008. A few years prior to that, the city had adopted a form-based code for the downtown to ensure new development supports pedestrian activity.

The money for thoroughfare redesign came through the local redevelopment agency, part of a system that was disbanded in 2012 due to a change in state policy. Talk of this disbandment caused the city to shift into high gear to protect its redevelopment funds.

**Figure 6.11** Lancaster Boulevard prior to reconstruction *(Source: City of Lancaster)*

The city conducted intensive public outreach. When talking with citizens and the business community, the officials did not seek agreement on everything. "We had to move quickly," says Caudle. "We told them we are seeking input, not consensus, which is hard to build and difficult to achieve. The business people were generally supportive. There were some naysayers."

The greatest concern came from citizens about removing traffic signals. "We could have taken the position that yes they are right, and no we don't want to hear the complaints, and we will not be leaders or forward thinking," says Caudle. "It would have been a less successful project. The willingness to do something different in street design had a direct impact on the success of the private investment."

The city hired the practitioners who conducted a workshop and wrote a report with a detailed vision in 2009. During the planning phase, skepticism about the project was rampant, Caudle says. "It was going to be a great success or the biggest waste of money ever. I don't think there was any in-between."

As the construction documents were prepared, the city sought developers to seek a financial return from the investment. The city found a primary private sector partner, Scott Ehrlich of Insite Development, based in Los Angeles, who believed strongly in the vision. "He moved in quickly acquiring new property and remodeling it, expanding it to include housing, retail, entertainment—all of the things we were trying to achieve," Caudle says. Other investors came forward, some in partnership with the city and some who worked independently.

"By the time the technical documents were finished, the boulevard project was ready to break ground," Bharne says. "It received immediate Council approval. There was no delay in terms of budget, finance, process, or bureaucracy." The speedy implementation was a necessity, says Caudle. "We had the money, so that wasn't an issue. We had the community buy-in and Council

**Figure 6.12** Lancaster Boulevard after reconstruction *(Source: City of Lancaster)*

support. And the businesses wanted to get back open as soon as possible." The city dedicated two-full staffers to work with businesses and deal with construction issues, working out of a temporary office on the boulevard. Within eight months of the final design, in 2010, the BLVD was built (Figure 6.12).

This $11.5 million project included streetscape costs—the street itself, center Ramblas parking/festival area, sidewalk with colored pavers, curb and gutter, trees, landscaping, lighting, removal of traffic signals, and street furniture (Figure 6.13). The redevelopment funds were available but limited, which forced specific design approaches, such as not "breaking the curb" in most of the corridor, notes Bharne.

The city took some unusual steps, such as designing and placing business kiosks for entrepreneurs. The city has set up 32 kiosk locations, many in the Ramblas, for rental at $500/ per month to start-up retail businesses that can't afford brick-and-mortar storefronts. The goal is that some of these businesses eventually graduate to storefronts.

## Results

Counts point to a doubling of pedestrians from just after completion in 2010 to 2016 on a typical weekday. Despite the greatly increased use of the corridor, injuries and crashes have dropped significantly. Total motor vehicle collisions are down 38 percent, and injury crashes have fallen by 49 percent—based on average numbers from 2011 to 2015. Pedestrian-involved collisions have plummeted by 78 percent.

The BLVD's total economic impact was second highest out of 37 complete streets projects studied by Smart Growth America in 2015, "The real genius of Lancaster is in economic development," says Bharne. "You can call it complete streets or whatever you want, but at the end of the day, the biggest contribution it made was the economic revitalization of the city."

Since the BLVD construction, 57 new businesses have opened in downtown Lancaster. Retail sales have risen 57 percent from 2010 to 2016. More than 800 housing

**Figure 6.13** The center median with parking, lighting, trees, planters, and bollards
*(Source: Moule & Polyzoides, Architects, and Urbanists)*

units have been built or refurbished, the vast majority affordable. Construction or rehabilitation of commercial space totals 177,000 square feet. Insite has built nine housing developments downtown and was a startup partner in a number of new businesses, including an underground bowling alley, a trendy restaurant called BeX, and a nightclub—the RoShamBo Lounge.

Commercial occupancy on the BLVD is now at 96 percent. Nearly 2,000 jobs have been created and the total economic impact is estimated at $282 million, based on a state formula.

A new art-house movie theater opened, in addition to a microbrewery, apparel stores like Urban Outfitters, and other shops and restaurants. The Lancaster Museum of Art & History also opened, which anchors one end of the boulevard. A pre-existing performing arts center anchors the other end.

Civic and social activity downtown has skyrocketed. Event attendance includes:

- Two thousand people visit a weekly summer farmer's market with concert series, with about half that many come to the winter market.
- Major annual festivals—including Halloween & Harvest, Christmas, Celebrate America, and a go-cart Grand Prix—draw 20,000 to 35,000 attendees each.
- Other regular events, such as Terrific Tuesdays, Artwalk, and Dinner & A Movie, draw Lancaster residents downtown year-round.

Prior to the project, Lancaster prepared a plan for increased congestion based on anticipated development. "The City has instituted two mitigation measures, restricting left turns from northbound Fig Street (by making it one way only) and by not providing an opening through the Ramblas at Genoa Street. However, these mitigation measures were for a traffic forecast for 2030, which assumed fairly dense buildout of the downtown," says Dow. The city is monitoring traffic flow and will consider more changes if necessary.

## Lessons Learned

Perhaps the greatest lesson of the BLVD is that "the design of the street actually affects how people behave. That's such a deeply important concept that we are taking it

into other areas of the community," Ludicke says. "In our community, people don't stop for pedestrians in crosswalks. On the BLVD, they stop. Rarely do I see people not stop when I need to cross."

The city is implementing more pedestrian improvements in and around downtown, including a road diet of 1.5 miles of Lancaster Boulevard to the west of the BLVD—which will reduce the travel lanes on the thoroughfare to two, from four, and provide on-street parking.

Although the Ramblas was built nearly exactly as designed, other planned elements were not built due to budget constraints. The original design included full-size roundabouts at the east and west gateways to the BLVD, which were dropped due to budget constraints—but the city may revisit building them in the future, Ludicke says.

With the exception of the removed signals, the intersections have not changed much—curb return radii stayed approximately 15 feet. Curb ramps are provided at the crosswalks for accessibility. Bollards mark the ends of the Ramblas on each block. Vehicles crossing the BLVD must stop at stop signs, and yield signs and markings are provided in the median for left-turns onto the BLVD, but vehicles traveling east and west along the BLVD have no signs or signals on this nine-block stretch. "The design of the street is supposed to influence behavior, and that was a wise decision, because people have gotten used to driving on the BLVD," says Ludicke.

While a significant number of housing units have been built, the vast majority are currently low- and moderate-income restricted," Dow explains. "We would like to see more diverse housing types available, including some market-rate options such as condos. As our housing market continues to gain strength, these types of projects are beginning to become more attractive financially."

When it came to transforming the city's main street, Lancaster refused to compromise on essential aspects of a strong design—and the results speak for themselves, says Caudle. Says Bharne: "Every city should be doing one 'Lancaster' over the next decade—why should they not?"

# Raleigh, North Carolina

## Hillsborough Street

| | |
|---|---|
| **Project Date** | Began 2009. Completed 2010. |
| **Uses/Modes** | Motorists, trucks, buses, bicyclists, people on foot |
| **Section Length** | 1 mile |
| **Street Classification** | Major thoroughfare |
| **Traffic Counts** | 26,000 vehicles per day. The corridor serves numerous bus routes and systems operated by North Carolina State University, the City of Raleigh, and the Triangle Transit Authority. As many as 14 heavy trucks use the corridor during the peak hour. |
| **Safety** | 23% reduction in crashes after construction. |
| **Intersections** | Bulbouts reduce crossing distances, and crosswalks have been added. |
| **Block Size/ Street Spacing** | 600'–700' average |
| **Right of Way Characteristics** | Before: Two 11' travel lanes in each direction, plus one parking lane. After: One 10' wide travel lane in each direction, and parking on both sides—plus a raised median and bicycle/buffer lanes between the parking and travel lanes. |
| **Cost/Funding** | $9.22 million in two phases came from a city transportation bond referendum. |
| **Additional Notable Features** | The project includes two roundabouts. |

## Objectives

### Overview

A dangerous major thoroughfare, crossed by a large number of pedestrians, was redesigned to make the street safer and less of a barrier for people on foot. The changes have created a main street ambience and spurred new development on the corridor.

### Community Goals

1. Alleviate safety concerns, particularly with regards to pedestrians crossing between the neighborhood and university.
2. Spur economic development and community use of the thoroughfare.
3. To slow traffic, but keep it flowing at moderate speeds.

### Project Champions

- City of Raleigh
- The Hillsborough Partnership, a neighborhood alliance
- Hillsborough Street Merchants Association
- University Park Homeowners Association

## Design

A wide suburban arterial road separating the campus of North Carolina State University from city neighborhoods was transformed through traffic-calming techniques. The rebuilt thoroughfare is more appropriate to the context of the adjacent walkable neighborhood that is lined with institutional, commercial, and residential buildings (Figure 6.14).

The project incorporated the following key elements:

- New brick-paved sidewalks were installed along a half mile of roadway, with curb extensions at intersections. The new sidewalks are 8- to 14-feet in width. The

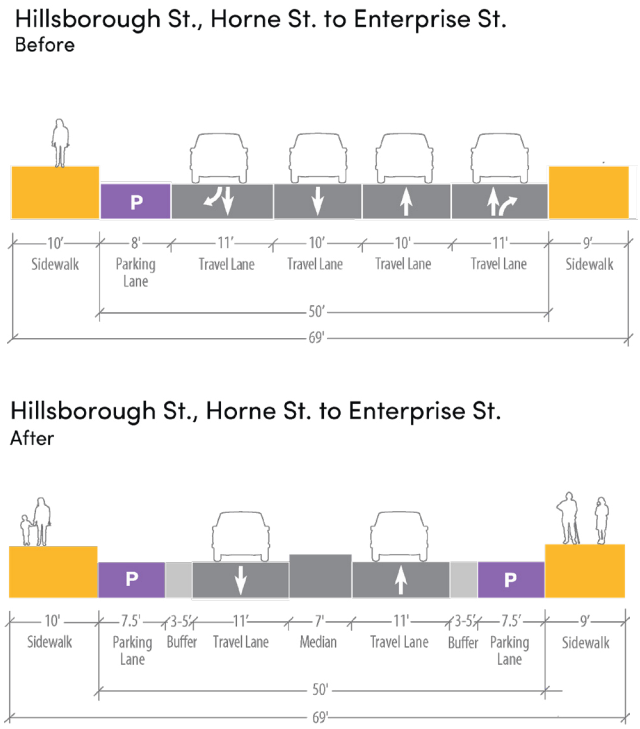



**Figure 6.14** Street design of Hillsborough Street from Horne Street to Enterprise Street before (top) and after (bottom) reconstruction *(Source: CNU)*

previous concrete sidewalks were narrower and obstructed by utility poles and signs.

- Roundabouts were installed at Pullen Road intersections with Hillsborough Street and Oberlin Road—the latter roundabout a half-block from Hillsborough Street. Traffic signals were eliminated at these intersections.
- On-street parking was established on both sides of the thoroughfare, instead of one. About 100 parking spaces were added to the corridor—more than doubling total on-street parking to support shops and restaurants.
- A 4-to 5-foot-wide bicycle/buffer lane was placed adjacent to on-street parking on both sides of the street.
- Motor vehicle travel lanes were reduced from four to two, with raised center medians covered in brick pavers installed between Gardner Road and Oberlin Road.
- Extensive landscaping, bicycle racks, and street furniture were added.
- Many crosswalks were added.
- The median gives way to a short left turn lane at intersections.
- An LED street lighting scheme was installed for pedestrians.

## Implementation

A pedestrian fatality in 1997 created a public outcry that galvanized a group of community leaders, and that initiative a lengthy process leading to eventual redesign of Hillsborough Street (Figure 6.15). A neighborhood group, the Hillsborough Partnership, organized a design charrette attended by 500 people, which identified high pedestrian crash rates, traffic congestion, a lack of on-street parking, and a lack of bicycle infrastructure as priority problems to be solved, North Carolina Department of Transportation (NCDOT) reports.

The charrette led to a feasibility study in 2001, and from that point the project moved forward slowly while funding was identified and an environmental impact study was conducted.

At least a dozen partners lined up behind the street project, pushing for eventual approval. First phase construction began in 2009 was completed in 2010. A second phase was later implemented.

"You must have a big vision, but you need to break it into doable projects. We started with one roundabout, and then moved forward to the next 4–5 blocks," says retired Raleigh Planning Director and neighborhood resident George Chapman.

## Results

The street was listed in 2007 as the most dangerous in the state for pedestrians, who cross by the hundreds in peak hours because of the university campus on the south side. Estimated cost of crashes during a three-year prior to the project was $12.6 million. Vehicles often exceeded the speed limit of 35 mph, according to the 2001 feasibility study. Now motorists slow at roundabouts to 15–20 mph, NCDOT reports, and maintain a moderate speed between the roundabouts.

"The improvements along Hillsborough Street have changed interactions between motorists and pedestrians, slowing down motorists and encouraging higher frequencies of pedestrian traffic," explains NCDOT.

A 2012 crash data analysis indicated a 23 percent overall reduction in crashes after construction. Each subsection of the study area saw a reduction in crashes, except for the roundabout at Pullen Road and Hillsborough Street. NCDOT engineers responded to the problem by modifying the roundabout from a double-lane to a single-lane

**Figure 6.15** Hillsborough Street prior to reconstruction *(Source: City of Raleigh)*

facility in July 2012, bringing crash rates back down at this location (Figure 6.16).

From $150 million to $200 million in new private investments have been made along the corridor since the reconstruction, according to reports by NCDOT and the Hillsborough Partnership. Prior to the project, the feasibility study reported that businesses were struggling and some failed partly due to "fast-moving traffic and non-supportive parking enforcement procedures." But now "a hearty business environment is in place and growing," notes a report by AARP.

A third phase of streetscape improvements is moving forward that will expand the project about nine-tenths of a mile westward.

## Lessons Learned

The project has impacted politics in Raleigh, notes AARP. Mayor and many council members now support walkability and transit as a result of the changes to Hillsborough Street (Figure 6.17). "These leaders consider themselves well versed in how transportation investments can be leveraged to build a sustainable future and a more enjoyable present for the community," AARP notes.

In addition to the street improvements, the City Council established a business improvement district in 2008 to revitalize areas along Hillsborough Street. Public transit improvements were implemented. Like a number of context-sensitive design projects, Hillsborough Street galvanized support for related policy decisions that

**Figure 6.16** The rebuilt Hillsborough Street *(Source: Kimley-Horn and Associates, © CJ Walker Photography, Inc., All Rights Reserved)*

**Figure 6.17** Two roundabouts built as part of the Hillsborough Street project
*(Source: Kimley-Horn and Associates, © CJ Walker Photography, Inc., All Rights Reserved)*

helped to boost economic and social conditions for the surrounding community.

Roundabouts are used to create attractive gateways and vistas, minimize speeds, reduce the problem of left turns (where most traffic accidents occur), simplify pedestrian crossings, and keep traffic flowing gently along the street, according to NCDOT.

Strong community and business support was critical to the overall success of the street reconstruction.

The community's focus for Hillsborough Street was directed toward transforming the area into a "great street and public realm," enhancing the street's retail appeal and improving vehicular and pedestrian safety, NCDOT reports.

# San Diego, California

## La Jolla Boulevard

| | |
|---|---|
| **Project Date** | Began 2007. Completed June 2008. |
| **Uses/Modes** | Motorists, pedestrians, bicyclists, bus transit, trucks |
| **Section Length** | 0.75 miles |
| **Street Classification** | Collector |
| **Traffic Counts** | Before: 23,000 vehicles per day. After: 22,000 vehicles per day. |
| **Safety** | Traffic incidents and crashes have dropped by 90%. |
| **Intersections** | Converted five intersections—including one traffic signal, two four-way stops and two two-way stops—to two roundabouts and three "mini-roundabouts." Also installed four traffic circles in nearby intersections. |
| **Block Size/Street Spacing** | Approximately 600' apart |
| **Right of Way Characteristics** | Five travel lanes (two in each direction, plus center turn lane at intersections) were converted to two lanes (one in each direction). New sidewalks, extensive landscaping, and more on-street parking were provided. 70' curb-to-curb distance. Sidewalks vary in width. |
| **Cost/Funding** | Approximately $3.2 million for construction of roundabouts and traffic calming. Project total cost of $7.2 million included replacement of sewer mains, planning, and engineering. Funding sources included $2 million smart growth grant from California Department of Transportation, a San Diego Association of Governments transportation grant, development impact fees, and private contributions. |
| **Additional Notable Features** | Three of the five roundabouts are "mini-roundabouts" —approximately 85' in diameter—because regular size roundabouts would have required expensive and controversial purchase of right of way. The project included substantial traffic calming on nearby streets. Thirty additional parking spaces, including diagonal and parallel parking, were provided in a five-block area. |

## Objectives

### Overview

An automobile-oriented thoroughfare was tamed to create a more pedestrian-friendly context that supports businesses facing the street. Pedestrians can cross more easily to the beach and the thoroughfare unites the neighborhood—rather than posing a barrier between houses and the Pacific Ocean.

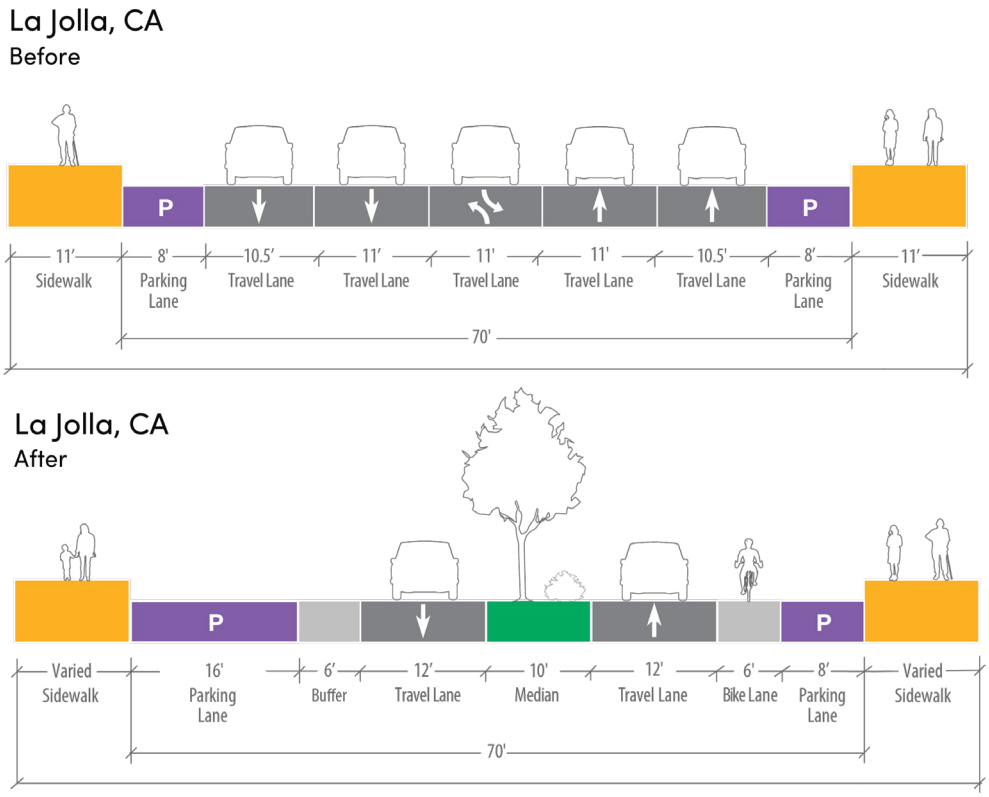
### Community Goals

1. To calm traffic on a wide suburban arterial and change the context to a pedestrian-friendly main street.
2. Improve safety on a thoroughfare that residents cross on the way to the beach.
3. Revitalize a commercial district.

### Project Champions

- Scott Peters, then president of City Council, now a congressman
- Bird Rock Community Council
- City of San Diego

**Figure 6.18** Street design of La Jolla Boulevard before (top) and after (bottom) reconstruction *(Source: CNU)*




## Design

The reconstruction of a section of La Jolla Boulevard and traffic calming on nearby streets yielded substantial safety benefits and spurred economic development in Bird Rock, San Diego.

The project was designed to transform a wide, automobile-oriented thoroughfare to a pedestrian-friendly, neighborhood center.

Travel lanes were reduced from five to two while adding five modern roundabouts, improved sidewalks, medians, landscaping, and increased angle parking. Traffic calming measures were installed on less busy side and parallel streets to avoid potential traffic diversion. This included installation of four traffic circles—designed like roundabouts but lacking splitter islands on the approaches. Diagonal parking is included on the west side of La Jolla Boulevard, and parallel parking on the east side.

Pedestrians once had 70 feet of pavement to cross at intersections. With the roundabouts, they now cross 12–14 feet of pavement at a time with refuge islands in the middle. Pavement flashers, activated by pedestrians, remind motorists to stop and yield for people on crosswalks (Figure 6.18).

The street redesign also includes relocation and reconfiguration of bus stops, including new bus pads and benches.

Substantial care went into the landscaping—the shrubs, flowers, trees, and other plants in the center median, the roundabouts, and both sides of the streets including the bulbouts. "If this landscaping wasn't here," Dan Burden, walkability consultant on the project, says, "we'd probably lose a third of the effectiveness."

The design addressed issues identified by the community: A shortage of parking, lack of comfortable public spaces, and financial stagnation of area businesses, notes *restreets.org*. "The wide, heavily trafficked road functioned as a barrier that divided the neighborhood physically and psychologically."

A parallel street, La Jolla Hermosa, is the designated bicycle route and includes bicycle lanes. However, due to the 15 mph design speed of the roundabouts and traffic calming, many bicyclists feel comfortable riding with traffic on La Jolla Boulevard or on Chelsea Street, another traffic-calmed parallel street, the city reports.

**Figure 6.19** La Jolla Boulevard prior to reconstruction *(Source: Dan Burden)*

## Implementation

The planning began in 2000. The Bird Rock Community Council surveyed residents and identified the safety of pedestrian crossings as a concern, after which a series of town hall meetings took place on potential traffic calming measures. The project had a champion in city government named Scott Peters who was council president at the time. In 2001, a heavily-attended community meeting identified lingering concerns, including cut-through traffic and loss of roadway capacity.

The city hired a walkability consultant, Dan Burden, who led a series of community workshops leading to consensus on a general traffic-calming approach. Burden then conducted a three-day, hands-on, public design charrette to work out a vision for the thoroughfare (Figure 6.19). A comprehensive traffic management plan was developed and adopted in 2003, addressing community concerns.

City council approved the project in 2004 without controversy, and the detailed engineering and design began. A roundabout design specialist, Michael Wallwork, worked with city transportation engineers.

After three years of detailed work like drainage and landscaping and securing a variety of financing sources, the project began construction in 2007. Phase one consisted of traffic calming throughout the neighborhood—especially on a parallel street, La Jolla Hermosa. Phase two included the construction of roundabouts on La Jolla Boulevard. The developer of a large condominium project built two of the roundabouts.

## Results

The traffic count remained approximately the same (23,000 vehicles per day before, 22,000 after), but walking, bicycling, transit use, on-street parking and retail sales all climbed to much higher levels, the city reports. Retail sales rose 30 percent and noise levels dropped 77 percent. Because traffic moves slower, businesses report higher visibility.

As a result of the roundabouts and traffic calming, speeds were reduced from 40–45 mph to 19 mph, according to

**Figure 6.20** La Jolla Boulevard after reconstruction *(Source: Dan Burden)*

city transportation engineers. "The once busy boulevard has been transformed into a slow-paced street with roundabouts, landscaped street dividers and diagonal parking," notes the *LaJolla Light* (Figure 6.20).

Traffic crashes fell by 90 pecent. The project has helped revitalize La Jolla Boulevard, acting as a catalyst to several new mixed-use developments, a 139-unit condominium development, and a major drugstore (Figure 6.21).

"Motorists," Burden reported in *The San Diego Union-Tribune* in February 2017, "understandably dreaded this change before it was made. But they found that instead of waiting 24 seconds for a pedestrian to cross 70 feet of road, they now only wait 3–4 seconds, or don't have to wait at all. Businesses that feared the loss of customers arriving in cars actually improved their trade. … Today motorists are getting to their destinations in less time, because they aren't stopping."

## Lessons Learned

The plan originally called for five full-sized roundabouts, which measure at least 100 feet in diameter, including the travel lanes, on La Jolla Boulevard, but when the city began detailed design, it was discovered that additional right-of-way was required for three of the roundabouts. With the advice of the roundabout practitioner, the city opted for three mini-roundabouts, about 85 feet in diameter, which required no land purchases. This saved money and time and avoided controversy. The smaller roundabouts allow all kinds of vehicles to pass through although transit buses cannot make U-turns, the city reports.

The roundabouts slow traffic speeds and provide inviting gateways to the neighborhood.

Fewer traffic lanes mean reduced crossing distance and fewer injuries to pedestrians and provide space for

**Figure 6.21** A family on a crosswalk on La Jolla Boulevard *(Source: Dan Burden)*

landscaped center medians and other appealing aesthetic features at intersections.

The phased construction allowed deficiencies to be addressed in the first phase, with improvements in later phases. The reconstruction and calmed traffic sets the stage for buildings to actively engage the street.

The roundabouts take some getting used to, and not long after installation citizens called city hall to complain about large vehicles rolling over the roundabout aprons but Peters explained, the wide aprons are designed so that large vehicles can go over them without difficulty. "It was intentional," Peters said. "We planned every inch of them so they would accommodate things like fire department engines, making sure they would convey traffic."

The corridor is a bus route and the site of many truck deliveries. There are back alleys on a portion of the corridor, but in other locations trucks still must deliver in front. At those times, cars have to wait. "That is one of the sacrifices that was made," says Mike Arnold, traffic engineer and project manager with the city. The street network and parallel thoroughfares provide alternative routes when necessary.

Some of the roundabout turns are very tight for large trucks like tractor-trailers, Arnold says. Because some intersections are not at 90 degrees, some truck-turning restrictions apply. The tightness of the roundabouts contributes to the slow traffic speeds and the success of the project, Arnold says.

Resurfacing is trickier with the new streetscape and must be carefully planned. Traffic is moved to adjacent streets and much of the work is done from 8 p.m. to midnight.

La Jolla Boulevard provides a model for how to do context sensitive streets, including roundabouts, in the San Diego area—prior to this project, few had been built in the region.

# South Miami, Florida

## Sunset Drive & Dorn Avenue

| | |
|---|---|
| **Project Date** | Redesign and reconstruction begun in the mid-1990s, completed 1998. |
| **Uses/Modes** | Motorists, pedestrians, bicyclists, trucks |
| **Section Length** | 0.25-mile section of Sunset Drive, 2 blocks of Dorn Avenue |
| **Street Classification** | State historic highway, Route 986 |
| **Traffic Counts** | 1986: 32,300 vehicles per day. 2015: 37,500 vehicles per day, including about 1,300 trucks. |
| **Safety** | 1991–1992: Three injury crashes involving pedestrians at Red Road and Sunset Drive. 2004–2013: Zero crashes involving pedestrians or bicycles at Red/Sunset. 1986: Three vehicular crashes at Red/Sunset. 2013: Zero vehicular crashes at Red/Sunset. |
| **Intersections** | Crosswalks and bulbouts installed at intersections. Ramps for access of by people with disabilities. |
| **Block Size/ Street Spacing** | Approximately 300′ |
| **Right of Way Characteristics** | Five travel lanes were converted to three lanes on Sunset Drive, including a center turn lane. Lanes were narrowed on Sunset. Dorn Avenue was a one-way street with a single, 23′ wide asphalt travel lane, with narrow sidewalks. Sidewalks were substantially widened and the travel lane was narrowed to 12′. Bulbouts further reduce crossing distances. |
| **Cost/Funding** | $1 million for Sunset Drive, paid for by developer impact fees from construction of a shopping mall. $200,000 for Dorn Avenue, paid for by the city and private donations. |
| **Additional Notable Features** | On Dorn Avenue, new pavement is brick pavers. |

## Objectives

### Overview

A streetscape redesign and construction helped spur the revitalization of the downtown of South Miami, a suburb in Dade County. The project was completed in conjunction with a plan and code changes that have transformed the image of the municipality and made it a destination for dining, retail, and entertainment.

### Community Goals

1. Make the center of South Miami more walkable—a place where residents can enjoy a sense of place.
2. Restore a Main Street context.
3. Revitalize businesses on both streets.

### Project Champions

- South Miami Hometown, Inc., a nonprofit
- City of South Miami
- Dover, Kohl & Partners, an urban design firm located in South Miami

## Design

The heart of South Miami—an early suburb built from the 1930s to the 1960s—had a car-oriented character 25 years ago. A change in design was made to create a main street ambience where pedestrians feel comfortable and to kick-start implementation of a long-term vision for the area.

South Miami's center, including the main street Sunset Drive and the two-block commercial street Dorn Avenue, languished for decades before getting a commuter rail station in 1984. Revitalization of the town center area, now called Hometown, began in earnest about 2000—following a street redesign completed in 1998.

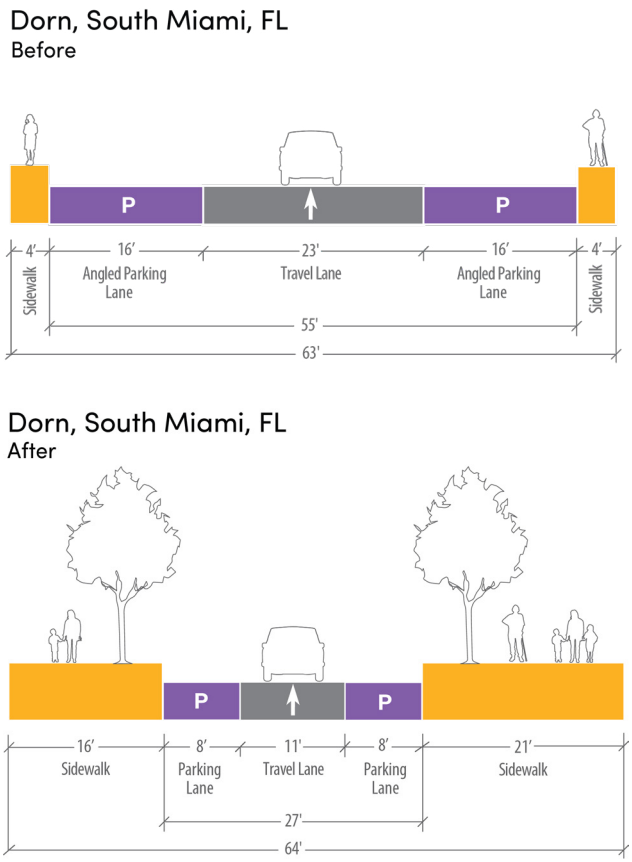



**Figure 6.22** Street design of Dorn Avenue before (top) and after (bottom) reconstruction *(Source: CNU)*

Sunset and Dorn are perpendicular to each other—the streets intersect less than 100 feet from US 1/Dixie Highway, where South Miami's Metrorail station is located.

The streets had been designed primarily for motor vehicles and did not support the desired context of a mixed-use, walkable center. In a subtropical climate, there was no shade. Cobra lights hung over the street. The sidewalks were narrow, leaving no room for café tables—if anyone had wanted to linger there. On the plus side, many of the buildings faced the sidewalks in main street fashion—although some buildings had been torn down for surface parking, leaving gaps in the urban fabric.

The Sunset and Dorn makeover was designed to show how the area could transform to a more walkable environment. The street redesign was made in conjunction with zoning and planning changes to promote street-oriented architecture, a mix of uses, and shared parking in public garages and along the street.

Right-of-way changes included the following: five travel lanes were converted to three lanes on Sunset Drive. Twelve-foot travel lanes were narrowed to 10 feet. Dorn Avenue was a one-way asphalt street with a single, 23-foot-wide travel lane, angled parking, and narrow sidewalks. Sidewalks were substantially widened on Dorn Avenue and the travel lane was narrowed to 12 feet. Bulbouts further reduce crossing distances (Figure 6.22).

Concrete sidewalks and asphalt roadways were converted to brick, which creates a slight rumble that tends to calm traffic, on Dorn. Aesthetically, the brick generates a warmer, more inviting tone to the streetscape. Street trees were lacking on both thoroughfares, but now they arch over the sidewalk and street, narrowing the perceived width of the roadway and providing shade for café tables, which didn't exist prior to the redesign. New buildings come up to the sidewalks and have doors, windows, and business entrances.

The narrow, brick, tree-lined Dorn Avenue is notable for being the only street of its kind in South Miami and one of the few in South Florida, according to Dover, Kohl & Partners, the firm that designed the new streetscapes.

## Implementation

The street changes resulted from a 1992 community planning process where residents repeatedly told practitioners "we want our main street back," according to Dover Kohl. Dorn Avenue was chosen as the first demonstration project for what was called the Hometown Plan, a vision plan covering 55 acres at the heart of the community, near the recently built transit station (Figure 6.23). After Dorn Avenue was successfully rebuilt, the reconstruction of Sunset Drive followed. The overall plan was geared toward reviving and enhancing a mixed-use walkable downtown for a suburb. Street redesign was needed to complete that vision. The area is now called South Miami's Hometown.

## Results

The result has been transformative for South Miami, according to Mayor Philip Stoddard. "We in South Miami embraced the gracious planning and design of our Hometown District, and we want to continue farther on this path," he says.

**Figure 6.23** Sunset Drive in South Miami in 1992 *(Source: Dover, Kohl & Partners)*

**Figure 6.24** Sunset Drive today *(Source: Dover, Kohl & Partners)*

Substantial development has taken place to support the new mixed-use, main street context. New buildings have first-floor shops and businesses, and upper-floor offices and residential units.

Total long-term redevelopment and investment in the Hometown area is estimated at $1 billion, including a multistory shopping mall, The Shops at Sunset Place, which takes up a large urban block and has stores fronting the street. South Miami, a place where people drove through on their way to Miami or Coral Gables, is now a regional destination.

Safety on the roadway is improved, particularly the intersection of Red Road and Sunset Drive, which had frequent crashes. In 1991 and 1992, as the Hometown Plan was created, three injury crashes that included pedestrians were reported at that intersection. From 2004 to 2013, the intersection had no crashes reported with pedestrians or bicyclists, according to the National Highway Traffic Safety Administration.

Even with the reduction in lanes, the volume of traffic on the thoroughfare has risen. Level of service on Sunset Drive has dropped from a D in 1986 to an F in 2015, according to Florida DOT.

The municipality had dropped in population in the 1970s and 1980s, but began to turn around with the Hometown Plan. Growth has been strong since 2000.

## Lessons Learned

A new streetscape can be the impetus for a broad revitalization of a district, changing the public perception of an area and bringing in visitors from other parts of the region. A community may fully realize the potential of a traffic-calming street redesign with the help of an overall vision plan and zoning changes. In the case of South Miami, all of these elements combined to create a more complete community with stronger retail, better transportation, and more residents and employment.

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7

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