SMART TRANSPORTATION GUIDEBOOK

Planning and Designing Highways and Streets that Support Sustainable and Livable Communities

New Jersey Department of Transportation

Pennsylvania Department of Transportation

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The Pennsylvania and New Jersey Departments of Transportation have partnered in the development of the Smart Transportation Guidebook — a roadmap to a successful future!

The goal of the Guidebook is to integrate the planning and design of streets and highways in a manner that fosters development of sustainable and livable communities. The Guidebook has equal applicability to rural, suburban and urban areas.

Transportation needs will always outweigh available resources. Smart transportation means incorporating financial constraints, community needs and aspirations, land use, and environmental constraints during project development. The result will be an effective use of resources and a lasting community asset.

Deep appreciation is extended to the design and planning personnel from both the New Jersey and Pennsylvania Departments of Transportation who participated in the preparation of this Guidebook. Their creativity was critical to the success of this effort.

Thanks also go to the Federal Highway Administration Division Offices from both New Jersey and Pennsylvania for their contributions and review of the guidebook. And special appreciation goes to the Delaware Valley Regional Planning Commission for administering the work of the consultant production team.

The principles and concepts in the Smart Transportation Guidebook are offered for use and thoughtful deliberation in all communities throughout Pennsylvania and New Jersey.

Sincerely,

Allen D. Biehler

Allen D. Biehler
PennDOT Secretary

Kris Kolluri
NJDOT Commissioner

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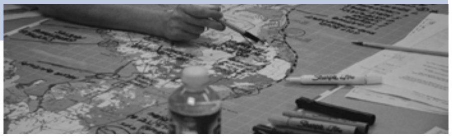

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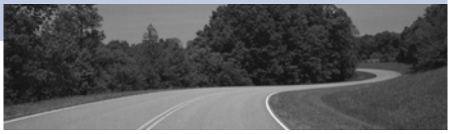

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HOW TO USE THIS BOOK

The Smart Transportation Guidebook *provides guidance on planning and designing non-limited access roadways in New Jersey and Pennsylvania, from local streets through multi-lane state highways.*

Turn to the following chapters for information:

What is "Smart Transportation"?

For an understanding of this new approach to planning and designing roadways, see the key principles of Smart Transportation in **Chapter 1: Introduction**.

Project planning on state roadways.

For assistance in project planning on NJDOT and PennDOT roadways, see **Chapter 2: Smart Transportation Tools and Techniques.** County and local governments should also review this chapter for ideas on how to create the best projects on their roadways. To understand the role of the local government in NJDOT and PennDOT projects, see **Chapter 3: A Local Commitment.**

Planning and designing the roadway.

For all roadway projects, proceed using the following steps:

- Identify the land use context; see **Chapter 4: Land Use Context**. Choose the land use context that best describes the study area. If there are plans for the study area, choose the land use context based on those plans.
- Identify the transportation context; see **Chapter 5: Transportation Context**. Choose the roadway type that best describes the role of the roadway in the community. Also evaluate the surrounding roadway network; in Smart Transportation, the relationship of the road to the larger network should always be understood.
- Choose design values for the roadway, appropriate to land use context and roadway type. See **Chapter 6: Designing the Roadway**.

Guidance on roadway and roadside design.

What factors should be considered in planning and designing the roadway? See Chapters 7 through 9:

- For guidance on the appropriate design of roadway elements – travel lanes, on-street parking, shoulders, bicycle facilities, medians, and intersections – see **Chapter 7: Roadway Guidelines**.
- For guidance on the appropriate design of roadside elements – pedestrian facilities, transit facilities, landscaping and streetscaping – see **Chapter 8: Roadside Guidelines**.
- For guidance on general systems issues – access management, traffic calming, operations and maintenance, and emergency response – see **Chapter 9: Road System Issues**.

1.0

Introduction

The New Jersey Department of Transportation (NJDOT) and the Pennsylvania Department of Transportation (PennDOT) have commissioned the preparation of the *Smart Transportation Guidebook*. Its focus is to guide the development of non-limited access roads as context sensitive roadways, with the goal of creating transportation facilities that work well for all users, are affordable, and support smart growth community planning goals.

1.1 WHY IS SMART TRANSPORTATION IMPORTANT? WHY THIS BOOK?

NJDOT and PennDOT cannot always solve congestion by building more, wider and faster state roadways. There will never be enough financial resources to supply the endless demand for capacity. Further, both states realize that the "wider and faster" approach to road construction cannot ultimately solve the problem. Sprawling land uses are creating congestion faster than roadway capacity can be increased. Figure 1.1 illustrates this never-ending cycle of transportation and land use changes.

Smart Transportation proposes to manage capacity by better integrating land use and transportation planning. The desire to go "through" a place must be balanced with the desire to go "to" a place. Roadways have many purposes, including providing local and regional mobility, offering access to homes and businesses, and supporting economic growth.

The Guidebook intends to help agencies, local governments, developers and others plan and design roadways that fit within the existing and planned context of the community through which they pass.

1.2 WHAT IS SMART TRANSPORTATION?

Smart Transportation recommends a new approach to roadway planning and design, in which transportation investments are tailored to the specific needs of each project. The different contexts - financial, community, land use, transportation, and environmental - determine the design of the solution. The best transportation solution arises from a process in which a

Figure 1.1 Transportation and Land Use Cycle

multi-disciplinary team, considering a wide range of solutions, works closely with the community. Inclusive of context-sensitive solutions (CSS), Smart Transportation also encompasses network connectivity, and access and corridor management. It will help both states and communities adapt to the new financial context of constrained resources.

***Smart Transportation* can be summarized in the following principles:**

1. Tailor solutions to the context.

Roadways should respect the character of the community, and its current and planned land uses. The design of a roadway should change as it transitions from rural to suburban to urban areas. Changes in roadway widths, the presence or absence of parking lanes, and other factors provide clues to motorists on how fast to drive when they pass from one land use type to another. If appropriately designed, vehicular speeds should fit local context. The concept of desired operating speed, described later in the Guidebook, is key to the context sensitive roadway.

Community context is much more than the physical appearance of buildings and street. At the local level, the context includes the role of the roadway in supporting active community life.

The transportation context of the roadway is essential. Use of the Guidebook is not meant to result in a cookie-cutter roadway template, in which the same Main Street or commercial corridor design appears in every town. The design of every roadway must respond to its unique circumstances. The states will continue to value the mobility offered by high-speed roadways that serve motorists drawn from a larger region or heavy freight traffic. Conversely, other state roadways serve mostly local traffic and can be designed to be more sensitive to the local context.

The presence of environmental resources must always be reflected in the development of alternatives.

Finally, the financial context must be considered. In both states, transportation funding is in short supply, and is far exceeded by needs. By permitting a narrower roadway, a Smart Transportation approach can save money on some projects. In other cases, streetscaping needs and other components may increase costs. But in all cases, designing a road to fit its context is the smart thing to do.

2. Tailor the approach.

Projects vary in need, type, complexity and range of solutions. Therefore, the approach should be tailored to that specific project. This tailored approach should be developed with the team members and project stakeholders early in the process. PennDOT's guidance on Linking Planning and NEPA (National Environmental Policy Act) describes this in more detail.

3. Plan all projects in collaboration with the community.

All state transportation projects are planned through on-going partnerships with local communities. Indeed, this Guidebook invites a wide-ranging discussion between the state, local officials, and citizens on the appropriate role of state roadways within the community. As part of this collaboration, both parties have responsibilities.

NJDOT or PennDOT will review proposed roadway projects to ensure that they maintain vital regional or statewide mobility goals. If the design is not consistent with community plans, the DOT may recommend revising the roadway design, or work with the community on alternative strategies to better accommodate regional trips.

For its part, the local government is responsible for sound land use planning. It should help create a well-connected street network that will better accommodate local trips, thus removing these trips from major roadways. Linking developments along arterials will also serve to moderate traffic growth on these roads. The local government should also encourage mixed use districts that cut down on the number of vehicular trips.

In summary, the collaboration between state and community involves the integration of land use planning with transportation planning, and a focus on the overall transportation network rather than a single roadway. These concepts should be incorporated into all corridor plans for NJDOT and PennDOT.

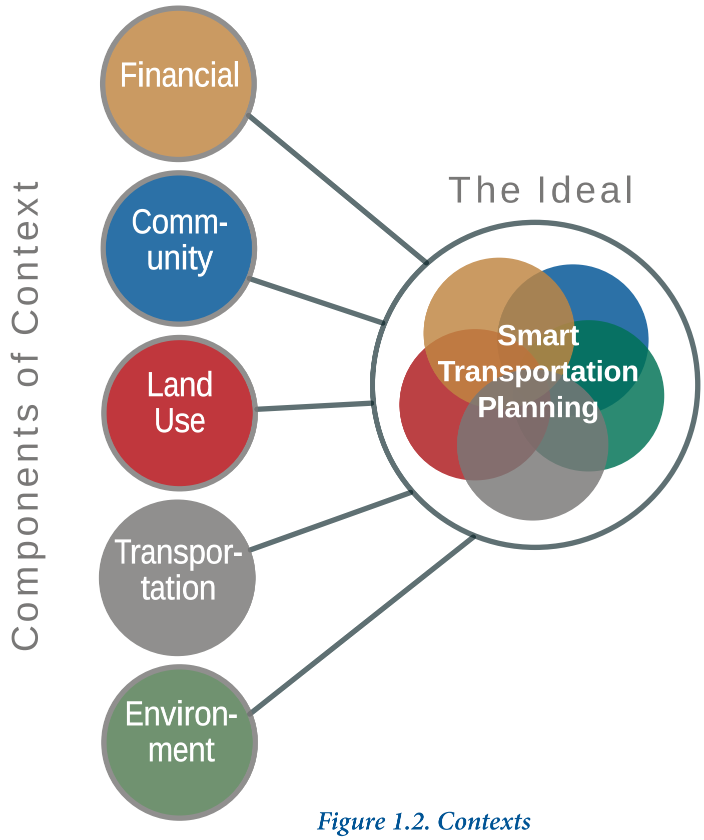


Figure 1.2. Contexts

Community involvement at work

"We shape our buildings, and afterwards our buildings shape us."

Winston Churchill, 28 October 1943 to the House of Commons (meeting in the House of Lords).

4. Plan for alternative transportation modes.

The needs of pedestrians, bicyclists and transit users must be considered in designing all roadway projects. Sidewalk networks should be well connected with opportunities for regular, safe street crossings. On collector and arterial roadways, bike lanes or wide curb lanes can encourage people to bike rather than drive for short and moderate distance trips. If a roadway is designed to discourage vehicular speeding, it can be comfortably used by pedestrians and bicyclists alike. Transit friendly design should support a high level of transit activity. By encouraging alternative transportation, communities can break the pattern of sprawling suburbs with rapidly multiplying vehicular trips and congestion.

It should be acknowledged that there are potential trade-offs between vehicular mobility and pedestrian, bicycle and transit mobility. A balance should be sought in attaining these goals on all projects.

5. Use sound professional judgment.

Although this book provides guidance on the range of dimensions for roadway elements, all recommendations should be filtered through the best judgment of the project team after considering the specific circumstances of each project. There is no one-size-fits-all approach to good decision-making. The smart solution on some projects may be to seek design exceptions or waivers to allow for true context-based design.

6. Scale the solution to the size of the problem.

Find the best transportation solution that fits within the context, is affordable, is supported by the communities, and can be implemented in a reasonable time frame. Examine lower scale alternatives like network additions or transportation system management before developing alternatives such as new or widened roadways. If safety and not congestion is the problem, consider focused solutions that can improve safety without increasing capacity. Safety must be considered on all roadway projects.

1.3 BACKGROUND OF SMART TRANSPORTATION

Smart Transportation is informed by two important concepts that have taken root in transportation and land use planning: Context Sensitive Solutions (CSS) and Smart Growth.

As defined by the Federal Highway Administration (FHWA), CSS is "a collaborative, interdisciplinary approach that involves all stakeholders to develop a transportation facility that fits its physical setting and preserves scenic, aesthetic, historic and environmental resources, while maintaining safety and mobility. CSS is an approach that considers the total context within which a transportation improvement project will exist."

Smart Growth has been defined many different ways but generally emphasizes environmental preservation, compact development patterns, alternative transportation, and social equity.

The ideas behind Smart Growth and CSS have permeated the operating philosophies of both NJDOT and PennDOT. PennDOT has developed 10 Smart Transportation themes:

1. Money counts
2. Understand the context; plan and design within the context
3. Choose projects with high value/price ratio
4. Enhance the local network
5. Look beyond level-of-service
6. Safety first and maybe safety only
7. Accommodate all modes
8. Leverage and preserve existing investments
9. Build towns not sprawl
10. Develop local governments as strong land use partners

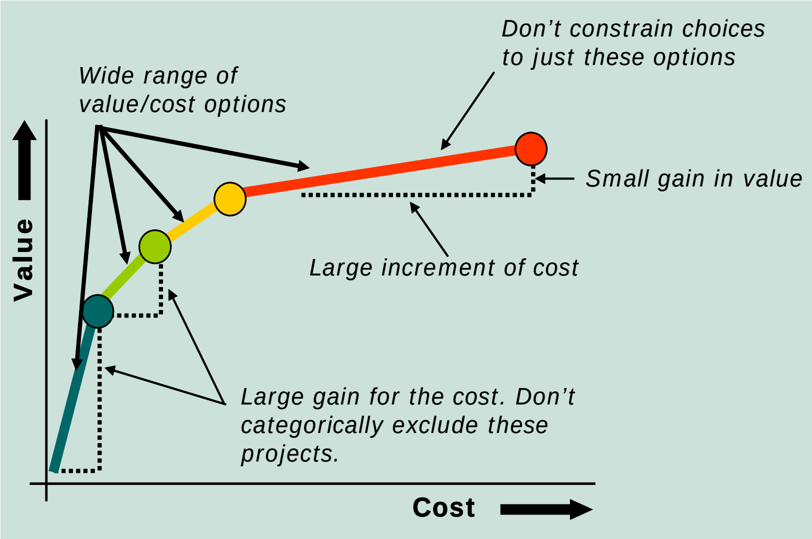


Figure 1.3. As shown here, it is important to look beyond choices of high cost and to develop solutions that have large gain in value for the cost.

The History of CSS

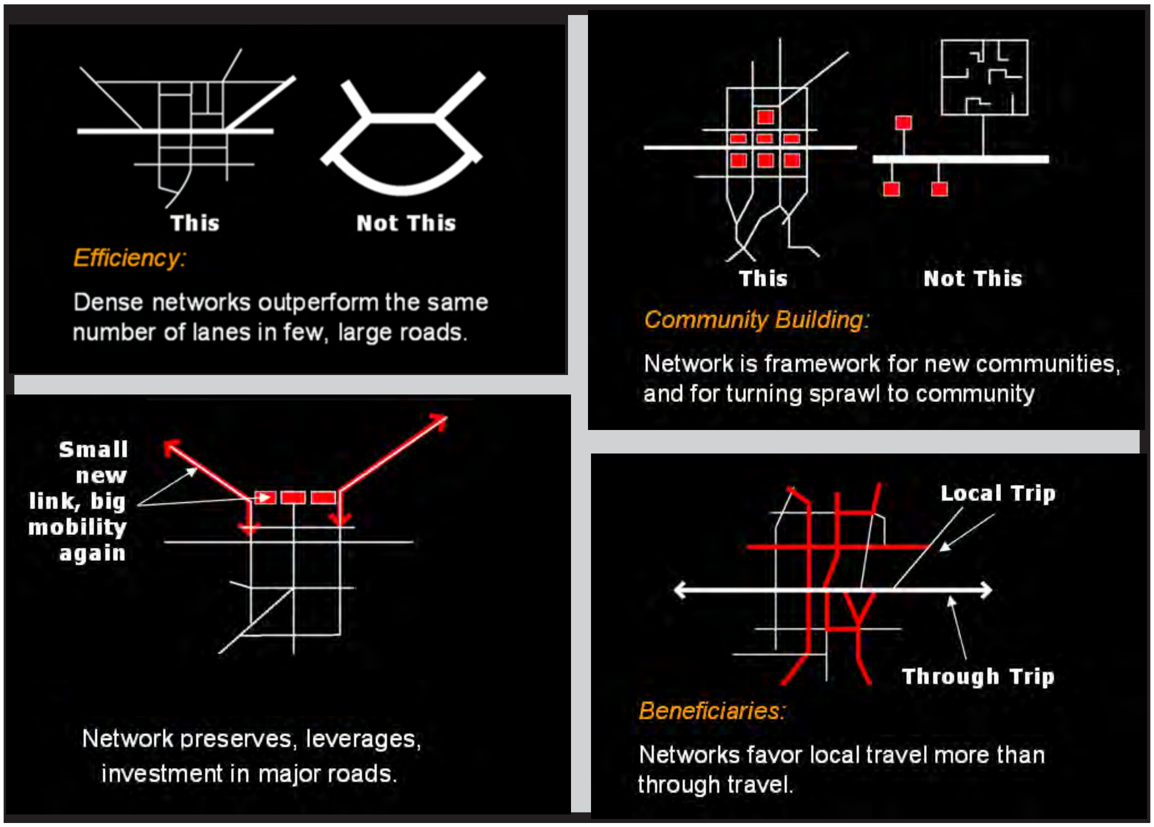
As this timeline shows, the idea that roadways should be planned for place is revolutionary, but not new:

1991 — **Intermodal Surface Transportation Efficiency** Act, a landmark transportation funding bill, emphasizes the importance of sensitivity to community resources in all transportation projects.

1995 — National Highway System Designation Act states that roadway designs may consider impacts of transportation projects on both the built and natural environment.

1998 — "Thinking Beyond the Pavement" conference sponsored by the Maryland State Highway Administration in conjunction with the FHWA and AASHTO coins the term "context sensitive **design." Following the conference, five pilot states** – Connecticut, Kentucky, Maryland, Minnesota, and Utah – are asked by FHWA to implement CSD principles and report on their experience.

Figure 1.4 Benefits of Network



NJDOT's definition of context sensitive design says that "CSD maximizes the integration of the roadway into the surrounding environment/community, while providing for the road user's needs in a manner which is fiscally feasible."

The NJDOT proactive design policy includes the following statements supportive of smart transportation:

- Our designs should result in motorists driving freeways like freeways, arterials like arterials, collectors like collectors, and local streets like local streets;
- Designers may include elements that encourage drivers to slow down to speeds appropriate to local conditions; yes, this includes traffic calming (below 35 MPH).

1.4 FLEXIBLE DESIGN STANDARDS

The preparation of the *Smart Transportation Guidebook* has benefited from the promotion of flexible standards by the federal government and experiences in other states.

Like most states, the design manuals for both New Jersey and Pennsylvania are heavily drawn from the AASHTO Green Book (officially, American Association of State Highway and Transportation Officials, *A Policy on Geometric Design of Highways and Streets*, Fourth Edition, 2001). It is important to note that the Green Book is not a design manual, but rather a series of recommended design values for roadways, and that not all its criteria is based on safety. FHWA has adopted the Green Book

2004 Transportation Research Board publishes Context-Sensitive Design Around the Country, providing examples of CSD implementation throughout the United States.

2006 Institute of Transportation Engineers (ITE), partnering with the Congress of New Urbanism (CNU), and in conjunction with the FHWA and EPA, issues a proposed "Recommended Practice": Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities (2006). Some of the practices from that text are referenced in this guidebook.

for all roadways on the National Highway System (NHS). Both the FHWA (*Flexibility in Highway Design,* 1997) and AASHTO (*A Guide for Achieving Flexibility in Highway Design,* 2004) recommend flexibility in application of the Green Book design values, particularly when considering impacts on the community. Even greater flexibility is possible for non-NHS roadways; on these roads, states can set their own standards.

Despite this, standards in most state design manuals hew closely to AASHTO values, and sometimes surpass them. This is the case in both states. It is now recommended that both states take advantage of the flexibility offered in FHWA and AASHTO guidance. Application of flexible design will allow for greater improvements to the overall network by maximizing limited funding.

The use of seven different "land use contexts" as an organizing framework is key to providing flexibility for the designer. Smart Transportation recognizes the major differences between urban and suburban land use areas, and the different expectations of motorists in these areas. By tailoring design values to both land use context and transportation context, and tying both context types to the desired operating speed, the Guidebook promotes driving behavior consistent with roadway design.

Smart Transportation has benefited from the opportunity to learn from successful experiences in other states, where flexible design has been implemented and safety maintained.[1] For example, Vermont revised its State Standards in 1996 to reduce lane widths from the previous standards. The roadway design speed is permitted to be equal or less than the posted speed. There has been no apparent reduction in safety on Vermont roads from application of the new standards.[2]

PRINCIPLES OF SMART TRANSPORTATION

1. Tailor solutions to the context.
2. Tailor the approach.
3. Plan all projects in collaboration with the community.
4. Plan for alternative transportation modes.
5. Use sound professional judgment.
6. Scale the solution to the size of the problem.

1.5 PURPOSE OF GUIDEBOOK

This book provides guidelines for improving the roadway system in accordance with Smart Transportation principles. It can be used in the planning and design of non-limited access roadways of all classifications, from principal arterial highways owned by the state government to local roadways. At the state level, it will serve as a link between context sensitive philosophy and the DOT design manuals as well as the AASHTO Green Book. All county and local governments in both states, and their private sector partners, are encouraged to use this Guidebook.

1.6 PROJECT SPONSORS AND USE OF THIS GUIDEBOOK

DVRPC is the metropolitan planning organization (MPO) for the Philadelphia-Camden-Trenton metropolitan area, including Burlington, Camden, Gloucester and Mercer Counties in New Jersey, and Bucks, Chester, Delaware, Montgomery and Philadelphia counties in Pennsylvania. Although overseen by the DVRPC, the potential application of the Guidebook extends beyond the region, since NJDOT and PennDOT are key partners and other parts of New Jersey and Pennsylvania have similar land use and roadway characteristics.

Both NJDOT and PennDOT require use of context sensitive practices in all projects. Now for the first time, the two states are working together to establish common design guidelines, and to link land use context to roadway values for every roadway type in the region.

This Guidebook has potential application for a wide range of users in New Jersey and Pennsylvania:

- MPOs and RPOs (Rural Planning Organization) in the two states – serve as guidelines for integrated land use and transportation studies.
- NJDOT and PennDOT – serve as guidelines for applying the NJDOT and PennDOT design manuals in a context sensitive manner.
- Municipalities and Counties – serve as guidelines for land use and roadway development projects.
- Developers – provide tools to realize "smart growth" goals for developments.
- Residents of New Jersey and Pennsylvania – guide community development and better understand their role in the transportation project development process.

SMART TRANSPORTATION

Tools and Techniques

This chapter describes tools and techniques that can be employed by PennDOT and NJDOT to develop transportation solutions that are context-sensitive and affordable, and that receive support from the community and resource agencies. These tools are not intended to replace the project development processes of NJDOT or PennDOT, but rather should be applied to existing processes in order to achieve smarter solutions. They are consistent with state and federal regulations, such as the National Environmental Policy Act (NEPA) and the federal transportation legislation referred to as SAFETEA-LU. Counties and municipalities can also benefit from the application of these tools.

2.1 WHY USE THESE TOOLS?

Project delays and escalating costs are discouraging to everyone involved. Planning and designing solutions that are not affordable and cannot be implemented do not solve problems. Projects that are built but do not meet the expectations of the community, the transportation agency or the general public are also frustrating.

The application of these tools will permit a better understanding of the problem, key issues, and potential solutions; agency and community opinion; and schedule and budget early in the process. In this manner, projects listed on the TIP can be implemented with more certainty, and completed within the estimated timeframe and budget.

Use of these tools will also help enable the following outcomes:

- Allocate financial resources to projects that address local, regional and statewide priorities.
- Achieve consistent expectations between project proponents and communities, and entities that evaluate and fund projects.
- Achieve the optimum accommodation for all modes.
- Ensure context sensitivity in the planning and design of projects.
- Decrease the amount of re-work in the preliminary engineering and final design phases of a project.

2.0

Early Project Budget Planning

Project planning is a complex undertaking, which involves identifying the transportation problems to be solved and finding the best alternative to solving the problems. Unfortunately, all too often, a project is defined, public commitments are made and then the news is delivered that the project is unaffordable.

In Smart Transportation, project planners and designers consider the potential project cost and funding resources at the earliest possible time. A cost estimate must be included when a project is introduced and continue to be updated as the project becomes better defined through the development process. As the project advances to decision points on whether it should move onto a TIP or into final design, the cost estimate must be up-to-date to enable decision makers to determine the project's future. A concerted effort must be made to fit a given project at the beginning of the pipeline into the window of available funding at the end. Projects that grow to exceed the available funding envelope must be evaluated to bring the scope in line with the established project budget, or be at risk of cancellation.

These Smart Transportation tools are applied in conventional transportation planning, but differ significantly by broadening many of the already-familiar steps. The tools are:

A. Understand the problem and the context before programming a solution for it.
B. Utilize a multi-disciplinary team.
C. Develop a project-specific communication plan.
D. Establish the full spectrum of project needs and quality of life objectives.
E. Focus on alternatives that are affordable and cost effective.
F. Define wide-ranging measures of success.
G. Consider a full set of alternatives.
H. Compare and test alternatives.

2.2 TOOLS AND TECHNIQUES

Both NJDOT and PennDOT implement a wide range of projects, from simple maintenance and roadway resurfacing projects to the construction of new highways. The tools and techniques described in this chapter can be applied at different levels, depending on the complexity and needs of each project.

NJDOT has organized each of their projects into four different "pipelines". Projects in pipelines 1 and 2 are more complex and will therefore require the greatest effort in planning and preliminary engineering to determine the best "fit" solution. On the other end of the spectrum, projects in pipeline 4 are much simpler and are often implemented through maintenance activities which require little preliminary engineering but will still benefit from early planning and coordination.

PennDOT has three categories of projects – minor, moderately complex and major. Although all of these projects include some level of problem identification and planning activities, the moderately complex and major projects will require the greatest effort in planning and preliminary engineering to determine the best solution.

For the purpose of this chapter, the terms "simple, moderate and complex" will be used to describe the general type of project. "Simple" projects will include PennDOT minor projects and NJDOT pipeline 4 projects. "Moderate" projects will include PennDOT moderately complex projects and NJDOT pipeline 3 projects. "Complex" projects will refer to PennDOT major projects and NJDOT pipeline 1 and 2 projects.

Tool A – Understand the problem and the context before programming a solution for it.

The purpose of the investment must be defined by project stakeholders from the beginning. Sufficient information must be gathered to understand the problem and its context, issues and opportunities, potential solutions and estimated costs, and draft implementation schedule.

What is the transportation problem? How much money is available for this problem? Is the problem related to safety, capacity, or roadway or bridge condition? Is the project intended to provide access for a specific economic development opportunity? Is it consistent with regional and state priorities? What is the role of the roadway within the study area?

To understand the problem and determine the project needs and objectives, the following activities should be conducted:

1. Review data that identified the need for the project. For some projects, this may simply be the output of the preservation and maintenance program. For more involved problems, such as safety or capacity, this should include crash data, projected traffic volumes, and future traffic generators in and around the study area.

2. Understand the existing and future context of the problem. This includes the financial context (order-of-magnitude costs, benefits and regional funding priorities), transportation context (function and use of the roadway), land use and community context (type of area that is served by the roadway), and environmental context. Evaluate regional and state priorities; if the problem is inconsistent with these priorities, it will likely not be funded. See Chapters 4 and 5 for information on determining the context.

3. Understand the project needs and objectives from the perspectives of the project sponsor, project team, local governments, potential users, and other interested parties. Establishing this understanding at the

beginning of the project will help to manage expectations. This activity will require more coordination for moderate and complex projects. For simple projects, the minimum activity involves coordination with municipal representatives and utilities on the anticipated schedule and potential impacts to their property, community or operations. Utilities should be notified even for routine resurfacing and rehabilitation projects to coordinate needed work.

Table 2.1 identifies techniques that can be used to achieve a solid understanding of the project, listed from least to greater effort. Routine maintenance and system preservation projects should use techniques that require the least effort. The full range of techniques could be used on more complex projects.

It can take many years for a transportation project to be implemented; it is important that the needs and objectives identified at the onset of the project are still valid and able to be addressed by the alternatives at the project's end. If a project has been in the development process for a few years, a review of the project, cost estimate, and its consistency with current priorities should be completed at major decision points in the process. NJDOT and PennDOT both employ go/no go decision points in their development processes.

Application

The following questions can be asked to determine if this tool was used effectively:

- Is there a clear understanding of the problem?
- How often, and for how long, does the problem occur?
- Has recent data been mapped and analyzed for a safety problem?
- Have the project team and stakeholders agreed to or adopted the project needs and objectives?
- What are the current and future transportation, environmental, land use and financial contexts of this problem?
- What alternatives should be developed?
- What are the order-of-magnitude costs for the potential alternatives? Are they consistent with state and regional priorities?
- What is the implementation schedule for the alternatives? Is the construction schedule understood by all potentially impacted parties?
- What is the agency and community opinion of this problem and potential solutions? What issues or concerns do municipal representatives have?
- Do the local municipalities, utilities, or private land owners have projects scheduled that may be facilitated or harmed by the project?

Table 2.1 Techniques to Understand Problems, Issues, and Opportunities - In Order from Most Simple to Most Complex

	Mapping	Collecting & Analyzing Data	Gathering Input from Municipalities and other Stakeholders
SIMPLE	Aerial Map of Existing Roadway or Bridge with 100' buffer on either side (Scale: 1" = 200')	Data from asset or performance management systems (pavement, bridge inspection, road safety audit, etc.)	Telephone calls to municipal representatives and utilities
		Crash history	Meeting with municipal representatives, on site
		Roadway Function – vehicle types, pedestrian activity, bicycle activity, trip characteristics, trip types, etc.	Small group discussion, conducted on site
	Regional Transportation Map	Major natural and environmental systems	One-on-one stakeholder interviews; conducted on site
		Existing context, land use and activity centers (trip generators)	Series of focus group meetings throughout the project area
COMPLEX		Anticipated future context, land use and activity centers	Meeting with regional elected officials

Tool B – Utilize a Multi-Disciplinary Team

The project team should encompass the skill sets and perspectives needed to address diverse viewpoints. A multi-disciplinary team contributes to a broader evaluation of data and measures of success, ensuring that the community's vision is well represented. The collaborative participation of all members of the team will permit a broad range of alternatives to be considered. Through local partnerships, network improvements and alternatives not located within the right-of-way can be implemented more easily.

Table 2.2 illustrates the relationship between specific problems or issues, the knowledge or skills needed to address these issues, and the internal and external team members that can provide that knowledge or skill. This table is merely an illustration of this idea and is not a complete list of issues or skills needed.

Solutions might target a single mode of transportation, or address the range of road users including pedestrians, bicyclists, transit operators, automobile drivers, and truckers. The issues and opportunities identified should inform the makeup of the team.

Table 2.2 Example Characteristics of Multi-Disciplinary Teams

Potential Problem or Issue	Specific Knowledge or Skills Needed	Potential Internal Team Member with Knowledge/Skills	Potential External Team Member with Knowledge/Skills
Drainage	Hydraulics	Drainage Engineer	DEP
Parklands	Section 4(f) Process	Environmental Specialist	County or Municipal Planner
Community Opposition	Communication & Conflict Resolution	Project Manager, Public Relations Representative	Municipal Manager, Community Groups, Elected Officials
Staged or Complex Construction	Construction Methods	Representative of Construction Unit	Construction Contractors
Soils with High Sinkhole Potential	Geotechnical/Hydrology	Geotechnical Engineer	DEP
Historic Bridge Structure	Structural Engineer Historic Resources	Bridge Unit, Environmental Unit	DEP, PHMC/SHPO
Pedestrian Fatalities	Safety, Pedestrian	Traffic & Safety Unit, Bike/ Pedestrian Coordination	Municipal Planner/Engineer
Speeding/Aggressive Driving	Safety, Roadway Design Traffic Calming	Traffic & Safety Group, Project Engineer, Traffic Calming Specialist	Municipal Planner/Engineer, Local Law Enforcement

Table 2.3 Example of Project-Specific Communications Matrix

	Communication Techniques				
Intended Audience/ Users of Facility	**Website**	**Visuals**	**Special Topic Meetings**	**General Meetings, Workshops, & Public Hearings**	**Radio/Press/ Newsletters**
General Public	X	X		X	X
Traveling Public	X	X		X	X
Resource Agencies	X	X	X	X	X
Elected Officials	X	X	X	X	X
Special Populations	X	X	X	X	X
Sounding Board	X	X	X	X	X

Complex projects often require input from many perspectives, including transportation planners, community leaders, citizens, environmental specialists, landscape architects, resource agencies, public works officials, design engineers, and agency executives. For complex problems, the roles and responsibilities should be defined at the beginning of the process. On federal and state-funded projects, the ultimate decision-makers will be the Federal Highway Administration and NJDOT or PennDOT.

Application

The following questions can be asked to determine if this tool was used effectively:

- What are the specific issues related to this project?
- Do team members have the specific knowledge and skills to address the project issues?
- Does the composition of the team reflect the complexity of the project?

Tool C – Develop a Project-Specific Communication Plan

A critical element of any project is gathering input from all interested parties, including resource agencies, project stakeholders, municipalities, users of the roadway, property owners, and citizens. Current transportation legislation requires that agencies and the public be provided an opportunity to comment on the purpose and need and potential alternatives as early as practicable in the decision-making process.

A Communications Plan should be developed for most projects. (The needed communication strategy should be determined during the scoping phase of the project.) The plan should consider all substantive issues likely to arise in the development and evaluation of alternatives. It can be a simple matrix that outlines the intended audiences and tools or techniques that will be used to reach these audiences. An example of this approach is shown in Table 2.3.

The communications plan should be developed with representatives of the intended audience, as they often know what tools and techniques have worked well in the past. During the course of the project, the effectiveness of the plan should be evaluated by the project team on a regular basis, and the plan and tools/techniques changed if necessary.

In general, the number of stakeholders and the level of agency and community coordination will grow with the increase in complexity and the number of sensitive issues that are associated with the project. Both PennDOT (Public Involvement Handbook) and NJDOT provide guidance on public involvement.

Table 2.4 lists the tools available to engage the public and agencies, ranging from tools that are applicable for simple projects to those that would be applied on more complex projects. Simple visualization tools, in particular, can be very effective in communicating ideas and gathering input on intended project outcomes.

Table 2.4 – *Example Techniques for Community Engagement*

- Phone calls
- Letters
- Meetings
- Newspaper advertisement/article
- Public meeting(s)
- Press releases
- Posters of upcoming events
- Project newsletters
- Advertisements
- Interactive project website
- Stakeholder interviews
- Visualization tools
- Open houses
- Public hearing(s)
- Neighborhood meetings
- Surveys
- Walking audits
- Design workshops/ charrettes
- Citizens Advisory Committee
- Field offices
- Steering committee
- Formalized partnerships or inter-local agreements
- Conflict resolution

Application

The following questions can be asked to determine if this tool was used effectively:

- Does the communication plan include techniques that will appeal to all intended audiences?
- Have the techniques proven effective in gathering input and fostering project understanding? If not, how should the communications plan be modified to better achieve this?
- Has the project team opened a dialog with the stakeholders, potentially interested parties, community leaders and elected officials?
- Is there a summary of issues and opportunities that can be easily understood by the project stakeholders and the general public?
- Is there project support from the community/stakeholders? If not, how will outstanding issues be addressed?
- What municipal representatives and stakeholders should be included in the next phase of project development?

Tool D – Establish the Full Spectrum of Project Needs and Objectives

The statement of purpose and need should include the objectives that the proposed project is intended to achieve. Consistent with SAFETEA-LU, objectives may include:

- Achieving a transportation objective identified in the statewide or metropolitan transportation plan;
- Supporting land use, economic development, or growth objectives in applicable federal, state, local or tribal plans; and
- Serving national security, or other national objectives as established in federal laws, plans or policies.

Project needs and objectives should be developed in collaboration with the study team and stakeholders. Following are some common examples of project objectives:

1. Structural integrity. For many projects, the primary objective is to provide safe and structurally-sound roads and bridges. Does this require full reconstruction, rehabilitation, or preventative maintenance? The character and design of the structure, and treatment of pedestrians and bicyclists, may also be important objectives for the community.

2. Safety. Crash data should be reviewed to determine if safety problems exist. Safety must be addressed for all users, including pedestrians and bicyclists. Is safety increased through the raising of design speed (crash-worthiness) or through the reverse method of matching desired operating speeds with the context (context sensitive design)? The solution must be commensurate with the documented problems.

3. Traffic service. This is a common measure on projects, but it is possible to refine the goal to a greater degree than typically seen. For example, do traffic service goals apply to service for all users? For daily local travel to destinations or for distant weekend ones? Is there a concern with traffic service all day, a peak hour, or something in between? Is mobility (the ability to get from origin to destination, possibly by a variety of routes), really the traffic issue, rather than speed or delay? Is parking part of the traffic service?

4. Non-motorized user service. Do the goals of "pedestrian-friendly," "bicycle-friendly," or "transit oriented" apply? If these are important goals in the study area, consideration could be given to the use of formal level of service measures for pedestrian, bicycle and transit service.

5. Community character. As a starting checklist, identify the character types defined in Chapters 4 of this guidebook. Variations on these basic context types within the study area could be identified, such as "Main Street" or "neighborhood business center."

6. Economic development. The role of economic development can be analyzed in numerous ways. Will the facility result in opening up more area to development? Is the project located in a growth area identified by the MPO, RPO and/or municipalities? Will it serve to attract "big-box" retail or regional distribution uses? Will it strengthen a "Main Street," or otherwise compete with sprawl? Will it add to the visitor appeal of a scenic or historical asset?

All objectives should be developed with, and accepted by, the project team and stakeholders. For simple projects, documenting agreement may involve a phone call, email and/or letter with the municipal representative. For complex projects, these goals must be vetted with the project team and stakeholders, and documented ***before*** project alternatives are developed.

Application

The following questions can be asked to determine if this tool was used effectively:

- Are the project needs and objectives understood by the project team and stakeholders?
- Were agencies and the public involved in the development of project needs and objectives?

Tool E - Focus on Alternatives that are Affordable and Cost-Effective

No matter how good a solution is, if it is not affordable, it will not solve the problem. Financial resources are very limited in both New Jersey and Pennsylvania. Construction costs have increased significantly (30-40% over the last few years) and federal and state funds are not keeping pace with demand. Wise investment in transportation infrastructure requires sensitivity to available funding.

Virtually all projects offer a range of options with different costs, corresponding to different levels of value. However, the importance of understanding alternatives based on the value to price ratio is often overlooked. Current guidance is fairly silent on this subject, and does not direct projects toward the most effective value to price yield. Frequently, one objective is given as an absolute mandate, which must be met at all costs. The concepts of "return on investment" and "right sizing" recognize the growing importance of evaluating the value to price ratio on proposed alternatives. Performance measures such as cost per existing trip, cost per new trip, and cost per time savings for a representative trip may be used to better understand the return on a proposed investment.

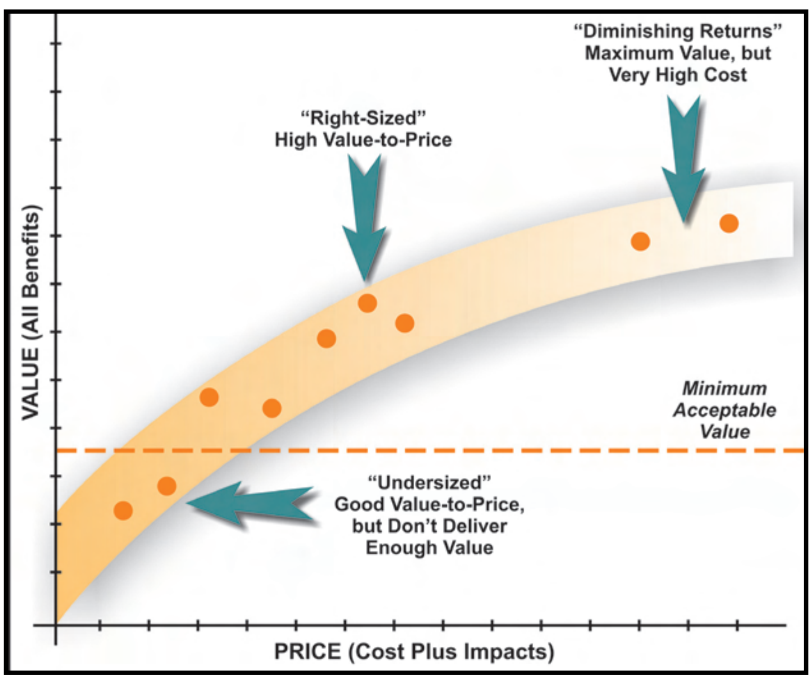


Figure 2.1 Value to Price Curve

Both NJDOT and PennDOT have capital investment committees that review cost estimates for all major projects and determine if the project should move forward. Acting as "gatekeepers," these committees are tasked at key decision points with evaluating the proposed investment in relation to potential benefits and federal, state and regional priorities. To ensure fiscal responsibility, the total estimated project costs should be determined for all alternatives at several steps within the project development process.

An evaluation of project costs and benefits can help define reasonable alternatives; the best alternative will often be one that achieves the greatest balance. For example, if Alternative A meets 100% of the defined project needs and objectives, while Alternative B meets 80% of these same needs and objectives, but costs 50% of Alternative A, then Alternative B may be a better investment than Alternative A. If Alternative A meets 100% of the project needs and objectives but is not a regional or state priority and cannot be funded for the foreseeable future, then it is not a good choice for solving the problem.

Application

The following questions can be asked to determine if this tool was used effectively:

- Is the total estimated cost of each alternative known before programming the project on a TIP? Is the cost known before a recommended alternative for final design is selected?
- Are each of the alternatives affordable given the current financial situation and state/regional priorities?
- What are the cost/benefits of the alternatives?

Tool F – Define Wide-Ranging Measures of Success

Setting measures of success is not unique to context-sensitive design; most road design projects measure the success of alternatives in meeting project needs and objectives. In Smart Transportation, it is recommended that measures represent the full spectrum of project needs and objectives, such as transportation for all modes, safety, economic development, community character, and land use (see Tool D: Establish Full Spectrum of Project Needs and Objectives). Wide-ranging measures are used to assess alternatives against these needs and objectives.

Although broad in outlook, measures of success (MOSs) can be simple to calculate, calculable from readily available data (for simple projects) and readily reproducible. It is completely acceptable for MOSs to be redundant, measuring different aspects of the same qualities. For example, the "volume to capacity ratio" and "queue length" computations as defined in the Highway Capacity Manual are both measures of effectiveness about a single quality (traffic service) but each is useful in its own way.

Measures of success should be directly related to the accepted project needs and objectives. For objectives relating to vehicular traffic service, measures should be chosen from the standard, widely used measures (for example, "level of service", "seconds of delay"). For objectives that capture community character, measures should be developed based on the specific concerns of the community. Chosen measures should be transparent and easily conveyed to all stakeholders.

Including measures of success that address community goals as well as traffic performance is critical to reaching a smart transportation solution. For example, traditional traffic-only measures, while accurate for their single goal (moving traffic) are usually devoid of context. Thus, an evaluation measure calling for "attaining peak hour traffic level of Service C" would gauge success only by that measure. The fact that the roadway may be located within a "Main Street" environment or a heritage neighborhood is not considered. Using this single measure, any alternative that attains the level is considered satisfactory, and any alternative that does not is often eliminated as "failing". Because projects have wide-ranging needs and objectives, no single measure of success should be used to determine the preferred solution for a problem.

Measures of success that address the full set of needs and objectives should be simple and yield a great deal of understanding with a minimum of computation. For example, the measure of pedestrian mobility (a critical element where the context is a "Main Street") is furnished by information as simple as the number of signalized crossings, the presence of pedestrian signal indications, the width of pavement to be crossed or the posted speed. All of this information is readily available from project inventories, photographs, GIS files or field visits.

The absence of a wide range of evaluation measures in transportation planning is generally not due to the difficulty of computing such measures. Rather, it is because they were not identified as issues earlier in the process. Even if only a few measures are finally selected for project evaluation, consideration of a wide range of measures at the beginning of a project can help identify important community values that may otherwise be overlooked.

Table 2.5 provides examples of measures and how they can be calculated. All measures of success should be tailored to the specific project. Some characteristics of effective measures include:

- Simple compilation, from readily available data (rather than complex computation using extensive new data – particularly for simple projects).
- Transparent, using a method understandable to the non-technical public.
- Reproducible results (rather than yielding different answers to different analysts, for same conditions).
- Objective (not judgmental).
- Yields degrees of success (not just "pass/fail").

Application

The following questions can be asked to determine if this tool was used effectively:

- Have the alternatives been compared using a wide-ranging list of measures of success?
- Do all needs and objectives have corresponding measures of success?

Table 2.5 Examples of Smart Transportation Measures of Success

Measure of Success	Units	Potential Source
TRAFFIC		
Peak Hour LOS (intersection) Non-Peak Hour LOS (intersection)	• Level of Service • Seconds of delay • Queue lengths • Daily Profile	HCS intersection – or SIDRA roundabout runs, existing and design year
Screen line capacity (at *X* segments throughout the corridor)	Peak hour/peak direction vehicles	HCM source flows on planned lane count
Volume/Capacity (at *X* segments throughout the corridor)	Peak hour volume/capacity ratio	• HCM source flows on planned lane count • Traffic Study
Corridor travel times between selected origins and destinations	Minutes	Simulation such as Synchro, VISSIM
Reduction in existing VMT	VMT	Simulation such as Synchro, VISSIM
Desired travel speeds in Area X, Area Y	MPH expected based on roadway design and characteristics	NJDOT/PennDOT Design Manual/ AASHTO Green Book
SAFETY		
Reduction in number of driveways	Number of driveways	Field Count
Reduction in unprotected left turns	Peak hour vehicles	Signalized intersection analysis and existing turning movements
Potential safety improvements at documented high-crash locations	Potential for increasing safety	Crash data and safety audit
Median that meets certain criteria	Linear feet (lf)	Map take-off
Shoulders that meet certain criteria	Linear feet (lf)	Map take-off
ALTERNATIVE MODES		
Sidewalk	lf of new sidewalk	Map take-off or GIS
Restored sidewalk	lf of replaced sidewalk	Map take-off or GIS
Safe pedestrian crossings	Number of well-marked crosswalks,and/or speed and volume of crossing traffic	Map take-off or GIS
Bicycle access	lf of bike lanes, paved shoulders, or wide curb lanes	Map take-off or GIS
Public transportation	Bus stops with safe pedestrian crossings	Map take-off or GIS
Ease of crossing for farm equipment in rural areas	• Crossings • Desired speed based on road design	Map take-off or GIS NJDOT/ PennDOT Design Manual/ AASHTO Green Book

Measure of Success	Units	Potential Source
COMMUNITY CHARACTER		
Rural road-front in purchased farm land, conservation easement	lf, Acres	Map take-off or GIS
Town streetscape	lf	Left turn lane placement and existing turning movements
Historic resources	• Number of NRHP-Eligible Buildings Impacted/Displaced • Number of NRHP-Eligible Districts Impacted	Map take-off or GIS
Businesses	Number Impacted/Displaced	Map take-off or GIS
Residences	Number Impacted/Displaced	Map take-off or GIS
Community facilities	Number Impacted/Displaced	Map take-off or GIS
Land use/growth management	Consistency with local and regional plans and policies	Comprehensive Plans or similar documents
Open space/parklands	Number Impacted/Displaced	Map take-off or GIS
ENVIRONMENTAL		
Wetlands	• Number Impacted • Acreages Impacted • Quality	Map take-off or GIS
Stream crossings	• Number of New Crossings • Acreage of New Crossings	Map take-off or GIS
Floodplains	Acreages Impacted	Map take-off or GIS
COSTS		
Total project costs	Dollars in Year of Expenditure	Estimated
Cost per new trip	Dollars per trip	Estimated cost, new capacity added
Cost per new VMT	Cents per mile	Estimated cost, new VMT capacity added
Cost per user	Dollars per user	Estimated cost, new users

Tool G – Consider a Full Set of Alternatives

A critical element of Smart Transportation is a structured search through a wide range of alternatives at an early stage in the process. Consistent with NEPA, this range will always include a no-build alternative, and, depending on the complexity of the project, could include one or many build alternatives. These alternatives should address the project needs and objectives identified earlier in the process.

The following pages provide some examples of potential solutions for common transportation problems. These are not listed in any particular order. However, consistent with Smart Transportation principles, the first alternatives to be developed should be low cost and low impact. High-cost, high-impact alternatives should be developed only if the low build alternatives do not address enough of the needs and objectives.

After full consideration of project context and objectives, a solution that requires a design exception may be the best project alternative. In these cases, the evaluation process and rationale for incorporating a design exception into the alternative must be well documented, in accordance with NJDOT or PennDOT procedures. The review process for design exceptions should determine the appropriateness of the alternative.

As discussed in greater detail in Tool E, an analysis of the "value to price" ratio should be conducted for all potential alternatives. This technique, and other techniques for exploring alternatives, are listed in Table 2.6.

Application

The following questions can be asked to determine if this tool was used effectively:

- Was a full range of alternatives developed? Were low cost, low impact alternatives considered?
- Do the alternatives address the needs and objectives that were agreed upon by the stakeholders and project team?

Table 2.6 Checklist for Exploring Alternatives

Strive For	Avoid
Multi-Party Input – DOT, engineering consultant, specialists (historic, environmental), stakeholder representatives.	Project Staff Only Input – Inside project team, generalists where specialists are needed.
Collaborative – Participants sift through wide range of alternatives, with no exclusions. Alternatives are discussed in structured dialogue sessions.	Prescriptive – Range of alternatives is prescreened and limited. Some alternatives are dismissed early as "fatally flawed."
Iterative – Alternatives are considered again, with the same process as described above, as further understanding and evaluation is gained.	One Time – Alternatives are "closed down" after an early "final screening."
Aware of Value/Price -- Some understanding of value/price relationship at early stage and throughout.	Focusing only on High Price Solutions – Little understanding of value/price during alternatives stage.
Expansive – Process seeks alternatives that yield multiple quality-of-life benefits.	Constrained – Alternatives are limited to narrow range that addresses only one issue or concern.

There is a wide range of solutions that can address mainline congestion, from increasing efficiency to managing demand. One choice that some areas have made is to evaluate the level of service that can reasonably be accommodated for all modes.

RANGE OF SOLUTIONS FOR MAINLINE CONGESTION

INCREASE EFFICIENCY (ON-ROUTE)

- Signal Coordination
- Manage Access
- Change Intersection (See Intersection Congestion)
- Time Based Changes (Reversible Lanes, Off-Peak On-Street Parking, etc.)
- Corridor-wide ITS
- One Way/Two Way Corridor Conversion

USE ALTERNATIVE MODES

- Bicycling
- Walking
- Transit Use

EVALUATE LEVEL OF SERVICE STANDARDS

INCREASE CAPACITY (ON-ROUTE)

- Add Lanes
- Reconfigure

USE ALTERNATIVE ROUTES (OFF-ROUTE)

- Build New Route
- Re-Direct Traffic to Existing Routes
- Augment Existing Network

MANAGE DEMAND (ON & OFF-ROUTE)

- TDM (Telecommuting, Employee Transit Passes, Employee Shuttles, etc.)
- Land Use Policies

The following provides some ideas for solutions related to roadway resurfacing.

RANGE OF SOLUTIONS FOR RESURFACING

RESURFACE TO CURRENT CONFIGURATION

EVALUATE THE NEED FOR MILLING TO IMPROVE ACCESS & DRAINAGE

RESTRIPE

- Add bicycle lanes
- Modify number of lanes
- Modify lane widths
- Modify on-street parking
- Allow for streetscape opportunities

There are a wide range of solutions that can address congestion at intersections. The focus is often limited to solutions at the specific location, but a number of solutions may be found by using or enhancing the surrounding network.

RANGE OF SOLUTIONS FOR INTERSECTION CONGESTION

RECONFIGURE (AT LOCATION)

- Change Lane Configuration
- Grade Separate
- Roundabout

CHANGE OPERATIONS (AT LOCATION)

- Reconfigure Signal
- Restrict Turns

DEVELOP NETWORK (AT A DIFFERENT LOCATION)

EVALUATE LOS STANDARDS (AROUND LOCATION)

IMPLEMENT MEASURES (AROUND LOCATION)

The following provides some ideas for solutions related to deficient bridges.

RANGE OF SOLUTIONS FOR BRIDGE DEFICIENCY

REHABILITATE

- Focus only on structural integrity (may require design exceptions)
- Upgrade to current geometric standards
- Introduce Roadway Elements
- Restore historic character of structure
- Use for another function- i.e. vehicular to pedestrian bridge

REBUILD

- In- place
- At another location

REMOVE

Safety problems can be very difficult to diagnose and to solve. This table outlines a range of solutions for increasing intersection safety.

RANGE OF SOLUTIONS FOR INTERSECTION SAFETY

MODIFY INTERSECTION CONTROL

- 2-Way Stop
- 4-Way Stop
- Signal
- Roundabout
- Grade Separation

SIGNAL TIMING

- Extend Yellow Phase
- Extend All Red
- Modify Cycle Length
- Consider Activated vs. Pretimed
- Protected Instead of Permissive Left Turn

MODIFY GEOMETRY

- Relocate Signal Mast Arms
- Add Turn Lanes
- Modify Alignment
- Increase/Decrease Curb Radius
- Evaluate Proximity of Curb Cuts to Signal
- Restrict/Modify Turning Movements
- Review Bicycle Striping

IMPROVE ROAD SURFACE

ENHANCE SIGHT LINES (ROADSIDE ELEMENTS)

- Vertical Curve
- Horizontal Curve
- Relocate Landscaping

EVALUATE INTERSECTION CONTROL MEASURE

- Relocate Signage
- Move Stop Bar Location

INCREASE ENFORCEMENT

- Camera
- Police

IMPROVE PEDESTRIAN/ADA ELEMENTS

- Ramps
- Pedestrian Crossing Signals
- Pedestrian Refuge
- Review Location of Bus Stops
- Review Markings

PROVIDE OR UPGRADE ILLUMINATION

Tool H – Compare and Test Alternatives

The purpose of this tool is to assess the full range of alternatives using the broad range of measures of success. The measures are "balanced" against one another to determine the best solution to meet project needs and objectives. The assessment process not only computes measures of success but also portrays the tradeoffs between measures, such as a reduced traffic level of service balanced against a corresponding increase in civic value associated with on-street parking.

The following steps are recommended in using this tool:

Summarize the assessment – Collapse the assessment to simple and appealing summary products, such as charts, tables, matrices and spreadsheets. Illustrations (photographs, sketches or even somewhat abstract computer graphics) should be used for those measures best described graphically.

Understand important tradeoffs – Illustrate the balance ("tradeoff") between important competing measures. One criterion should offset another, such as pairing vehicular traffic service and pedestrian level of service. Successful Smart Transportation understands these tradeoffs and achieves a balance of values that can gain community consensus.

Most important measures needing to be balanced are usually "apples and oranges," impossible to collapse to a single common measure. Although disparate measures cannot be directly compared in common terms, simply computing and comparing them represents an improvement under Smart Transportation. The "apples and oranges" dilemma is not a fault of the process, but more likely an indicator that a meaningful set of evaluation measures has been included.

Avoid weighting and scoring schemes – These are likely to be cumbersome and contentious. At this nearly final stage in the Smart Transportation planning process, participants' energy is far better directed toward arriving at a solution that addresses the wide range of project needs and objectives, rather than in creating numerical weighting schemes for disparate measures of success that do not lend themselves to such treatment.

Collaborate, not vote, on a recommended solution – Avoid putting the decision on a recommended solution to a vote, regardless of how representative the study group is of broad community viewpoints. Rather, informed consent or negotiated recommendation should be reached through a collaborative process. At this point a "third party" facilitator, skilled in consensus building, may be a valuable input.

Application

A successful outcome of this tool can be tested by asking the following questions:

- Have the agreed upon measures of success been used to compare and test the range of alternatives?
- Are the results summarized in a manner that is easily understood by a non-technical audience?
- Are the analyses repeatable by others?

2.3 TESTING THESE TOOLS AND TECHNIQUES

Use of the tools outlined in this document does not guarantee a context sensitive solution, but it greatly improves its likelihood because:

1. Smart Transportation brings a wide range of viewpoints into the process, assuring a thorough look at alternatives and success criteria.
2. The process reduces or eliminates adversarial counter-planning, by including issues at the very beginning that may be important to stakeholders and project opponents alike. The same energy which can serve to obstruct non-inclusive projects is channeled in a positive direction on Smart Transportation projects.
3. The analytical steps of the recommended process – broadened goals, structured search through alternatives and wide-ranging evaluation – serves as a systematic checklist for all stakeholders and decision-makers. It is also a transparent process that everyone can follow and in which everyone can participate.

A Local Commitment

On projects with NJDOT or PennDOT, the community partners with the state and has an essential role in planning state roadway projects. The community's input is needed on a number of tasks:

Planning the Community Vision

On some projects, the vision of the community for land uses adjacent to the roadway will be well established. However, the state will also become involved in projects where a new or reconfigured roadway may spur the community to create a new vision. In such cases, community discussions that include visioning workshops or charrettes should be held to foster a new plan. Local representatives should agree upon the land use plan for the study area, and clearly communicate that vision to the DOT. This must take place early in the study in order to determine the future land use context.

Committing to Improvement of the Roadway Network

Development of a network that effectively ties together all roadway classes – arterial, collector and local - is a key Smart Transportation strategy. The presence of a roadway network gives the state and community more flexibility if they coordinate on converting a state roadway into a Main Street, or any other traditional commercial street. Further, since neither state has the financial resources to eliminate congestion on all state highways, improving the network will give community residents more options on future trips.

The community should:

- Achieve greater connectivity by updating its official map and circulation plan to show desired links; and
- Consider regulations that require greater connectivity in future developments.

3.0

Smart Transportation should help in the development of smart growth communities. Following are the 10 principles of Smart Growth from the US EPA:

- *Create range of housing opportunities and choices*
- *Create walkable neighborhoods*
- *Encourage community and stakeholder collaboration*
- *Foster distinctive, attractive places with a strong sense of place*
- *Make development decisions predictable, fair and cost effective*
- *Mix land uses*
- *Preserve open space, farmland, natural beauty and critical environmental areas*
- *Provide a variety of transportation choices*
- *Strengthen and direct development towards existing communities*
- *Take advantage of compact building design*

The community can regulate:

- Block size, by setting a maximum block length of 300 to 600 ft.;
- Connectivity, by requiring developers to meet the connectivity ratios given in Section 5.2.2; and,
- Pedestrian/bicycle connections, by requiring these connections (even in developments with cul-de-sacs) every 300 to 600 ft.

Revising Comprehensive Plans and Ordinances

The community should:

- Encourage mixed use development, which reduces the number of trips on public streets, and gives community residents the opportunity to make walking trips;
- Control the rapid increase in traffic associated with large single-use developments;
- Change zoning as needed to ensure projects are built at good locations with the appropriate density. If a town is planning a Main Street, it should revise both its comprehensive plan and zoning ordinance to encourage center-based development.
- Prepare access management plans or ordinances to encourage or require shared driveways, cross access drives or frontage roads to reduce both turns and traffic on the public road.

Encouraging Alternative Transportation Modes

The community should:

- Require installation of sidewalks in developments as appropriate (see suggested guidelines in 8.1.1);
- Install sidewalks on "missing links," using federal, state and local funds;
- Develop a bike network plan, and install bike lanes, shoulders, or wide curb lanes on selected roadways according to plan and as opportunity permits;
- Encourage walking and biking through public education programs, such as "Safe Routes to School" and "Bicycle Rodeos" at schools.

CONNECTIVITY CODES

A growing number of municipalities are adopting "connectivity codes" as part of subdivsion and land development ordinances, requiring well-connected networks in new developments. Following are excerpts from two municipalities:

Beaverton, Oregon, *Development Code Chapter 60*
"In new residential, commercial, and mixed-use development, local street connections shall be spaced at intervals of no more than 530 feet as measured from near side right-of-way line, except where impractical due to physical or topographic constraints…Local street connections at intervals of no more than 330 feet shall be considered in areas planned for the highest density mixed-use development."

Cary, North Carolina, *Land Development Ordinance*
"Any residential development shall be required to achieve a connectivity index of 1.2 or greater unless the Planning Director determines that this requirement is impractical due to topography and/or natural features. In the event that this requirement is waived, a six-foot pedestrian trail shall be provided to link any cul-de-sacs within a residential development…"
Note: The measure of connectivity is the number of street links divided by the number of nodes.

Source: APA, *Planning for Street Connectivity*, Planning Advisory Service Report 515.

4.0

Land Use Context

Land use context and roadway type comprise the organizing framework for the selection of appropriate roadway design values. A context area is a land area comprising a unique combination of different land uses, architectural types, urban form, building density, roadways, and topography and other natural features. The existing and planned land use context should be defined on every project. The roadway design should be compatible with the existing land use context, or a planned land use context that reflects the community vision.

4.1 WHY CONTEXT MATTERS

Understanding the land use context provides guidance on who will need to use the road and how. This understanding influences the geometric design of the roadway and the types of amenities required in the right-of-way.

For this document, the design elements are organized into three general categories:

Desired Operating Speed: This is the speed at which it is intended that vehicles travel. The roadway context should play a large role in determining the desired operating speed. For example, pedestrian travel and the presence of civic uses and retail close to the street all suggest the need to use the lower range of the desired operating speed.

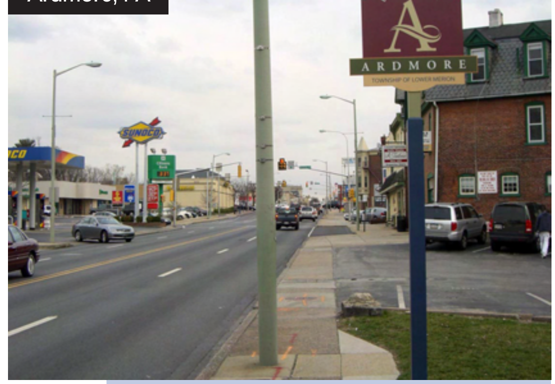
Roadway: The design team should select roadway elements and geometry with a clear understanding of surrounding land uses. For example, in urban areas the design team should always seek to provide parking lanes. Travel lanes are often narrower than in suburban areas, particularly if this enables the installation of bike lanes.

Roadside: The roadside primarily serves the pedestrian and the transit rider and provides a transition between public and private space. The design of the roadside elements should support the land use context. Civic uses such as schools and parks, and high density neighborhoods which generate higher pedestrian activity may require wider sidewalks.

A Tale of Two Contexts

Route 30, classified as a principal arterial, has a cross-section of four 10 ft. travel lanes in both Ardmore, PA, and Wayne, PA, as shown below. The speed limit on both roads is 25 mph. In a workshop for this guidebook, DVRPC stakeholders agreed that the Wayne town center is friendlier for pedestrians, identifying Route 30 in Wayne as "an example of an arterial roadway that has evolved to a village feeling." The difference? In Wayne, the presence of on-street parking and the traditional town center context (with zero building setbacks) results in more watchful motorists and creates a defined space for pedestrians. With sporadic on-street parking and with the greater prominence of parking lots, Ardmore is an example of a suburban center.

Ardmore, PA



Wayne, PA

4.2 DEFINING LAND USE CONTEXT

Seven context areas are described in the following section, from the least to the most developed: Rural, Suburban Neighborhood, Suburban Corridor, Suburban Center, Town/Village Neighborhood, Town Center, and Urban Core.

The context areas are illustrated in Figure 4.2. This drawing does not arrange the areas in order of intensity, but is an illustrative example of how these areas might fall across the land.

"Quantifiable characteristics," summarized in figure 4.3, are provided for each context. They are similar to what community planners refer to as "bulk standards," normally used to prescribe the desired appearance of land uses within a zoning district. Each land use context should be identified based upon this information.

In practice, land uses do not always fit neatly into the defined context areas, or the boundaries between context areas may be fluid. The planner or designer should use their best judgment in selecting the context that most closely matches the existing and proposed land uses.

It is recommended that contexts be broadly defined, avoiding segments less than 600 ft. in length. This is largely an issue of practicality. There is a limit on the number of different roadway cross-sections that can be implemented to respond to land use context within a small area.

1. Rural

This context area consists of a few houses and structures dotting a farm or forest landscape. The areas are predominantly natural wetlands, woodlands, meadow or cultivated land. Small markets, gas stations, diners, farm supplies, convenience grocers, etc. are often seen at the intersections of arterial or collector roads. Areas with a few commercial or civic uses and a number of homes close to the roadway can be placed into the sub-context type of "rural hamlet." Once the population of the settled area exceeds 250, it should be classified into the town/village context.

Examples include areas of Burlington and Gloucester Counties to the east, and Tioga and Jefferson Counties to the west.

2. Suburban Neighborhood

Predominantly low-density residential communities, many built since WWII. House lots are typically arranged along a curvilinear internal system of streets with limited connections to regional road network or surrounding streets. Lot sizes are usually two acres to one-quarter acre, but in older suburbs, it is common to find one-eighth acre lots. Garden apartments are also included in this type. Neighborhoods can include community facilities such as schools, churches, recreational facilities, and some stores and offices. When suburban houses line an arterial roadway but have their primary access to frontage roads or rear access roads, it is possible to classify this area as a "suburban corridor."

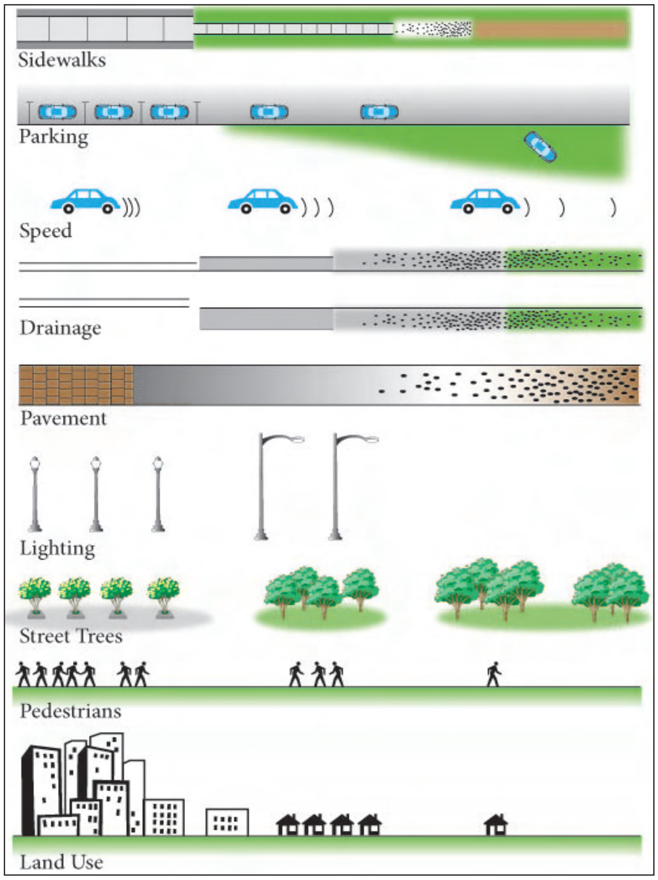


Figure 4.1 From Urban to Rural. As intensity and mix of uses along a roadway increase, there is a greater need to accommodate and prioritize other modes of travel, including bicyclists, pedestrians, and transit riders.

Figure 4.2 The Seven Land Use Contexts

3. Suburban Corridor

This area is characterized by big box stores, commercial strip centers, restaurants, auto dealerships, office parks, and gas stations. These uses are sometimes interspersed with natural areas and occasional clusters of homes. Buildings are usually set back from the roadway behind surface parking. Office buildings are usually set back a bit more than adjacent retail frontage to establish garden separation from ground windows.

These areas are found along many arterial roadways, such as Route 38 in Cherry Hill and Route 611 north of Philadelphia.

4. Suburban Center

Often a mixed-use, cohesive collection of land uses that may include residential, office, retail, and restaurant uses where commercial uses serve surrounding neighborhoods. These areas are typically designed to be accessible by car, and may include large parking areas and garages.

They are less accommodating to pedestrians than town centers, and opportunities to cross the primary roadway can be limited. On-street parking may or may not be provided.

Examples include Lancaster Avenue in Ardmore, PA, and Montgomery Avenue in Bryn Mawr, PA.

5. Town/Village Neighborhood

Predominantly residential neighborhoods, sometimes mixed with retail, restaurants and offices. In urban places, residential buildings tend to be close to the street. Rowhouses fronting the sidewalk, and houses back 30 feet behind a front lawn are both common types. Small retail establisments sometimes occupy principal corners. Block sizes are regular and often small in comparison to suburban neighborhood blocks. Even where streets are narrow, on-street parking is common and typically well used. The large majority of neighborhoods have sidewalks.

Existing examples include Fairview in Camden and Society Hill in Philadelphia.

Figure 4.3 Defining Contexts

	RURAL	SUBURBAN			URBAN		
	Rural	Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town Center	Urban Core
Density Units	1 DU/20 ac	1 DU/ac - 8DU/ac	2 - 30 DU/ac	3 - 20 DU/ac	4 - 30 DU/ac	8 - 50 DU/ac	16 - 75 DU/ac
Building Coverage	NA	< 20%	20% - 35%	35% - 45%	35% - 50%	50% - 70%	70% - 100%
Lot Size/Area	20 acres	5,000 - 80,000 sf	20,000 - 200,000 sf	25,000 - 100,000 sf	2,000 - 12,000 sf	2,000 - 20,000 sf	25,000 - 100,000 sf
Lot Frontage	NA	50 to 200 feet	100 to 500 feet	100 to 300 feet	18 to 50 feet	25 to 200 feet	100 to 300 feet
Block Dimensions	NA	400 wide x varies	200 wide x varies	300 wide by varies	200 by 400 ft	200 by 400 ft	200 by 400 ft
Max. Height	1 to 3 stories	1.5 to 3 stories	retail -1 story; office 3-5 stories	2 to 5 stories	2 to 5 stories	1 to 3 stories	3 to 60 stories
Min./Max. Setback	Varies	20 to 80 feet	20 to 80 ft	20 to 80 ft	10 to 20 ft	0 to 20 ft	0 to 20 ft

6. *Town/Village Center*

A mixed use, high density area with buildings adjacent to the sidewalk, typically two to four stories tall with commercial operations on the ground floor and offices or residences above. Parallel parking usually occupies both sides of the street with parking lots behind the buildings. Important public buildings, such as the town hall or library, are provided special prominence.

Places like Haddon Avenue in Collingswood and State and Main Streets in Doylestown are classic "Main street" town centers.

7. *Urban Core*

Downtown areas consisting of blocks of higher density, mixed use buildings. Buildings vary in height from 3 to 60+ stories with most buildings dating from an era when elevators were new technology - so five to twelve stories were the standard.

Examples are Trenton's Downtown and Center City Philadelphia.

4.3 PLANNING FUTURE CONTEXT AREAS

The planned land use context along the corridor is assessed by consulting the following plans and documents:

- Municipal comprehensive plan (referred to as master plan in New Jersey)
- Multi-municipal or regional comprehensive plan (applicable in Pennsylvania)
- Zoning ordinance
- Redevelopment plan (if applicable)
- State Plan designation (applicable in New Jersey)

As part of the collaboration between state and community, the study team consults with local stakeholders on the vision for their community. If no vision exists, a workshop or charrette can be held to help crystallize the community vision.

5.0

Transportation Context

The transportation context consists of the role that the roadway plays, or is anticipated to play within the local community and the larger region. It also refers to the supporting street network, and the interaction of the roadway with that network.

5.1 ROADWAY TYPE

A new roadway typology is proposed for the Guidebook in order to design roadways that better reflect their role in the community and the larger transportation network.

Currently, every roadway owned by NJDOT or PennDOT, or by county governments in New Jersey, is assigned a functional classification consistent with the AASHTO Green Book:

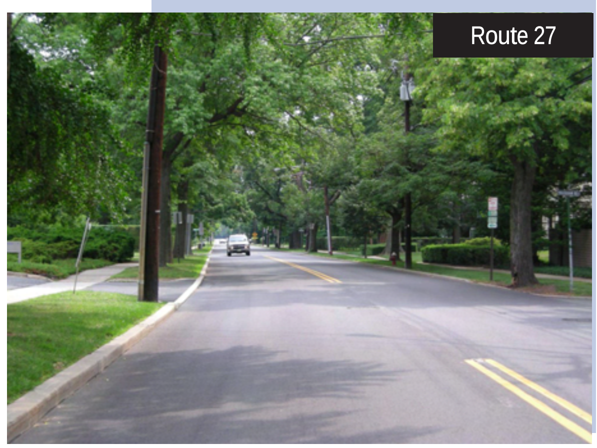
- Principal Arterial
- Minor Arterial
- Collector (subdivided into major collector and minor collector within rural areas)
- Local

A problem with the existing functional classification system is that an entire highway is sometimes placed into a certain class based on select characteristics – such as the overall highway length, or traffic volumes – although its level of access and mobility are not consistent with other roadways in that class. For example, many state highways are classified as principal arterials even if they are far more vital to community access than to regional mobility. This creates a dilemma for highway designers: the application of design standards for that class may encourage higher operating speeds than are appropriate for segments serving community access.

To address this issue, a roadway typology is proposed which better captures the role of the roadway within the community. It focuses more narrowly on the characteristics of access, mobility and speed. If a segment of an arterial roadway has a relatively low speed, is important to community access, and has a lower average trip length, it should not be designed like a high order arterial. Further, under this approach, roadways

Routes 1 and 27 in Central New Jersey (below) are both classified as principal arterials in traditional functional classification, but they have very different roles within the roadway network. This chapter proposes a new roadway typology to better capture the role of roadways in a community.

Route 1



Route 27

are segmented to a greater degree than traditional functional classification. If one segment of a roadway has low average trip lengths and has consistently lower speeds, its design should be different than another section which carries long trips.

The roadway typology is presented in Table 5.1 and illustrated in Figure 5.1. It should be emphasized that this should be used only as a planning and design "overlay" for individual projects, and does not replace the traditional functional classification system used in both states. The roadway classes shown in Table 5.1 correspond to the classifications of arterial, collector and local as described in the 2001 AASHTO Green Book. Their design values should likewise correspond to the design guidelines provided in the Green Book.

Different state highways have different community roles, and the Guidebook recommends that this should be reflected in the design. Some state highways, such as NJ Route 1, will be considered as a Regional Arterial because of their importance to regional mobility. On the other hand, Route 27, which is classified as a principal arterial by NJDOT, actually operates more like a community arterial or a community collector. Parallel to Route 1 and the New Jersey Turnpike, this highway has a low average trip length. Maintaining regional mobility becomes a smaller concern on Route 27 and similar state roadways.

Whatever the road classification, traffic mobility and safety are important goals on state highways, and must be considered on all roadway projects. These goals will continue to receive significant attention on roads with acute safety or congestion problems. Mobility and safety goals are balanced with local development goals on projects.

PennDOT owns many roads in Pennsylvania, from arterials down through local roads. NJDOT controls a much smaller share of the road network, and virtually all of its roadways are arterials. Because of the relatively high volumes found on many NJDOT roadways, the maintenance of mobility on regional arterials remains a strong emphasis.

5.1.1 Main Street

Although not one of the Smart Transportation roadway categories, the concept of Main Street has an important place in Smart Transportation. Anchoring the center of a town, village or city, the Main Street is characterized by:

- Wide sidewalks and regular pedestrian activity;
- Mostly commercial and civic uses, with residential uses primarily found on the upper level of buildings;
- High building density;
- Buildings oriented to the street, with little or no building setbacks;
- Street furniture and public art;
- Heavy use of on-street parking;
- Speeds of 30 mph or less;
- Preferably no more than two travel lanes, although three to four lanes are seen on occasion.

Table 5.1 Roadway Categories

Roadway Class	Roadway Type	Desired Operating Speed (mph)	Average Trip Length (mi)	Volume	Intersection Spacing (ft)	Comments
Arterial	Regional	30-55	15-35	10,000-40,000	660-1,320	Roadways in this category would be considered "Principal Arterial" in traditional functional classification.
Arterial	Community	25-55	7-25	5,000-25,000	300-1,320	Often classified as "Minor Arterial" in traditional classification but may include road segments classified as "Principal Arterial."
Collector	Community	25-55	5-10	5,000-15,000	300-660	Often similar in appearance to a community arterial. Typically classified as "Major Collector."
Collector	Neighborhood	25-35	<7	<6,000	300-660	Similar in appearance to local roadways. Typically classified as "Minor Collector."
Local	Local	20-30	<5	<3,000	200-660	

Route 27, Kingston

Route 27, Princeton

The Main Street would typically belong to the Community Arterial road type, or to the Collector road type. This is the case on Route 27 in New Jersey; this roadway hosts two Main Street segments between New Brunswick and Trenton, in the towns of Princeton and Kingston. As defined here, a municipality can have more than one Main Street.

Main Streets are desirable in Smart Transportation because they support more sustainable communities, and because of their potential to increase walking, biking and transit use, as well as vehicular trip chaining.

For information on planning Main Streets, see Section 6.2.1.

5.2 ROADWAY NETWORK

Network design establishes critical parameters for roadway design—type of roadway, its general purpose (i.e., what type of traffic it is to handle) and number of lanes necessary to achieve the purpose. By increasing the options of motorists to travel from one point to another, a well-connected regional network permits greater flexibility in designing individual roadways. Improving roadway connectivity can serve regional mobility equally well as widening major roadways, and a well-connected network always serves the needs of pedestrians and bicyclists better than simply widening arterial roadways.

Because network connectivity is so important in Smart Transportation Solutions, it appears as a recurring theme in this guidebook. Network types, basic principles, and evaluating and creating a network are discussed in this section and in Chapter 3, "A Local Commitment."

5.2.1 Network types

The traditional urban grid has short blocks, straight streets, and a crosshatched pattern (Figure 5.2). The typical contemporary suburban street network has large blocks, curving streets, and a branching pattern (Figure 5.3). The two networks differ in three respects: (1) block size, (2) degree of curvature, and (3) degree of interconnectivity.

Both network designs have advantages and disadvantages. Traditional grids disperse traffic rather than concentrating it at a handful of intersections. They offer more direct routes and hence generate fewer vehicle miles of travel (VMT) than do contemporary networks. By offering many different routes to a destination, they better meet the needs of local motorists. They encourage walking and biking with their direct routing and their options for travel. Grids are also more transit-friendly; transit ridership is greatest between tracts that have relatively direct transit connections.[3]

Contemporary networks do have some advantages, such as the ability to lessen traffic on local residential streets. With their curves and dead ends, contemporary networks can go around or stop short of valuable natural areas.

Traditional grids best fulfill Smart Transportation goals, and are recommended for application in most areas.

5.2.2 Evaluation of the network

All roadway networks should be evaluated using the measures on internal connectivity, external connectivity, and route directness.

RURAL ——— to ———

Rural Places	Suburban Neighborhood	Suburban Corridor	Suburban Center

Figure 5.1 Roads in Context

URBAN

REGIONAL to LOCAL

	Town/Village Neighborhood	Town Center	Urban Core
Regional Arterial			
Community Arterial			
Community Collector			
Neighborhood Collector			
Local Road/ Street			

The photos enclosed in a yellow box indicate the Town Center and Core City streets that also operate as a local or regional Main Street.

Internal Connectivity. *Use either of the following two measures:*

- **Beta Index** — This is equal to the number of street links divided by the number of nodes or link ends. A higher ratio indicates higher street connectivity. When applied to the developments shown in Figures 5.2 and 5.3, Apalachicola is rated 1.69, and Haile Plantation is rated 1.19. Traditional developments generally rate above 1.4. [4]
- **Intersections per square mile** — Strict grid systems have about 25 intersections per square mile, while conventional branching systems have about one-third to one-half that many. [5]

External Connectivity

- All neighborhoods in the community should be connected to the larger street system at least every ¼ mile.

Route Directness

- This measures the distance a pedestrian would walk between two points compared to the straight line (or radial) distance between the same two points. The closer the ratio is to 1.0, the more direct the route; route directness values of 1.2-1.5 describe reasonably connected walkable networks.[6]

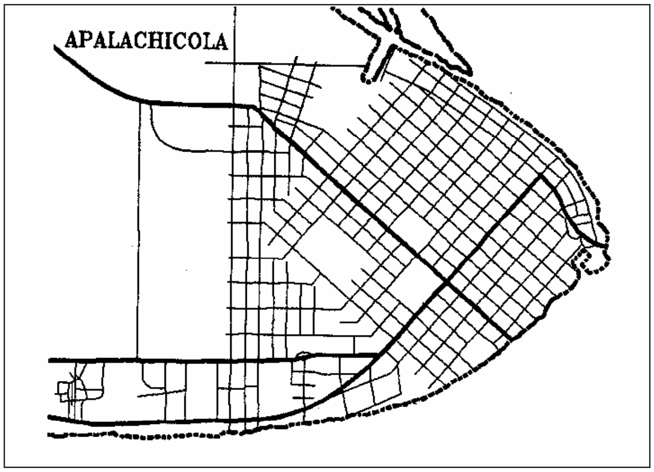
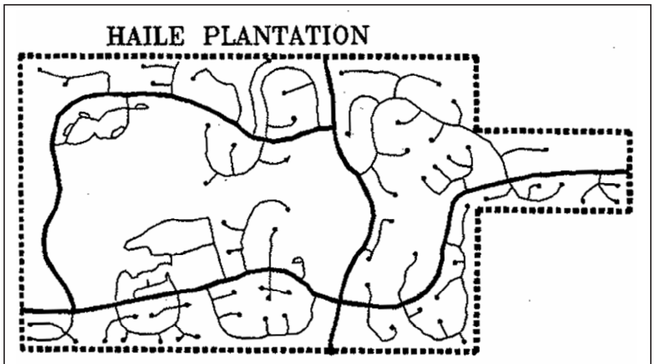


Figure 5.2. Traditional Urban Grid



Source: Ewing (1996)

Figure 5.3. Contemporary Branching Network

5.3 CREATING EFFICIENT NETWORKS

In Smart Transportation, network evaluation becomes a critical task anytime existing or projected traffic congestion is identified as a potential issue on projects. The role of the network differs somewhat for projects in built-out areas versus newly developing areas.

5.3.1 Existing and Built-out Areas

In a built-out area, can the network be improved such that local traffic can use local streets to a greater degree? It should be determined how much traffic can be removed from regional roadways if the local and collector system is made to work more effectively. The network should be evaluated using measures of internal connectivity, external connectivity, and pedestrian route directness, described in Section 5.2.2.

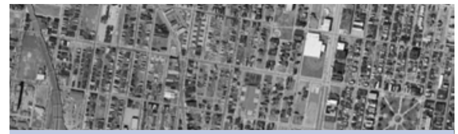
If improving the network will not address the problem or is not an option, the two primary choices are to widen the roadway or to build a parallel roadway.

Roadway widening

The planner should first determine if segment improvements, access management, or intersection changes will address the problem, and then consider mainline widening. Widening should be done only if the resulting roadway is compatible with the land use context. Planners should identify the existing roadway role, its consistency with the community vision, and whether an alternative roadway type would better support the community.

Parallel roadway

If a parallel roadway is necessary, the planner should consider development of a regional or community arterial. It should be consistent with an area network plan, and be tied in where possible to the existing road system. This would improve the effectiveness of this road link.



5.3.2 Creating a Road Framework for New Development

A newly developing area offers the opportunity to implement a highly connected street system with less reliance on multi-lane arterials. Following are guidelines to be used in laying out a context sensitive roadway network capable of providing safe, multimodal choices for all trips. Initial planning should identify higher order roads needed for ultimate build-out; local roads and neighborhood collectors should then be included, depending upon specific developments proposed.

Network Configuration – Areawide

- Arterial roadways should be continuous and networked in generally rectilinear form with spacing of ½ to 1 mile in suburban contexts and ¼ to ½ mile in urban contexts. Closer spacing may be needed depending on activity levels and through movements.
- Collectors may be spaced at 1/8 mile intervals, if needed.
- Urban cores and town centers should be connected by community arterials and community collectors. These roadways should have the area's highest level transit service.
- Collectors should link neighborhood centers with adjacent neighborhood centers and town centers. All such connectors should be able to accommodate transit service.
- Major roadways that are to serve as major truck routes or primary through traffic routes should avoid the centers of urban areas or neighborhoods wherever possible. Community arterials and community collectors may be designated local truck routes to reach clusters of commercial uses in centers or cores.
- Sketch planning demand estimation or travel forecasting models should be used to estimate the density/spacing and capacity needs for major roadways beyond the minimum spacing described above.

Spacing

- Irrespective of thoroughfare spacing, pedestrian facilities should be well networked. In suburban contexts, block sizes of no more than 600 feet on a side with a maximum area of 7 acres will provide a reasonable level of connectivity.[7] In urban contexts, block sizes of 300 to 400 feet with a maximum area of 3-4 acres are ideal.
- Where streets cannot be connected, provide bike and pedestrian connections at cul-de-sac heads or midblock locations as a second-best solution to accessibility needs. Recommended maximum spacing is 330 ft.
- Bicycle-compatible roadways should comprise a bicycle network of parallel routes with effective spacing of ½ mile.

5.3.3 Network principles

All new networks should be evaluated using the measures on connectivity in Section 5.2.

Route 63, a principal arterial highway, runs through Harleysville, PA (top) and Lansdale, PA (bottom). Harleysville lies six miles northwest of Lansdale, with I-476 passing between the two municipalities. Motorists on Route 63 in Harleysville have an average trip length of 30 miles, much longer than the 10 mile average trip length of motorists found on Route 63 in Lansdale. Motorists commuting from the north prefer to take I-476 into Philadelphia, and avoid driving through Lansdale. Further, Route 63 in Lansdale serves as that borough's main street. The highway thus serves a different role in these two municipalities.

5.4 SIGNAL SPACING

Recommended signal spacing corresponds to the optimal spacing of arterial, collector and local streets (Table 5.2), although signals should be installed only where warranted.

Signal spacing of 300 ft. on arterials and collectors can be an important strategy in complementing traditional grid networks where low traffic speeds and high pedestrian activity are desired. On roadways in traditional urban contexts where regular cross traffic flows can be accommodated by stop-controlled intersections, signal spacing of 500 to 660 ft. on arterials and collectors may be sought.

On lower order suburban roadways, spacing of 660 ft. (1/8 mile) permits safe pedestrian crossings at the upper boundary of desirable block lengths. Signal spacing of 1320 ft. (1/4 mile) begins to permit the speed progression sought by NJDOT or PennDOT on those corridors where traffic flow is a priority.

The spacing of traffic signals has a major influence on roadway operating speeds and capacity. Studies have found that a four lane divided arterial roadway with signal spacing of 2640 ft. carries the same amount of traffic as a six lane arterial with signals spaced at 1320 ft.[8] Neither situation is optimal for pedestrians. On the one hand, narrower roadways are more amenable to pedestrian crossings. On the other hand, wider signal spacing reduces the opportunities for pedestrians to cross roadways at controlled locations. Further, motorists who desire to turn left onto an undivided major roadway may be tempted to access it at a Stop-controlled crossing, rather than traveling farther out of their way to access the roadway at a signal. On higher-order roadways where major pedestrian generators straddle the corridor, the best choice is sometimes smaller signal spacing and acceptance of a lower progression speed.

Table 5.2. Recommended Signal Spacing

	Urban Contexts	Suburban Contexts	Rural Contexts
Regional Arterial	660 to 1320 ft.	1320 to 1540 ft.	1980 ft.
Community Arterial	300 ft. to 1100 ft.	1320 ft.	1540 ft.
Community Collector	300 to 660 ft.	660 to 1320 ft.	1540 ft.

6.0 Designing the Roadway

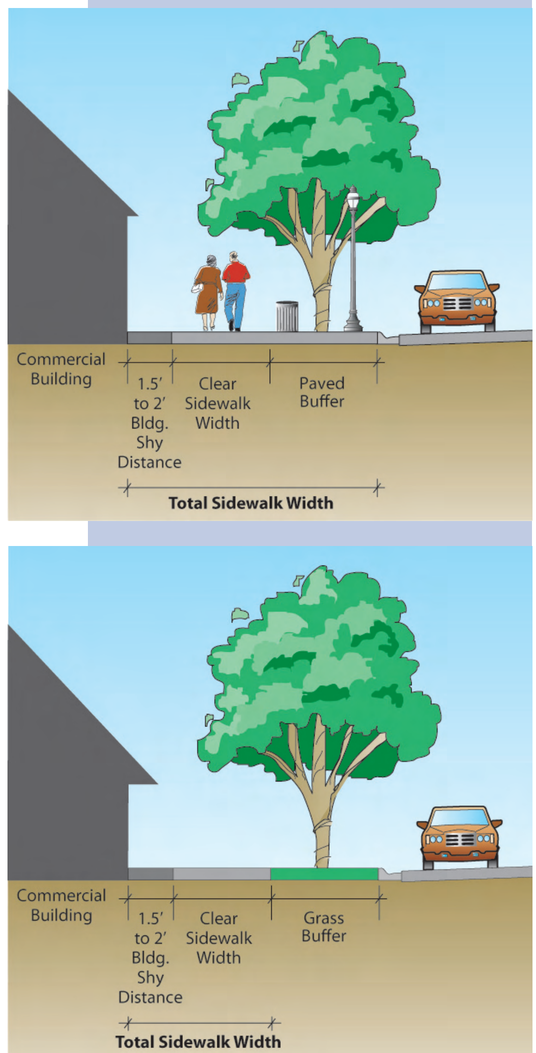
6.1 SELECTING DESIGN VALUES

Once the desired land use context and roadway types are established, the roadway design should begin to be assembled. This section contains the Matrix of recommended design values, cross-referenced by land use context and design element.

6.1.1 Roadway

- **Lane Width** — The width depends on roadway type, context area, bus and freight activity, and whether bicycle activity is to be accommodated in the absence of a bike lane. Dimensions for wide curb lanes, an option for accommodating bicyclists, are shown in the Matrix along with standard lane widths. See Section 7.1.
- **Parking Lane** — On-street parking is desirable on most urban and many suburban roadways where desired operating speeds are 35 mph or lower. Parking should be provided on both sides of streets in traditional business districts, and on at least one side of residential areas. See Section 7.2.
- **Shoulder Width** — Shoulders should be considered for rural and suburban contexts. In urban areas, paved shoulders should be employed only as part of retrofits, to narrow existing wide travel lanes and accommodate bicyclists if bike lanes are not optimal. See Section 7.3.
- **Bike Lane** — Bike lanes may be a desirable addition on all but local and high-speed roads. The decision to install bike lanes should stem from a comprehensive bike plan. See Section 7.4.
- **Median** — Medians can improve access control along arterial and collector roadways and provide refuge for pedestrians at crossings. See Section 7.5.
- **Travel Lanes** — The number of travel lanes is selected based on the balance of providing capacity versus enhancing the roadside. This is determined as part of the broader planning effort.

Figure 6.1 Total Sidewalk Width



6.1.2 Roadside

- **Clear Sidewalk Width** — The width of the sidewalk available for walking. This is the most essential component of the roadside. See Section 8.1 for more details on this element.
- **Buffer** — In suburban areas, this refers to the planted strip between the curb and sidewalk; in urban contexts, this refers to the part of the sidewalk adjacent to the curb that accommodates street furniture and opening car doors. See Section 8.3, Landscape Design, and Section 8.4, Street Furniture for more details.
- **Shy Distance** — The area along sidewalks closest to buildings, fences, plantings and other structures generally avoided by pedestrians. This is only applicable in urban contexts, where a zero building setback is common.
- **Total Sidewalk Width** — The total width of the sidewalk on one side of the street. In urban contexts, it is derived by adding together clear sidewalk width, buffer, and shy distance. In suburban contexts, the buffer is composed of a planted area, and there is typically an ample building setback (and thus no "shy distance" dimension). The total sidewalk width thus repeats the dimension for the clear sidewalk width.

6.1.3 Speed

See Section 6.4 for the discussion on planning the desired operating speed.

6.1.4. Priority of elements

The Matrix lists all elements that would normally comprise the cross-section of a roadway. No roadway should have all of these elements. For example, when a roadway is provided with a bike lane, it would not have a shoulder, and vice-versa. A suburban roadway with a shoulder would not have a parking lane. Table 6.1 summarizes the desirability of key cross-section elements on each roadway type.

Table 6.1 Cross-Section Elements

	Paved Shoulder	Parking Lane	Bike Lane	Median (physical or two-way left turn lane)	Sidewalk*
Regional Arterial	Recommended for rural, suburban corridor, suburban neighborhood contexts	Evaluate for urban contexts	Evaluate for suburban center and urban contexts	Recommended for multi-lane roads; evaluate on other roads	Recommended for urban contexts; recommended for suburban contexts as appropriate
Community Arterial	Recommended for rural, suburban corridor, suburban neighborhood contexts	Recommended for urban contexts; evaluate for suburban center, suburban neighborhood contexts	Evaluate for suburban and urban contexts	Recommended for multi-lane roads; evaluate on other roads	Recommended for urban contexts; recommended for suburban contexts as appropriate
Community Collector	Recommended for rural and suburban corridor contexts; evaluate for suburban neighborhood	Recommended for urban, suburban center contexts; evaluate for suburban neighborhood	Evaluate for suburban and urban contexts	Recommended for multi-lane roads	Recommended for urban contexts; recommended for suburban contexts as appropriate
Neighbor-hood Collector	Recommended for rural, suburban corridor contexts	Recommended for urban, suburban center, suburban neighborhood contexts	Evaluate for suburban and urban contexts	Consider primarily for aesthetic enhancement	Recommended for urban contexts; recommended for suburban contexts as appropriate
Local	Evaluate for rural contexts	Recommended for urban, suburban center, suburban neighborhood contexts	Typically not needed	Consider for aesthetic enhancement only	Recommended for urban contexts; recommended for suburban contexts as appropriate

**Sidewalks are recommended as part of State and Federally funded roadway projects in suburban contexts unless one or more of the following conditions is met:*

- *pedestrians are prohibited by law from using the roadway*
- *the cost of installing sidewalks would be excessively disproportionate to the need or probable use.*
- *sparsity of population or other factors indicate an absence of need.*

Table 6.2 Matrix of Design Values

	Regional Arterial	Rural	Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core
Roadway	Lane Width[1]	11' to 12'	11' to 12' (14' to 15' outside lane if no shoulder or bike lane)	11' to 12' (14' to 15' outside lane if no shoulder or bike lane)	11' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)
	Paved Shoulder Width[2]	8' to 10'	8' to 10'	8' to 12'	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)
	Parking Lane[3]	NA	NA	NA	8' parallel	8' parallel; see 7.2 for angled	8' parallel; see 7.2 for angled	8' parallel
	Bike Lane	NA	5' to 6' (if no shoulder)	6' (if no shoulder)	5' to 6'	5' to 6'	5' to 6'	5' to 6'
	Median	4' to 6'	16' to 18' for LT; 6' to 8' for pedestrians only	16' to 18' for LT; 6' to 8' for pedestrians only	16' to 18' for LT; 6' to 8' for pedestrians only	16' to 18' for LT; 6' to 8' for pedestrians only	16' to 18' for LT; 6' to 8' for pedestrians only	16' to 18' for LT; 6' to 8' for pedestrians only
	Curb Return	30' to 50'	25' to 35'	30' to 50'	25' to 50'	15' to 40'	15' to 40'	15' to 40'
	Travel Lanes	2 to 6	2 to 6	4 to 6	4 to 6	2 to 4	2 to 4	2 to 6
Roadside	Clear Sidewalk Width	NA	5'	5' to 6'	5' to 6'	6' to 8'	6' to 10'	6' to 12'
	Buffer[4]	NA	6'+	6' to 10'	4' to 6'	4' to 6'	4' to 6'	4' to 6'
	Shy Distance	NA	NA	NA	0' to 2'	0' to 2'	2'	2'
	Total Sidewalk Width	NA	5'	5' to 6'	9' to 14'	10' to 16'	12' to 18'	12' to 20'
Speed	Desired Operating Speed	45-55	35-40	35-55	30-35	30-35	30-35	30-35

1 12' preferred for regular transit routes, and heavy truck volumes > 5%, particularly for speeds of 35 mph or greater.
2 Shoulders should only be installed in urban contexts as a retrofit of wide travel lanes to accommodate bicyclists.
3 Buffer is assumed to be planted area (grass, shrubs and/or trees) for suburban neighborhood and corridor contexts; street furniture/car door zone for other land use contexts. Min. of 6' for transit zones.
4 Curb return radius should be as small as possible. Number of lanes, on street parking, bike lanes, and shoulders should be utilized to determine effective radius.

	Community Arterial	Rural	Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core
Roadway	Lane Width[1]	11' to 12'	10' to 12' (14' outside lane if no shoulder or bike lane)	11' to 12' (14' to 15' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)
	Paved Shoulder Width[2]	8' to 10'	4' to 8' if no parking	8' to 10'	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)
	Parking Lane[3]	NA	7' to 8' parallel	NA	8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled
	Bike Lane	NA	5' to 6' (if no shoulder)	5' to 6' (if no shoulder)	5' to 6'	5' to 6'	5' to 6'	5' to 6'
	Median	4' to 6'	12 to 18; for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians only
	Curb Return	25' to 50'	25' to 35'	25' to 50'	20' to 40'	15' to 30'	15' to 35'	15' to 40'
	Travel Lanes	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4
Roadside	Clear Sidewalk Width	NA	5'	5' to 6'	6'	6' to 8'	6' to 10'	8' to 14'
	Buffer[4]	NA	6'+	5' to 10'	4' to 6'	4' to 6'	4' to 6'	4' to 6'
	Shy Distance	NA	NA	NA	0' to 2'	0' to 2'	2'	2'
	Total Sidewalk Width	NA	5'	5' to 6'	10' to 14'	10' to 16'	12' to 18'	14' to 22'
Speed	Desired Operating Speed	35-55	30-35	35-50	30	25-30	25-30	25-30

1 12' preferred for reguar transit routes, and heavy truck volumes > 5%, particularly for speeds of 35 mph or greater.
2 Shoulders should be installed in urban contexts only as part of a retrofit of wide travel lanes, to accommodate bicyclists.
3 7' parking lanes on this roadway type to be considered in appropriate conditions.
4 Buffer is assumed to be planted area (grass, shrubs and/or trees) for suburban neighborhood and corridor contexts; street furniture/car door zone for other land use contexts. Min. of 6' for transit zones.

Sources for values in matrix: AASHTO Green Book (2001), and ITE "Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities" (2006).

	Community Collector	Rural	Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core
Roadway	Lane Width[1]	11' to 12'	10' to 12'	11' to 12'	10' to 11' with bike lanes; w/o bike lanes or shoulder, 14' for bike routes	10' to 11' with bike lanes; w/o bike lanes or shoulder, 14' for bike routes	10' to 11' with bike lanes; w/o bike lanes or shoulder, 14' for bike routes	10' to 11' with bike lanes; w/o bike lanes or shoulder, 14' for bike routes
	Paved Shoulder Width[2]	4' to 8'	4' to 8' if no parking or bike lane	8' to 10'	4' to 6' (if no parking or bike lane)	4' (if no parking or bike lane)	4' (if no parking or bike lane)	4' (if no parking or bike lane)
	Parking Lane	NA	7'	NA	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled
	Bike Lane	NA	5'	5' to 6'	5' to 6'	5' to 6'	5' to 6'	5' to 6'
	Median	NA	12 to 16 for LT; 6' for pedestrians only	12 to 16 for LT; 6' for pedestrians only	12 to 16 for LT; 6' for pedestrians only	12 to 16 for LT; 6' for pedestrians only	12 to 16 for LT; 6' for pedestrians only	12 to 16 for LT; 6' for pedestrians only
	Curb Return	20' to 40'	15' to 35'	20' to 40'	20' to 35'	10' to 25'	10' to 25'	10' to 30'
	Travel Lanes	2	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4
Roadside	Clear Sidewalk Width	NA	4' to 5'	5' to 6'	6' to 8'	5' to 6'	6' to 8'	6' to 10'
	Buffer[3]	NA	5'+	5' to 10'	4' to 5'	4' to 5'	4' to 5'	4' to 6'
	Shy Distance	NA	NA	NA	0' to 2'	0' to 2'	2'	2'
	Total Sidewalk Width	NA	4' to 5'	5' to 6'	10' to 15'	9' to 13'	12' to 15'	12' to 18'
Speed	Desired Operating Speed	35-55	25-30	30-35	25-30	25-30	25-30	25-30

1 11' to 12' preferred for heavy truck volumes > 5% and regular transit routes.
2 Shoulders should be installed in urban contexts only as part of a retrofit of wide travel lanes, to accommodate bicyclists.
3 Buffer is assumed to be planted area (grass, shrubs and/or trees) for suburban neighborhood and corridor contexts.

	Neighborhood Collector	Rural	Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core
Roadway	Lane Width[1]	10' to 11'	10' to 11'	NA	NA	9' to 11' with bike lanes; w/o bike lanes or shoulder, 12' to 14' for bike routes	9' to 11' with bike lanes; w/o bike lanes or shoulder, 12' to 14' for bike routes	9' to 11' with bike lanes; w/o bike lanes or shoulder, 12' to 14' for bike routes
	Paved Shoulder Width[2]	4' to 8'	4' to 8' if no parking or bike lane	NA	NA	NA	NA	NA
	Parking Lane	NA	7' parallel	NA	NA	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled
	Bike Lane	NA	5'	NA	NA	5'	5'	5'
	Median	NA	8' to 10' landscaping; 6' - 8' for peds	NA	NA	8' to 10' landscaping; 6' - 8' for peds	8' to 10' landscaping; 6' - 8' for peds	8' to 10' landscaping; 6' - 8' for peds
	Curb Return	15' to 35'	15' to 35'	NA	NA	10' to 25'	10' to 25'	10' to 25'
	Travel Lanes	2	2	NA	NA	2	2	2
Roadside	Clear Sidewalk Width	NA	4' to 5'	NA	NA	5' to 6'	6'	6' to 8'
	Buffer[3]	NA	4'+	NA	NA	3' to 5'	3' to 5'	4' to 6'
	Shy Distance	NA	NA	NA	NA	0' to 2'	2'	2'
	Total Sidewalk Width	NA	4' to 5'	NA	NA	8' to 13'	11' to 13'	12' to 16'
Speed	Desired Operating Speed	20 to 35	25-30	NA	NA	25-30	25-30	25-30

1 11' to 12' preferred for heavy truck volumes > 5% and regular transit routes.
2 Shoulders should be installed in urban contexts only as part of a retrofit of wide travel lanes, to accommodate bicyclists.
3 Buffer is assumed to be planted area (grass, shrubs and/or trees) for suburban neighborhood and corridor contexts.

	Local Road	Rural	Suburban Neigh-borhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core
Roadway	Lane Width [1]	9' to 11'	See roadway width	NA	NA	See roadway width	9' to 11'	9' to 11' with bike lanes; w/o bike lanes or shoulder, 12' to 14' for bike routes
Roadway	Roadway Width [2]	See lane and shoulder width	Wide: 34' to 36' Medium: 30' Narrow: 26' Skinny: 20'	NA	NA	Wide: 34' to 36' Medium: 30' Narrow: 26' Skinny: 20'	See lane and parking width	See lane and parking width
Roadway	Paved Shoulder Width	2' to 8'	NA	NA	NA	NA	NA	NA
Roadway	Parking Lane	NA	See roadway width	NA	NA	See roadway width	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled
Roadway	Bike Lane	NA	NA	NA	NA	NA	NA	NA
Roadway	Median	NA	NA	NA	NA	NA	NA	NA
Roadway	Curb Return	10' to 25'	10' to 25'	NA	NA	5' to 25'	5' to 25'	5' to 25'
Roadway	Travel Lanes	2	2	NA	NA	2	2	2
Roadside	Clear Sidewalk Width	NA	4' to 5'	NA	NA	5'	5' to 6'	6' to 8'
Roadside	Buffer [3]	NA	4'+	NA	NA	3' to 5'	3' to 5'	3' to 5'
Roadside	Shy Distance	NA	NA	NA	NA	0' to 2'	2'	2'
Roadside	Total Sidewalk Width	NA	4' to 5'	NA	NA	8' to 12'	10' to 13'	11' to 15'
Speed	Desired Operating Speed	20 to 30	20 to 25	NA	NA	20 to 25	20 to 25	20 to 25

1 11' to 12' recommended for industrial districts.

2 Index to residential streets:
Wide: High-density neighborhoods, two-way, parking both sides
Medium: Can be used in all neighborhoods-two-way, parking both sides
Narrow: Low-density and medium density - two-way, parking both sides; all neighborhoods - one-way street, parking both sides, or two-way, parking one side
Skinny: All neighborhoods - one-way, parking one side; two-way, no parking

Low-density - less than or equal to 4 dwelling units/acre.
Medium-density - >4, and less than or equal to 8 units/acre.
High-density - >8 units/acre.

3 Buffer is assumed to be planted area (grass, shrubs and/or trees) for suburban neighborhood and corridor contexts; street furniture/car door zone for other land use contexts.

Route 73 in Burlington County is the prototypical regional arterial in a suburban setting, with divided median and wide shoulders.

Torresdale Avenue in Philadelphia, which functions as a community collector in an urban area, has 11 ft. travel lanes, 5 ft. bike lanes, 8 ft. parking lanes, and 6 ft. sidewalks.

6.2 SPECIAL ROADWAY TYPES

6.2.1 Main Street

As noted in Section 5.1.2, a "Main Street" is an overlay of the Community Arterial, or Community Collector road type. The design of a Main Street is taken from the elements of those road types within the Town Center or Urban Core contexts. Major characteristics are:

- Lane Width: 10 to 12 ft., with 14 ft. considered to create wide curb lanes on a bike route if no bike lane is provided.
- Parking Lane: 7 to 8 ft. parallel, or 13 to 19 ft. for angled parking.
- Clear Sidewalk Width: 6 to 14 ft, although widths rarely exceed 10 ft.
- Buffer: 4 to 6 ft.
- Building Shy Distance: 2 ft.
- Desired Operating Speed: 25 mph is optimal speed, but 30 mph is acceptable.

Creating a Main Street on a state roadway that has focused on serving through traffic may require a variety of strategies, such as:

- Installing signals at increased frequency on a smaller block structure;
- Narrowing a multi-lane roadway in order to widen sidewalks or install on-street parking or bike lanes, and to facilitate easier pedestrian road crossings.

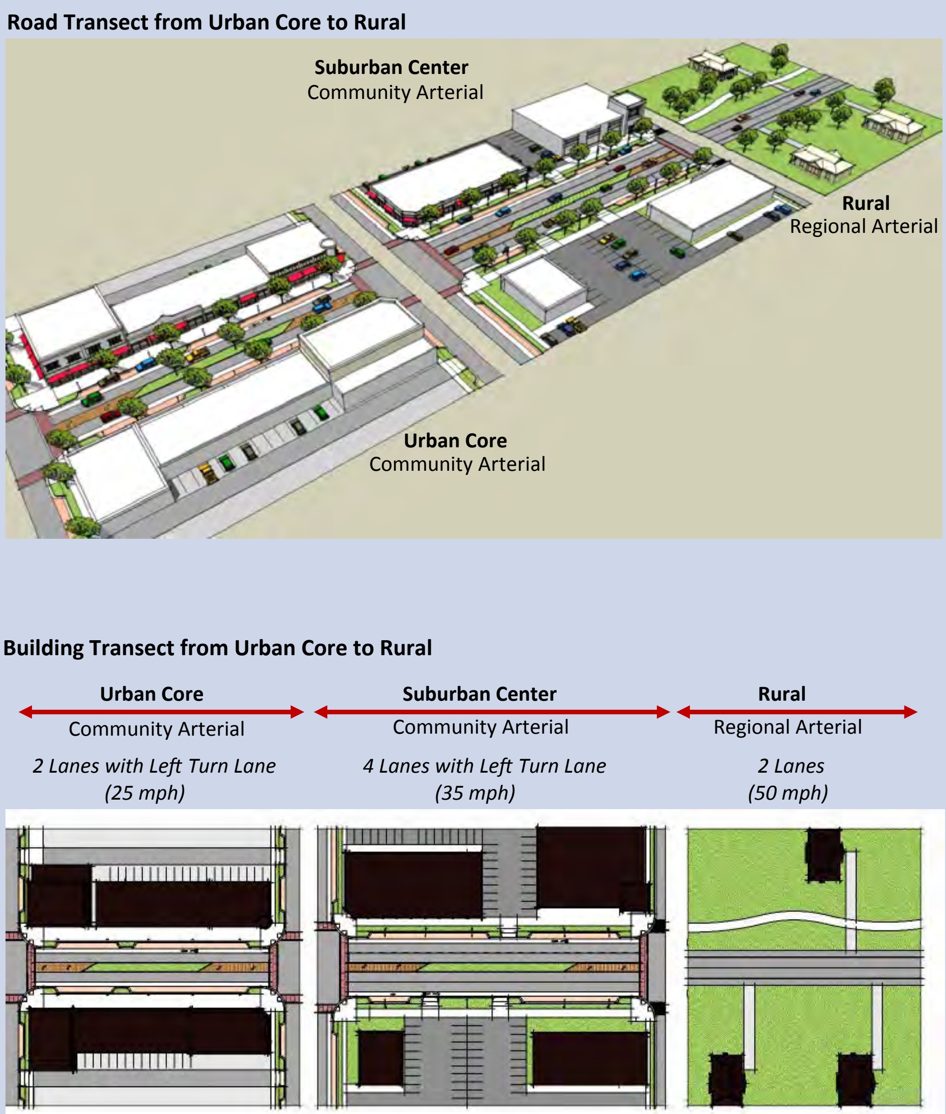


Figure 6.2 Roadway and Building Transect from Urban Core to Rural Contexts

Main Streets should be encouraged as part of efforts to create sustainable town centers. However, the decision to create a new Main Street should be more carefully evaluated on regional arterial roadways, particularly those with four or more lanes. Roadways on which heavy trucks account for more than 5% of traffic volumes, and on which the average trip length is greater than 15 miles, should be scrutinized. More flexibility is possible on Community Arterial roadways, and even more so on Community Collector roads.

If creation of a Main Street will lengthen delays on the state roadway, or make it difficult to implement strategies to reduce existing high levels of congestion, the following questions should be explored:

- What strategies will be implemented by the community to encourage walking, biking, and transit in the community?
- What smart growth strategies will be advanced by creation of the Main Street?
- What is the impact on traffic delays if capacity is reduced on the study corridor? If the reduction greatly increases delays, the study team and community should be prepared to address alternatives:
  - Can the existing system of arterial and collector roadways accommodate an increase in volumes if capacity is reduced on the study corridor, and motorists shift to alternative routes?
  - Can the supporting roadway network be improved to accommodate diverted traffic?
  - Can lower-order roadways in the network be modified? If the network can better accommodate local trips and local traffic has less need to travel on the state roadway, there will be more flexibility for converting the state roadway into a Main Street.

An important question is the acceptability of increased delays under roadway reconfiguration. The "Level of Service" at intersections is normally a chief performance measure used to evaluate roadway projects. Nationwide, the FHWA has long sought at least a Level of Service 'D' for intersections in urban areas (not more than an average delay of 55 seconds per vehicle). However, it is increasingly difficult to achieve these Levels of Service at the heavily congested intersections found in the two states. Many intersections today operate at Levels of Service 'E' or 'F,' and on a growing number of projects, it is considered a success to achieve a 'good F' (V/C ratio of 1.5 to 1.0).

As described above, the DOTs will always have an interest in keeping delays on major arterials at a reasonable level. However, if the state roadway is not critical to regional movements, both state and community should consider whether a Level of Service 'E' or 'F' at intersections is acceptable. The project would involve a trade-off between vehicular levels of service, and "local service." That is, the community could encourage walking and make a business district a greater destination, by accepting slower traffic on the roadway.

6.2.2 Industrial Street

An industrial area may be located in an urban, suburban, or rural context. Streets in these areas may provide access to manufacturing or warehouse/distribution uses. The primary design consideration of these streets is the large trucks that service such uses. Travel lanes on these streets should be 12 ft., along with curb and gutter or open drainage. On-street parking on local industrial streets is normally needed on only one side, if at all.

6.2.3 Rural Crossroads

As discussed in section 4.2.1, a "rural hamlet" is a subtype of the rural context, consisting of a limited number of commercial and civic uses, as well as single-family homes. It is typically located at the crossroads of arterial or collector roads. Travel lane widths for roads through rural hamlets are often consistent with lane widths outside the hamlets or sometimes narrowed by 1 ft. Shoulders are often narrowed from their full width at these locations. Sidewalks are occasionally present, but on-street parking is atypical. The desired operating speed may be stepped down 10 mph, but no more than 20 mph, from the prevailing speed on the roadway outside the hamlet.

6.3 RETROFITTING

The design values presented in Table 6.2 are intended to be compatible with the needs of 3R (resurfacing, rehabilitation and restoration) and reconstruction projects in addition to new construction projects. In general, context-sensitive design philosophy views retrofit projects as an opportunity to improve conditions for walking and biking. Travel lanes wider than needed present the opportunity to narrow travel lanes and install bike lanes. If travel lanes are below Design Manual standards, and the road has shoulders, these should be preserved to better accommodate bicyclists if existing lane widths do not translate into a high crash rate for associated crash types, such as sideswipes. On ambitious reconstruction projects, a wider cartway than necessary permits the moving of curbs to provide wider sidewalks and create a better environment for pedestrians.

6.4 DESIRED OPERATING SPEED

"Desired operating speed" is one of the most important concepts in this guidebook. The desired operating speed is the speed of traffic that, in the expert judgment of the highway designer and community planner, best reflects the function of the roadway and the surrounding land use context. Identification of this speed allows the designer to select the design speed and appropriate roadway and roadside features. It must be approved by the DOT for all roadways.

The desired operating speed is the speed at which we would like vehicles to travel. It is operationally defined here as the desired speed of the 85th percentile vehicle.[9] It is equivalent to "environmental reference speed" in European design practice, which is the "speed used in designing roadways in such a way that it is difficult to drive above this speed."[10]

The concept of desired operating speed is best explained by its relationship to three other concepts of speed: operating speed, posted speed, and design speed.

- Operating speed is the speed at which a typical vehicle operates, commonly measured as the 85th percentile speed of all vehicles.[11]
- Posted speed is the legal speed limit on a roadway. It is often set without any means of self enforcement, and drivers tend to travel at what they perceive as a safe speed regardless of the posted speed. Fewer than a third of drivers go the speed limit on urban and suburban arterials.[12]
- Design speed (as defined in the AASHTO Green Book) is the speed used to determine various geometric design features, including horizontal curvature, gradient, superelevation, stopping sight distance, and, for rural highways only, lane width.

Historically, New Jersey has required the design speed to be 5 mph above posted speed for existing roadways, and 10 mph for new roads; Pennsylvania typically requires a 5 mph difference for both new and existing roads. Many design features also include a "safety margin." If the design speed of a curve is 35 mph, drivers can safely navigate the curve above this speed; however, they will not feel quite as comfortable doing it.

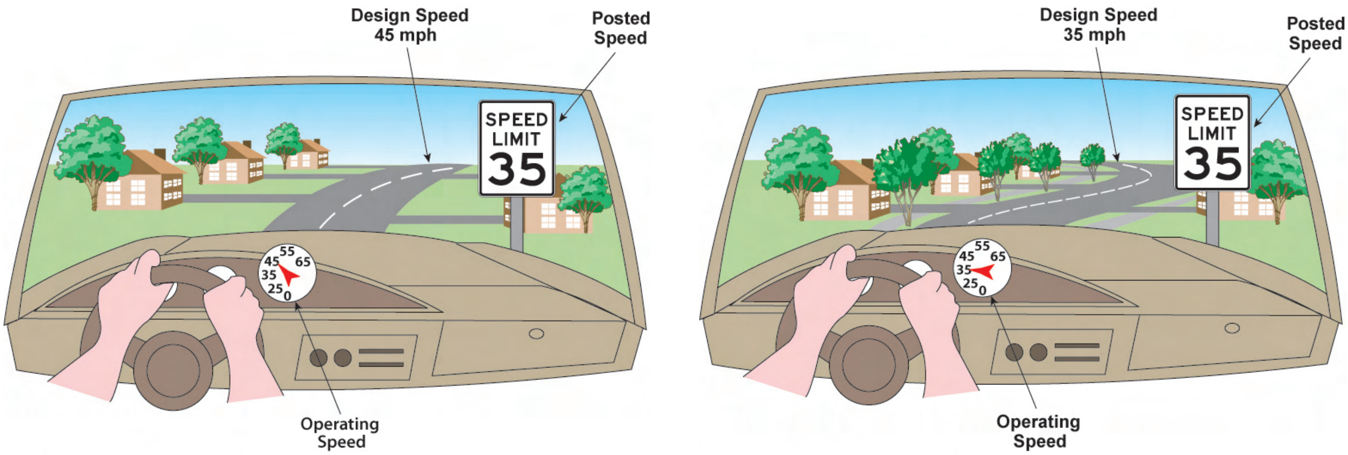
The greatest drawback to the existing design speed approach is that drivers usually drive as fast as they believe the road can safely accommodate. Existing policy may thus encourage operating speeds higher than the posted speed limit and/or selected design speed in an area.

In the interest of highway safety, it is desirable to have a stronger relationship between the posted speed limit, design speed, and operating speed.[13] Therefore, this guidebook recommends that the desired operating speed for most roadway types be the same as the design speed, and also the same as the posted speed. For all roadways posted at 45 mph or above, the design speed should be set 5 mph over the desired operating speed.

The desired operating speed of all roadway types is indicated in Table 6.2. For the highest order roadway – regional arterial – the desired operating speed ranges from 30 to 60 mph. The desired operating speed drops to 20 to 30 mph on local roads, the lowest order roadway. Viewed by context, the desired operating speed may be as high as 60 mph in rural contexts, 50 mph in suburban contexts, and 35 mph in urban contexts. The speed may be as low as 20 mph in all contexts.

Under this policy, all of the controlling design elements directly related to design speed – horizontal curvature, gradient, superelevation, and stopping sight distance – would be set equal to, and therefore reinforce, the desired operating speed. Roadway features not directly related to design speed, such as lane and shoulder width, and the presence or absence or a parking lane, should also support the desired operating speed. Roadside design features, such as the building setback or use of street trees, should likewise support the desired speed.

Figure 6.3 Desired Operating Speed



Conventional Design | **Using Desired Operating Speed**

On roadway segments with vertical or horizontal curvature, the selected design speed will have a role in controlling speeds. However, on many roadways in urban and suburban areas, vertical and horizontal curvatures are minor, and other design elements must be used to control speeds.

Marshalling all contributing roadway and roadside factors to encourage motorists to travel at the desired operating speed will require the best judgment of the highway designer. Design elements should be used in a consistent manner, in accordance with guidance from the AASHTO Green Book. Following is a discussion of design features that have been found to affect operating speeds: [14]

- ***Horizontal and Vertical Curvature*** — A tight curve radius has a greater impact on operating speed than any cross-section or roadside element. Vertical curvature also impacts operating speeds.
- ***Sight Distance*** — As sight distance decreases, so does operating speeds. One study found that when street trees and shrubbery restrict sight distance, this has a greater impact on speeds than density of adjacent land use.[15] Adequate sight distance should always be provided, per AASHTO guidelines.
- ***Street Trees*** — Street trees in planting strips appear to have a traffic calming benefit by causing the motorist to believe the space is tighter and more restrictive.[16]
- ***Lane Widths*** — Narrower lane widths are associated with lower speeds. One study of suburban arterials found that, once posted speeds are discounted, lane width is the only significant variable for operating speeds on straight sections.[17] A relationship between lane widths and speeds was also identified in a study of urban collector roadways in central Pennsylvania.[18] It should be acknowledged that other studies have found no relationship between lane width and speeds.
- ***Shoulder Widths*** — This has received less study than other design features, and the relationship between shoulder widths and speeds is still inconclusive.[19]
- ***Total Roadway Widths*** — Narrower roadway widths are associated with lower operating speeds.[20,21]
- ***Clear Zone*** — Narrower clear zones are associated with lower speeds.[22]
- ***Access Density*** — Higher density of access points is associated with lower operating speeds.[23,24] Along roadways with uncontrolled access, drivers must be vigilant to interaction with driveways, intersections, median areas, and parking.
- ***Signal Density*** — Higher signal density is associated with lower operating speeds.[25] In their recommendations for signal progression, particularly on roadways with closely spaced signals, engineers have great influence on the speed of prevailing traffic.
- ***Median*** — Roadways without medians have lower speeds than roadways with medians.[26] Speeds appear to be higher on roadways with two-way left turn lanes than roadways with physical medians.
- ***On-Street Parking*** — On-street parking leads to lower speeds, due to side friction between moving and passing vehicles. One study found that on otherwise similar roadways, speeds were 7.5 mph lower on roadways with parked cars.[27]
- ***Curbs*** — Speeds appear to be lower on streets with curbs than streets without curbs,[28] although one study found no relationship between speeds and the presence of curbs.[29]

- ***Pedestrian Activity*** — Speeds are lower on roadways with higher pedestrian activity.[30]
- ***Roadside Development*** — Speeds are lower in residential areas than commercial areas.[31] Building setback also matters. As part of an effort to quantify "Main Streetness" for *Flexible Design of New Jersey's Main Streets,* building setback from the street was determined as one of the five key variables in whether people perceive a roadway to be a "Main Street."[32]
- ***Physical Traffic Calming Measures*** — The ability of traffic calming measures to lower vehicular speeds has been well documented.[33] Nationwide, speed humps and mini circles are the most popular measures on lower-order roadways. On higher order roadways, less intrusive measures, such as curb extensions or roundabouts should be considered.
- ***Superelevation*** — Low or no superelevation reduces speeds;[34] this recommendation is targeted to low speed streets.
- ***Curb Return Radii*** — Smaller radii, and the modification of high-speed channelized right turns, can reduce the speed of turning vehicles.[35]
- ***Horizontal Offset Between Inside Travel Lane and Median Curbs*** — A smaller offset can reduce speeds.[36]

6.4.1 Transitions

Design consistency promotes safe roadways. Transitions from one speed zone to another should be introduced in a manner that gives motorists adequate time to prepare for, and react to, changes in roadway design. It is undesirable to surprise motorists with design features inconsistent with motorist expectation. Designers should thus avoid reducing design speed by more than 10 mph on design features in adjacent segments.[37] For example, when a series of curves on a roadway section are built using a design speed of 45 mph, a curve designed for 25 mph should not be introduced into the middle of the section as a traffic calming measure. Speed limit reductions should occur on tangent sections, removed from intersections.

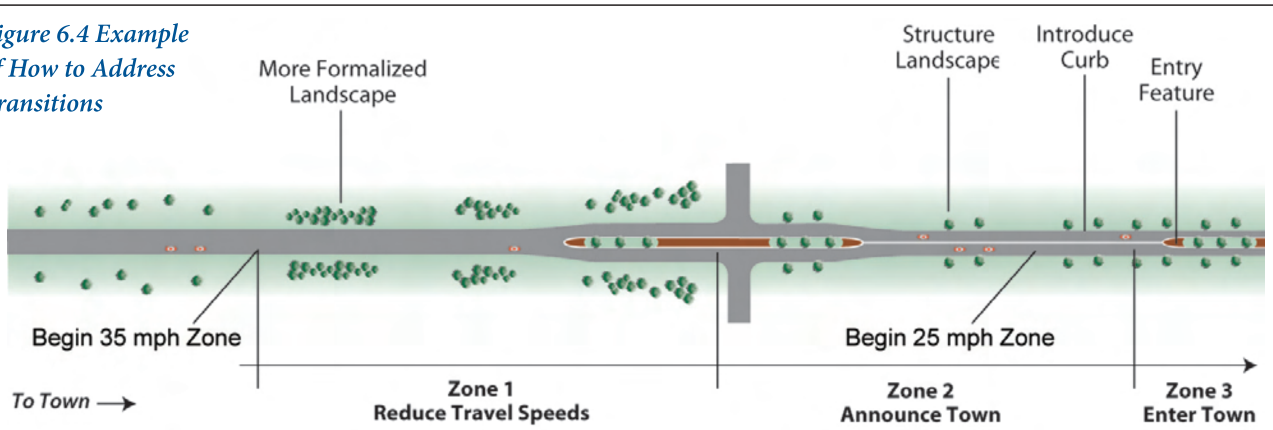
The same principle holds for transitions from a 55 mph speed zone on the outskirts of a town, to 25 mph in a town: speed limits would ideally be stepped down in 10 mph segments. Exceptions can be made in appropriate situations. For example, when a traffic signal or roundabout falls between two different context areas, a reduction of 20 mph could be considered.

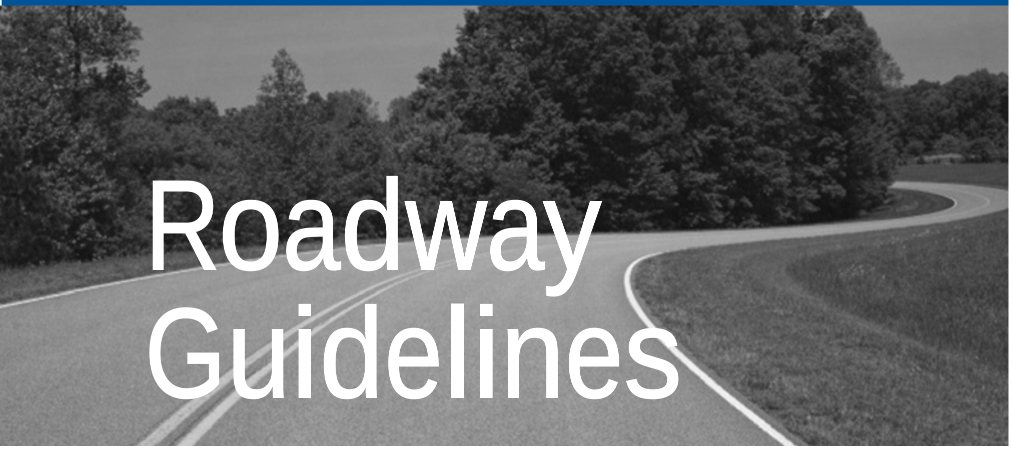
In all cases, the designer needs to introduce transition measures that will safely lower the speed of vehicles entering the project area by sending a clear message to the driver that there is a change in context. Changes in building height and setback, the width and number of travel lanes, and the shoulder treatment are all means of providing visual cues.

Transition measures could include:

- Changing an 8 ft. shoulder on the outskirts of a town to an 8 ft. parking lane, and/or introducing a bike lane.
- Narrowing the lane width. For example, lanes that were 12 ft. in the rural area could be narrowed to 10 ft. within the town.
- Introducing curvature, such as roundabouts at the entrance to the populated area. This is a very common technique in England, and in increasing use here in this country.
- Installing "gateway" treatment, with landscaping and signage, and the use of physical measures such as medians, curb extensions, and decorative pavement.

Figure 6.4 Example of How to Address Transitions





7.0

Roadway Guidelines

7.1 TRAVEL LANES

The designer is encouraged to make full use of the normal range of travel lane widths – from 9 to 12 ft. – depending upon context and project goals. The designer should select the lane width that best complements the desired operating speed of the roadway. The optimal lane width depends on at least five factors:

Yorkship Village in Camden, NJ. The 18 ft. roadway, on-street parking, and horizontal curves ensure that vehicles will travel slowly through this traditional planned development.

- **Roadway type.** Widths of 11 to 12 ft. should be used for regional arterials in rural and suburban areas, although widths may be reduced to 10 ft. in urban contexts. The fullest range of lane widths – 10 to 12 ft. – are regularly used for the community arterial, since this roadway type has the greatest need for flexibility. On collector roadways, lanes of 10 to 11 ft. are recommended for urban areas and suburban centers in order to encourage driver behavior that is compatible with the context, although widths of up to 12 ft. are possible on suburban corridors. Widths of 9 to 11 ft. are recommended for local roads in urban and suburban centers.
- **Desired operating speeds**. Lane widths of at least 11 ft. are recommended when posted speeds are 35 mph or higher. Widths of 10 to 11 ft. are often used for roadways posted less than 35 mph, and are recommended for speed control purposes.
- **Context area.** Narrower lane widths are commonly used in urban areas, especially traditional commercial districts or neighborhoods.
- **Truck and bus volumes.** Lane widths of 12 ft. are recommended for arterials with posted speeds of 35 mph or higher and that have heavy truck volumes in excess of 5 percent, and/or bus service headways of more than twice per hour. Widths of 11 to 12 ft. are recommended for other roadways with significant heavy truck volumes, or in industrial districts.
- **Bicycle facility.** If bike lanes or paved shoulders of at least 4 ft. are provided, travel lanes can be striped as narrow as 10 ft. on community arterials and lower speed roadways. In the absence of bike lanes, an outside lane width up to 14 ft. should be considered where the roadway is part of a planned bike network, although a width of 12 ft. is adequate for low speed roadways with modest volumes.

The AASHTO Green Book states the advantages of using narrower lane widths on roadways posted at 45 mph or less: "More lanes can be provided in areas with restricted rights of way; allow shorter pedestrian crossing times because of reduced crossing distances; and are more economical to construct."[38] Further, studies have suggested that wide travel lanes can encourage higher travel speeds. In short, narrower travel lanes are better for pedestrians.

Studies have increasingly validated the ability to safely use lanes narrower than 12 ft. lanes on roadways. As noted in a paper on suburban and urban arterials at the 2007 TRB conference, "There is no indication that the use of 10- or 11-ft. lanes rather than 12-ft. lanes for arterial midblock segments leads to increases in accident frequency."[39] A similar conclusion was reached for lane widths at intersections.

Lane widths are not prescribed for local roads in the town/ village neighborhood and suburban neighborhood contexts. Historically, streets have been calmed in these neighborhoods through the use of shared lanes. Narrow roadway dimensions result in yield movement, a traffic calming condition where motorists must occasionally pull over and wait for an approaching car to pass before proceeding. In these context areas, Table 6.2 offers four different "street modules," ranging from 20 to 36 ft. The appropriate street module depends upon the housing density in the neighborhood, the presence of parking, and whether the roadway is one-way or two-way.

Local street design is intended to make the motorist vigilant for the presence of other motorists, pedestrians and bicyclists, and hamper the ability to speed. Many new suburbs have local streets designed for on-street parking that is never used because of low residential densities and ample driveways. Wide, empty streets can lead to higher speeds, and should be avoided.

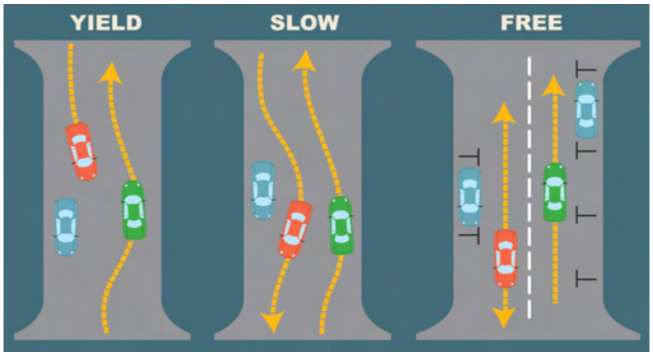


Figure 7.1 Local Street Design. "Yield" and "slow" conditions are traditional ways of calming traffic on local streets.

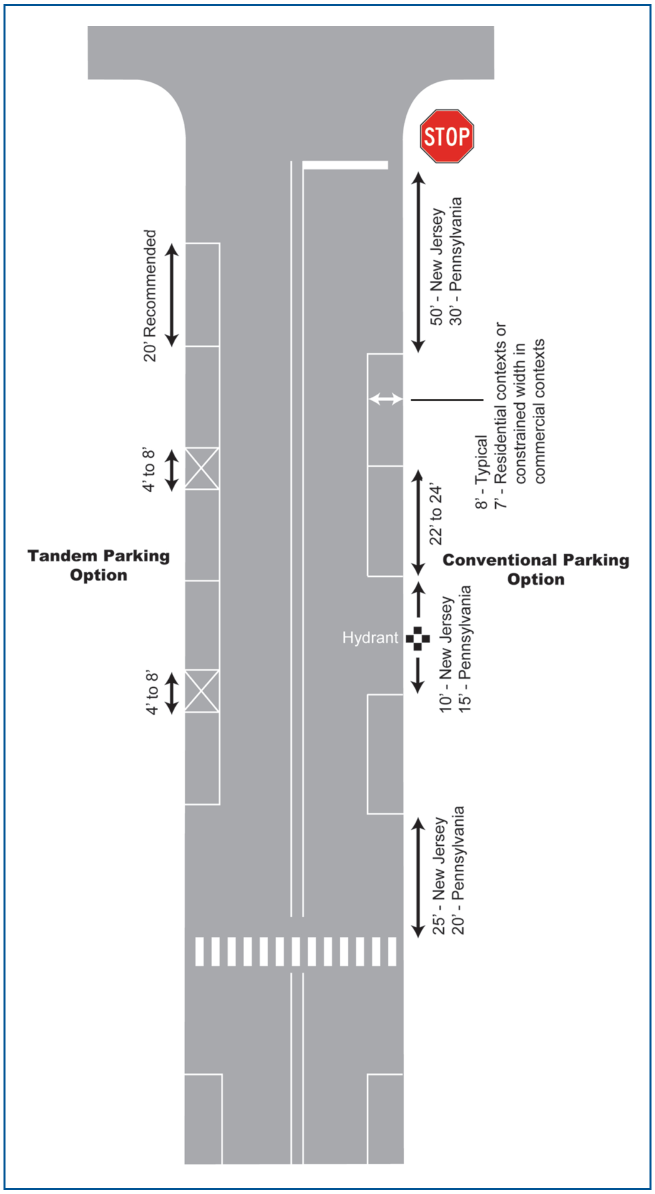


Figure 7.2 On Street Parking Dimensions.

7.2 ON-STREET PARKING

On-street parking is an important part of the urban fabric. Parking lanes benefit pedestrians, since they serve as a buffer from traffic, and can reduce the speed of passing vehicles by creating side friction. Further, on-street parking acts as a visual cue that tells motorists they are in a more urbanized, lower-speed area. On-street parking should be considered in all contexts except the rural and suburban corridor context areas, and on all roadway types. On-street parking is preferred over the use of a shoulder in urban areas.

7.2.1 Parking Types

Parallel Parking

A parallel parking space is typically 8 feet wide and 22 to 24 feet in length. Parking lanes wider than 8 feet are generally not recommended; they increase pedestrian street crossing distance, and reduce the right-of-way available for bike lanes and sidewalks and buffers. However, widths greater than 8 feet are possible when incorporated into innovative bike lane treatments.

Parking spaces of 7 ft. may be acceptable on commercial streets with lower traffic volumes and parking turnover. Widths of 7 ft. should be assumed on all residential streets. At least 1.5 feet should be kept clear between the edge of the curb and any objects such as telephone poles, benches, and trees, in order to allow space for opening and closing of car doors.

"Tandem" parallel parking spaces are recommended for higher-order and congested roadways. Rather than stripe each parking space at 22 to 24 feet in length, parking spaces are typically striped at 20 feet in length with a marked out box of 4 to 8 ft. in length in between two spaces. Under this configuration, the time required for parking a vehicle is cut significantly.

Angled Parking

Angled parking should be considered on wide streets in commercial areas with lower volumes and speeds. Angled parking can provide up to 50 to 75 percent more spaces than parallel parking. Parking spaces are typically 8.5 ft. wide, with the depth (measured perpendicular to the street), and minimum width of adjacent lane dependent on the stall angle, as indicated in Table 7.1.

Angled parking should be considered on wide streets in commercial areas with lower volumes and speeds.

Table 7.1 Angled Parking Dimensions

Angle	Stall Length	Minimum Width of Adjacent Lane
45°	17 ft., 8 in.	12 ft., 8 in.
50°	18 ft., 3 in.	13 ft., 3 in.
55°	18 ft., 8 in.	13 ft., 8 in.
60°	19 ft., 0 in.	14 ft., 6 in.
65°	19 ft., 2 in.	15 ft., 5 in.
70°	19 ft., 3 in.	16 ft., 6 in.
90°	18 ft., 0 in.	24 ft., 0 in.

Source: ITE, *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities,* **2006.**

Back-in angle parking in Pottstown, PA.

Rutgers University in New Brunswick, NJ striped a shoulder on George Street through its central campus as the most expedient way to create a facility for bicyclists.

Angled parking can be head-in or back-in:

- **Head-in angled parking.** Standard "head-in" angled parking requires motorists to back out into the travel lane when leaving the parking space, often with limited visibility. For this reason, traffic speeds should be less than 30 mph when angle parking is used.
- **Back-in angled parking.** Some communities have found back-in, drive-out angle parking an attractive alternative to head-in angle parking. This design removes the sight-distance issues associated with standard angle parking, directs passengers to the sidewalk rather than the street and is the preferred configuration of diagonal parking on roadways with bicycle lanes or a higher number of bicyclists. This technique is being championed in some projects within the two states, such as High Street in Pottstown, PA.

7.3 SHOULDERS

The shoulder is the portion of the roadway contiguous with the traveled way that accommodates stopped vehicles, emergency use, and bicyclists. Consistent with the AASHTO Green Book, this Guidebook recommends the use of shoulders as being more critical on higher speed roadways in urban and suburban contexts. On these roadways, shoulders are desirable for avoiding crashes and stopping due to mechanical difficulties.

Shoulders are generally not recommended in urban and suburban center contexts, where on-street parking and/or bike lanes are more desirable. On medium to lower speed roadways where vehicles cannot completely pull off the road, the presence of stopped vehicles can slow traffic down, but they rarely pose a hazard for passing motorists. However, shoulders can perform a useful role in retrofitting existing urban and suburban center roadways with wide travel lanes, minimal demand for on-street parking, and where bike lanes are not practicable. In these situations, a shoulder of 4 to 6 ft. in width narrows the travel lane for motorists, and provides a dedicated area for bicyclists. As noted in the Green Book, a narrow shoulder is also useful in emergency situations; if a vehicle pulls over such that it occupies no more than 4 ft. of the traveled way, the remaining travel way width can be used by passing vehicles.

Recommendations for shoulders are provided in the Matrix; the dimensions refer to paved surfaces only. Paved shoulders are more advantageous for bicycle travel and should be encouraged. Shoulders in urban and suburban areas are generally curbed, with a closed drainage system.

Shoulder widths recommended in Table 6.2 range from 2 ft. to 12 ft. The 12 ft. shoulder is only recommended for the regional arterial on suburban corridors. Shoulders of 8 to 10 ft. in width are recommended for the higher speed roadways: arterial roadways in rural and suburban corridor contexts, and the community collector in the suburban corridor context. Shoulders of 4 to 10 ft. are recommended for higher order roadways in suburban neighborhoods.

Lower width shoulders are recommended in other contexts. In urban areas, shoulders of 4 to 6 ft. are recommended for use only to retrofit existing wide travel lanes and enhance bicycle travel. No shoulders are recommended for neighborhood collector roadways in urban contexts, or for local roads in general, with the exception of rural areas.

7.4 BICYCLE FACILITIES

Encouraging alternative transportation modes is a key principle of smart growth development. All reconstruction or restriping projects for arterial and collector roadways should routinely consider the best means of accommodating bicyclists.

7.4.1 Facility Types

There are three principal types of bike facilities:

1) **Shared roadway** – Most bicycle trips take place on roadways in which bicyclists share the travel lane with motorists, or ride on the shoulder. There are no markings on the roadway to indicate the presence of bicyclists, but signs may be erected to indicate that the roadway is part of a bike route. The compatibility of the roadway for bicyclists depends upon many factors, including the width of the travel lane and shoulder (if present), roadway operating speed, traffic volumes, mix of heavy vehicles, and parking. This category can be divided into two sub-categories: wide curb lanes and paved shoulders. Both of these sub-categories are explained in greater detail later in this section.
2) **Bike lane** – A striped lane and markings on the roadway, accompanied by signing, designate an area for preferential or exclusive use by bicyclists. Bike lanes accommodate one-way travel only, and lie on both sides of the roadway.
3) **Shared use path** – These paths lie outside the roadway. The term bicycle path is rarely used for these facilities since they are shared by many other non-motorist modes, such as pedestrians and roller-skaters. They may be seen along abandoned rail lines, greenways, and within parks, and they are highly valued for their recreational opportunities. However, they are much less functional for everyday transportation than the first two categories discussed. They access relatively few land uses within their community. When installed parallel to roadways, shared use paths experience a higher rate of motorist-bicyclist conflicts and crashes than on-road facilities.[40] A major problem is that motorists turning at intersections or driveways may be taken by surprise by bicyclists who suddenly enter the roadway, opposite the flow of normal traffic. This issue is particularly acute on roadways with a high number of driveways and/or high traffic volumes at driveways, and where sight distance is less than ideal.

Due to the limitations of shared use paths, states and local governments should emphasize bike lanes and compatible shared roadways to accommodate bicycle use. Of these two facilities, bike lanes have some advantages. Surveys have shown that bicyclists prefer bike lanes to wide curb lanes.[41] Fewer bicyclists ride on sidewalks on streets with bike lanes than on streets with wide curb lanes.[42] Bicyclists ride father from the curb edge, improving sight distance and the ability to respond to vehicles entering the roadway from streets and driveways. Through defining areas for both users, erratic maneuvers by motorists are reduced. However, both facilities reduce encroachment by motor vehicles into adjacent lanes.

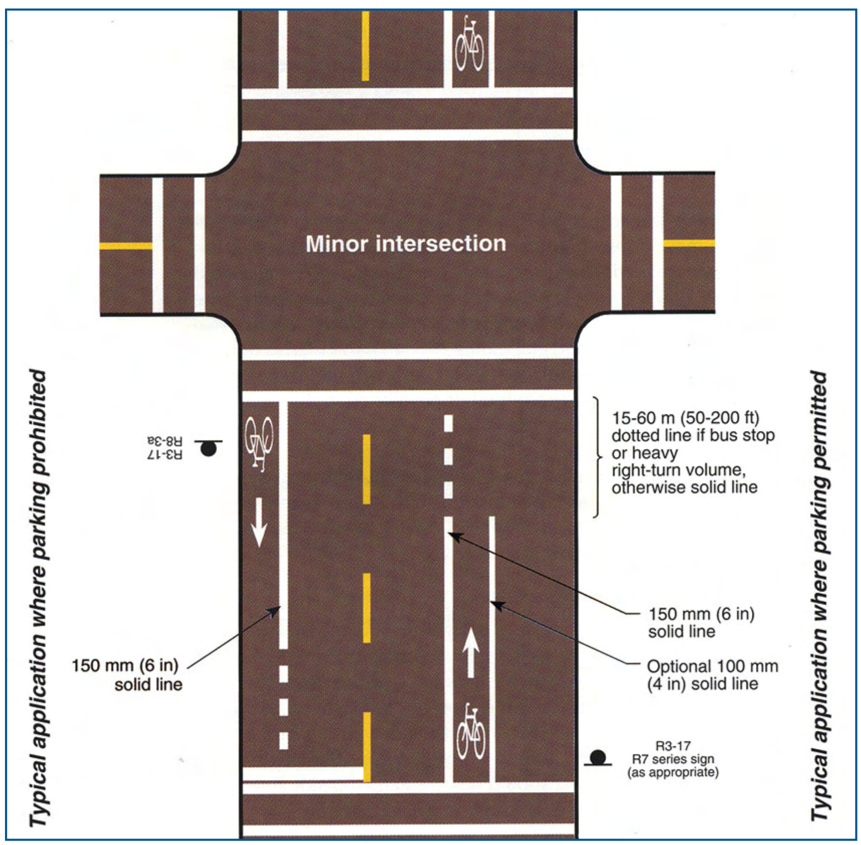


Figure 7.3 Typical bike lane striping. (AASHTO Guide for the Development of Bicycle Facilities.)

Baltimore Avenue, a principal arterial in Philadelphia, was striped with 10 ft. travel lanes to enable the installation of bike lanes. The effective curb radius of this intersection is significantly increased by the presence of the bike lane – as well as the parking lane – enabling motorists from the side street to easily turn right into the 10 ft. lane.

The 5 foot bike lane and 10 foot travel lane comprise a common cross-section in urban areas.

Bicyclist education is highly recommended for supplementing all facility types. Well-designed bike facilities cannot substitute for good judgment on the part of the cyclist. Even on roads with bike lanes, cyclists are still obliged to follow all prevailing rules of the road.

The AASHTO *Guide for the Development of Bicycle Facilities* is the most authoritative national guide for designing bicycle facilities. Both states also have their own bicycle plans: NJDOT, *Bicycle Compatible Roadways and Bikeways*, April 1996; and PennDOT, *Statewide Bicycle & Pedestrian Master Plan: Bicycle Guidelines*, April 1996.

7.4.2 Bike Lanes

Bike lanes are the ideal facility for accommodating basic bicyclists. By designating a space only for bicyclists, they give bicyclists a measure of comfort that motorists will not move into their path. They serve to advise motorists of the possible presence of bicyclists. The presence of bike lanes encourage bicyclists to separate themselves from parked cars more than they otherwise might, reducing the possibility of being "doored."[43]

A bike lane width of 5 ft. is recommended by AASHTO *Guide for the Development of Bicycle Facilities*, and is the most widely accepted standard. Widths of 6 ft. are recommended with the presence of considerable truck traffic, and under most circumstances when roadway speeds exceed 40 mph. Widths greater than 6 ft. are generally not used, to discourage motorists from using the bike lane as a parking lane or turning lane.

Some municipalities across the country have striped 4 ft. bike lanes, typically to reduce the width of 14 ft. travel lanes and reduce vehicular speeds. This practice is similar to striping shoulders on wide travel lanes in urban environments, described in section 7.3. This use should be permitted in constrained rights-of-way, particularly as part of an effort to narrow wide travel lanes.

The 5 ft. of width for standard bike lanes should be provided outside the joint if the roadway between the gutter pan and pavement is not smooth. Some municipalities have elected to pave asphalt up to the curb for this reason.

Bike lanes should not be installed between parking lanes and curb lanes. The presence of parking would obstruct the visibility by bicyclists and motorists at the approaches to intersections. Further, bicyclists desiring to turn left would be starting from the right curb, not an ideal position.

Bike lane markings should not extend through an intersection or through a pedestrian crosswalk. The AASHTO *Guide for the Development of Bicycle Facilities* should be consulted for striping options on bike lanes through intersections. It is problematic to continue

In addition to improving sight distance of and by pedestrians, a curb extension provides room for a bike rack in a constrained urban area.

bike lanes adjacent to the curb in intersections with dedicated right-turn lanes. In this scenario, through bicyclists would have to contend with motorists turning into their path within the intersection. It is instead recommended to dash or to completely interrupt the bike lane in advance of the intersection. This marking pattern serves to notify bicyclists that they must weave with motorized traffic at a safe opportunity and position themselves between through and right-turning motorists at the intersection approach.

Bike lanes are usually not needed on local streets, due to the lower traffic volumes and speeds.

7.4.3 Shared Roadway

Shared roadways can be subdivided into two categories: paved shoulders and compatible curb lanes.

Paved shoulder

The practical effect of paved shoulders is little different than that of bike lanes, and should also be considered for accommodating bicyclists.[44] The minimum width of 4 ft. recommended for shoulders coincides with the minimum width recommended for bike-compatible facilities. The same qualities that make wide shoulders desirable on higher-speed, higher-order facilities also pertain to bicycle travel.

Wide Curb Lane

Given the relatively narrow rights-of-way for many roadways in the two states, wide curb lanes are often the most practical bicycle facility. These have less potential for encouraging bicycle use than bike lanes and paved shoulders, but are often preferred by experienced bicyclists. These bicyclists may find that bike lanes limit their options for various maneuvers. Bike lanes also may collect more debris than wide curb lanes, since they are not "swept" by the movement of passing traffic.

The recommended width for a wide curb lane on most streets is 14 ft. A width of 15 ft. is recommended for roadways with steep grades, and for roadways with speeds above 40 mph. On lower-speed, lower trafficked urban roadways without parking, a curb lane of 12 ft. suffices.

Bicyclists appreciate any extra width provided to them on higher-order roadways, whether the curb lane width meets the recommended standard or not. If space is available in restriping a multi-lane roadway, the outside lanes should be wider than the inside lanes.

7.4.4 Facility Selection

Guidance on selecting a bicycle facility should be provided by a bike network plan that identifies the most important bicycle generators in the community, and provides recommendations on how to best accommodate bicyclists between those destinations. Bicycle generators include schools, parks, major shopping areas, employment centers, transit stations, and large residential developments.

A bike network plan should identify roadways for bike lanes, compatible shoulders or shared lanes, and shared use paths. In many cases, the selected roadways will be arterial and collector roadways. Bicyclists prefer to travel on these roadways for the same reason that motorists do: they provide the most direct route to key destinations. A representative bike network plan is shown for West Windsor Township in Mercer County, NJ (Figure 7.4).

7.4.5 Road Diets and Other Treatments

Sometimes bike lanes can be installed as the valued by-product of a "road diet" treatment, in which a four-lane roadway is converted into two through lanes with a two-way left-turn lane and two bike lanes. These have many beneficial effects:[45, 46]

- create a designated facility for bicyclists;
- reduce crossing distance in which pedestrians are exposed to vehicular traffic;
- provide a refuge for crossing pedestrians if physical medians are created;
- can reduce incidence of left turn crashes for motorists;
- can reduce vehicular speeds by 1 to 5 mph on roadways where speeding is common.

On a roadway in Portland, Oregon, where travel lanes were variously reduced in width or number to permit the installation of bike lanes, motorists traveling at faster than 31 mph decreased from 58% of all motorists to 51%.[47]

Many jurisdictions have approved the use of 10 ft. lanes in order to install bike lanes. The presence of bike lanes addresses at least two operational issues that designers might perceive with the use of 10 ft. lanes:

- Increase separation from parked vehicles, or from curbs if no parking lane is present;
- Bike lanes are incorporated into the effective turning radius for vehicles, facilitating turns for larger vehicles.

The City of Philadelphia has been a national leader in creating bike lanes, striping a total of 150 miles since 1996. A common cross-section has been 44 ft. wide roadways with 7 ft. parking lanes, 5 ft. bike lanes and

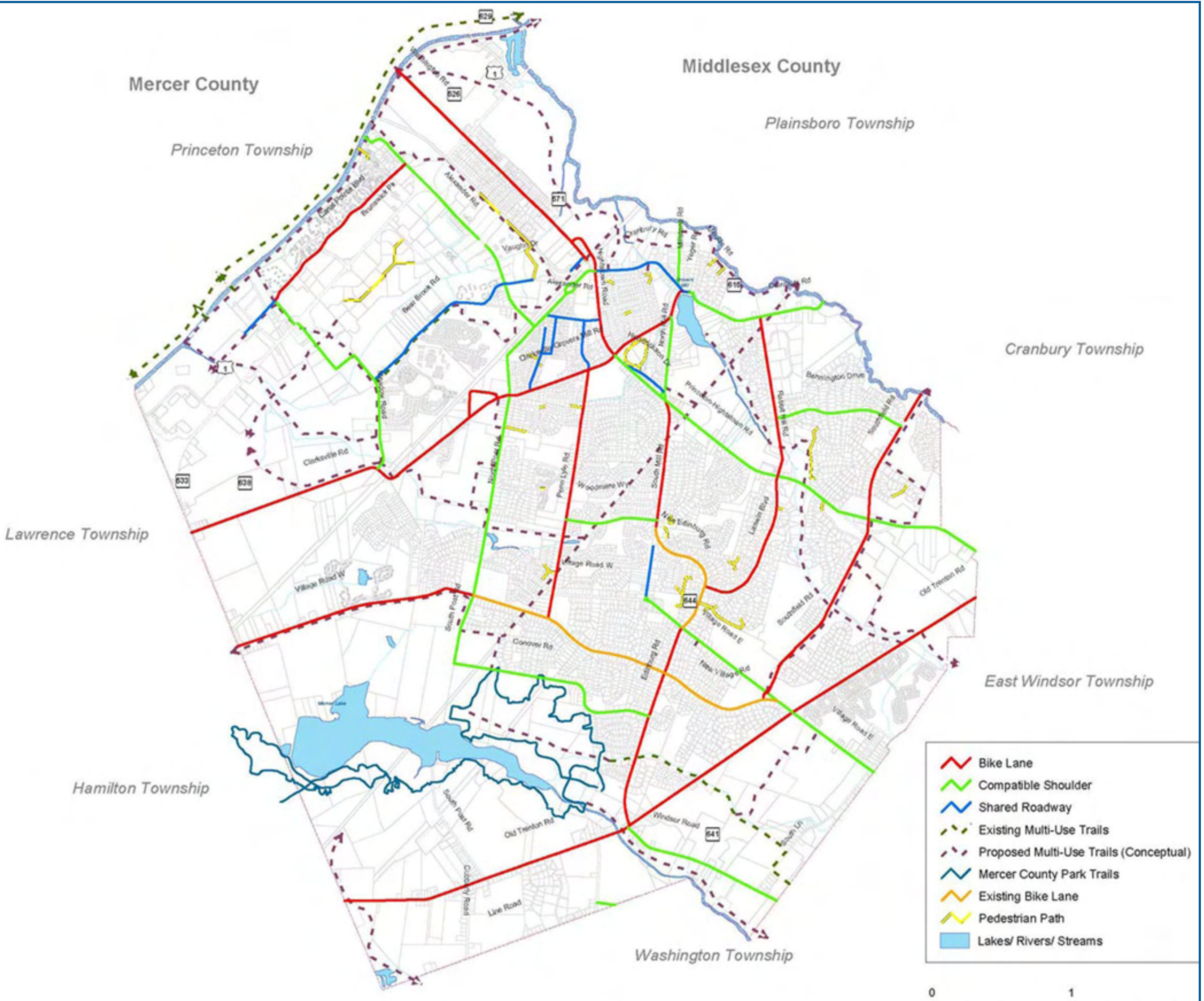


Figure 7.4 Bike Network in West Windsor, NJ

10 ft. travel lanes. To encourage traffic calming on some wider roadways, medians of 4 ft. to 6 ft. were striped in order to narrow travel lanes to 10 ft. The City elected not to stripe 11 to 12 ft. lanes even though that would have been an option.[48]

On many existing roadways – particularly urban commercial and mixed-use districts - bike lanes can be installed only if parking lanes are removed. Because on-street parking is perceived as vital to the activity of these areas, and serves to slow down traffic on these streets, communities will rarely elect this option.

In the absence of a bike network plan, the sponsoring agency must assess the feasibility of different bike facilities, and consider community goals for the project. On main streets or roadways on which traffic calming is needed, the installation of bike lanes or wide curb lanes may be a lower priority. The presence of bike compatible roadways on parallel roads may also help determine the need to install bike facilities on the project roadway.

Landscaped medians provide an aesthetic enhancement for business districts, and facilitate pedestrian crossings.

7.5 MEDIANS

The primary function of a center median is to separate opposing traffic flows. Other purposes include serving as a refuge for pedestrians crossing the street, storing or restricting left-turn vehicles, managing access, and providing an attractive landscaping or streetscaping treatment.

The TRB *Access Management Manual* groups medians into three categories:

- **Nontraversable** – Examples include Jersey barriers, raised with curbing, flush grass or guiderails. Jersey barriers are common in the two states, particularly in New Jersey, where their narrow width (24 in. wide by 32 in. tall) have made them the median of choice in retrofitting arterial roadways with restricted ROW. Raised medians with curbs are useful for facilitating pedestrian crossings. Although grass medians are classified as non-traversable, they are sometimes crossed by wayward vehicles, and have been the site of several fatal crashes on New Jersey highways in recent years. NJDOT has begun installing guiderails in grass medians on stretches of limited access roadways to reduce the possibility of cross-over crashes.
- **Traversable** – Painted medians that do not discourage vehicles from entering or crossing. This type of median is discouraged since left turns are made from the left or passing lane, and trailing vehicles make lane changes to avoid the left turning vehicles.

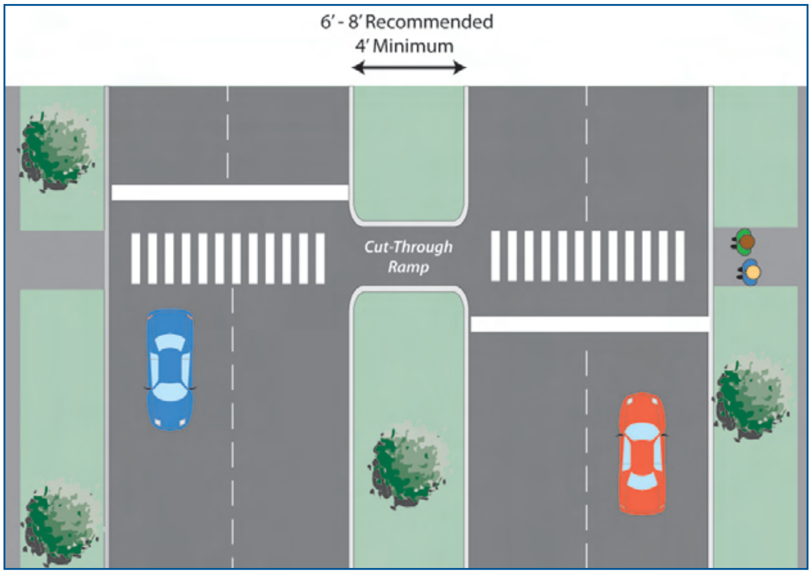


Figure 7.5 Raised medians should accommodate regular pedestrian activity.

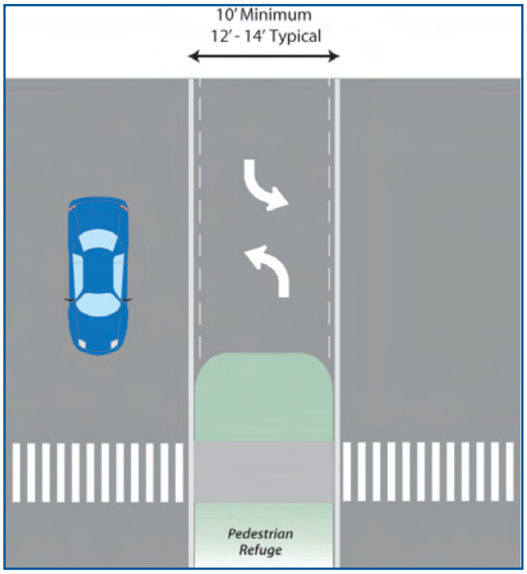
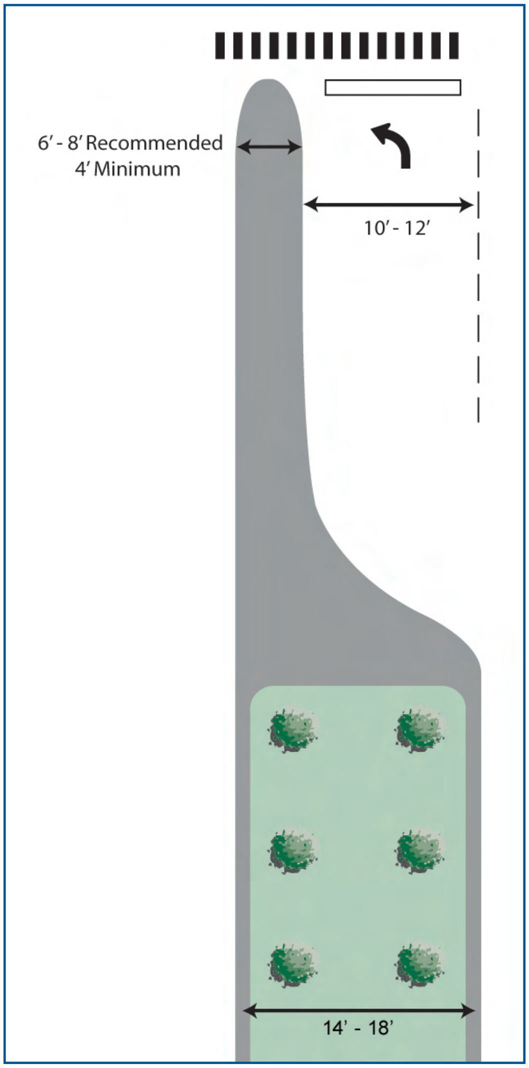


Figure 7.6 Two-way left turn lane with median.

Figure 7.7 Raised median with left turn lane.



- **Continuous Two-Way Left Turn Lane** (TWLTL) – Striped to permit left turns in either direction. These can be stamped pavement or pavers to create the perception of reduced lane widths and slow vehicles entering the TWLTLs.

The nontraversable median is the preferred median type. Due at least in part to its efficiency in reducing conflicting maneuvers at driveways, it has the lowest crash rate. In one study, roads with nontraversable medians were found to experience 5.6 crashes per million vehicle miles, versus 6.9 for TWLTLs and 9.0 for undivided roadways.[49]

Among nontraversable medians, the raised median with curbing is preferred due to its ability to encourage safe pedestrian crossings on higher order roadways. One study found a pedestrian crash rate of 19.11 per 100 million miles on arterials in CBDs with raised medians, versus 41.11 for TWLTL and 87.31 for undivided roadways. In suburban areas, the rate was 6.31 per 100 million miles for raised median, versus 12.89 for TWLTL and 13.91 for undivided roadways.[50] The advantage in pedestrian safety for raised medians has been found in other studies.[51] However, the installation of physical islands within the TWLTL at locations of regular pedestrian crossings can serve to make this median type pedestrian friendly.

Furthering another context sensitive design goal, raised medians can enhance the appearance of a corridor, by hosting trees or other vegetation as part of a boulevard treatment (see guidelines for planting medians in Landscape Design, Section 8.3.) An attractive brick or textured concrete surface is another option.

Raised medians are desirable to aid pedestrian crossings on roadways over 60 ft. in width. It should be noted, however, that on higher speed roadways of restricted widths, the Jersey barrier is often preferred to the raised median with curbing. A Jersey barrier has greater ability to separate opposing traffic and prevent head-on collisions than a narrow raised median (less than 10 ft.). On certain high speed and high volume highway segments, NJDOT seeks to discourage all midblock pedestrian crossings due to concern about pedestrian safety, and deploys a Jersey barrier in these cases. Each site should be analyzed on a case-by-case basis to determine how to safely accommodate pedestrians.

The use of TWLTLs is appropriate in certain situations. Although their crash rate is higher than nontraversable medians, their crash rate is 35% lower than undivided roadways.[52] They are suggested for consideration on roadways with volumes from 10,000 to 24,000 vpd.[53,54] Other parameters include highways with extensive commercial development, driveway density of more than 45 per mile, high left turn volumes and / or high rate of rear-end or angle crashes from left turns.[55] Concerns that TWLTLs increase head-on collisions are unfounded; indeed, studies show similar head-on crash rates for raised median and TWLTLs, and both have much lower head-on crash rates than undivided roadways.[56]

Recommended widths of medians are provided in the Matrix. Medians installed to serve as pedestrian refuges should ideally be 8 ft. in width, with 6 ft. the recommended minimum (measurements of physical medians are from face-of-curb to face-of-curb). Median widths of 12 to 18 ft. can accommodate left turn bays. Medians of 60 ft. in width or more should only be used for regular traffic operations in rural areas, or to provide landscaping treatments and/or parks in suburban and urban contexts. TWLTLs are typically 12 to 14 ft. in width, although 10 ft. widths are common in many urban areas.

If a proposed median will prevent access to a commercial driveway, a project can incorporate median breaks, U-turn jughandles, flush textured pavement medians, or TWLTLs.

7.6 INTERSECTIONS

Balancing the needs of motorists, pedestrians and bicyclists can become even more difficult at intersections than at mid-block locations. Following are features desired by each user group:

Features desired by pedestrians:

- Well-defined facilities, with sidewalks on all corners, crosswalks in good condition, and pedestrian signal indications that are easily visible from every corner of intersections.
- Short crossing distance. This can be accomplished by:
  - Controlling the number and width of travel lanes.
  - Using the smallest curb radius practicable.
  - Controlling the degree of skew, and thus disproportionately long crossing legs.
  - Installing curb extensions ("bulb outs").
- Adequate time to cross intersection.
- Presence of median islands at major intersections, to provide a refuge if pedestrians are not able to cross the intersection within their signal phase.
- Management of conflicts with vehicles. Turning vehicles present the greatest conflicts. These can be addressed through a wide range of treatments, from use of regulatory signs ("Turning Traffic Must Yield to Pedestrians", R10-15) to leading or exclusive pedestrian intervals or protected left turn phases at signalized intersections.
- Features to accommodate disabled pedestrians.
- Good sight distance.

Features desired by motorists:

- Minimal traffic delays.
- Ability to complete turns without encroaching into lanes of opposing or adjacent traffic, and without leaving roadway (especially larger trucks).
- Predictability of conflicting traffic flows, through the use of protected (green arrow) phases and exclusive travel lanes.
- Well delineated facilities. At large, complex intersections, the use of median islands with accompanying signage, and dashed lane markings help keep motorists in the appropriate lanes when turning.

- Responsive signal operation with minimal "wasted" signal green time, usually accomplished through vehicular detection on minor streets.
- Avoidance of extreme angles.
- Good sight distance.

Features desired by bicyclists:

- Adequate width travel lanes to accommodate bicyclists.
- Signals capable of detecting bicycles, or operating on pretimed phases. In short, the ability to navigate through an intersection without the need to dismount the bicycle.
- Low vehicular speeds.
- Good sight distance/visibility of signals and conflicting vehicles.
- Predictability of conflicting traffic flows, through the use of protected (green arrow) phases and exclusive travel lanes.

The needs of these different groups must be balanced on every roadway. For example, the addition of turn or through lanes can be the most effective means of resolving serious traffic congestion on a roadway, but they can also make intersections more difficult for pedestrians to navigate. In these cases, the roadway designer should identify improvements to assist pedestrian mobility, whether through the addition of pedestrian refuges or signalization, striping and signing strategies.

7.6.1 Curb Radii

In a context where only motor vehicles are important, the radius of corners at an intersection would be large enough to comfortably and safely accommodate the design vehicle without encroachment into adjacent or opposing lanes. However, large turning radii increase the length of crosswalks and hence the exposure of pedestrians to vehicles. (See Figure 7.8.) They permit vehicles to take turns faster, which is also detrimental to pedestrian safety. Therefore, all curb radii must balance vehicular needs with pedestrian needs.

To avoid over-sized curb radii, determining the appropriate design vehicle is important. ITE *Context Sensitive Solutions in Designing Major Urban Thoroughfares* recommends that curb return radii "be designed to accommodate the largest vehicle type that will frequently turn the corner. This principle assumes that the occasional large vehicle can encroach into the opposing travel lane." Designers should use available tools such as turning templates or AutoTURN to determine the best curb radii for the specific context and conditions.

Conversely, designers should avoid making curb radii too small if larger vehicles are regularly present. In this case, large vehicles will frequently travel over the curb into the pedestrian realm, jeopardizing safety and degrading the curb. It is this conflict that engineers must address in designing curb return radii that are sensitive to their context.

The designer should keep in mind that the effective turning radius may be much larger than the curb radius once parking and bicycle lanes are taken into account as illustrated in Figure 7.9.

There are five types of design vehicles usually taken into consideration by roadway designers:

- passenger vehicle
- SU (single unit truck)

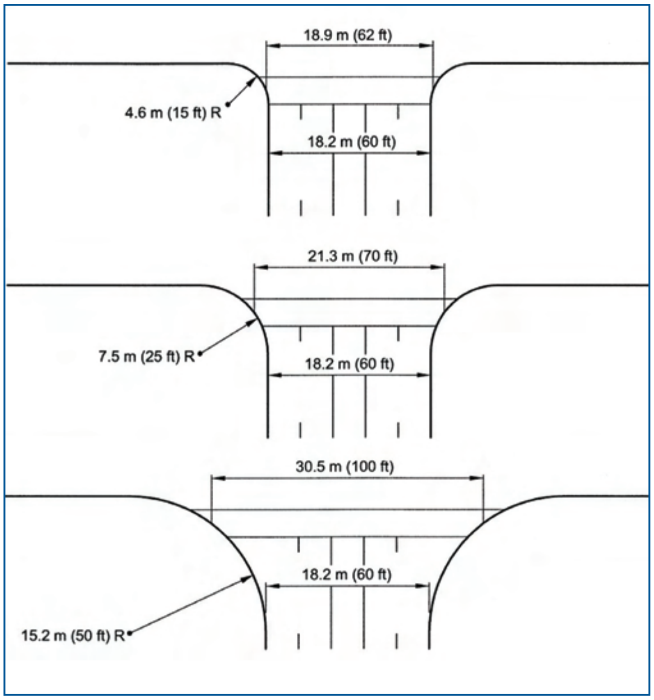


Figure 7.8 Curb radii at driveways and intersections must be selected with care in urban areas, balancing the impacts on truck circulation and pedestrian crossing distances. Example shown: While keeping the mainline constant at 60 ft., a change in radius from 15 ft. to 50 ft. will increase the crossing distance from 62 ft. to 100 ft. The time required for pedestrians to cross increases from 16 to 25 seconds. *Source: FHWA, 2004.*

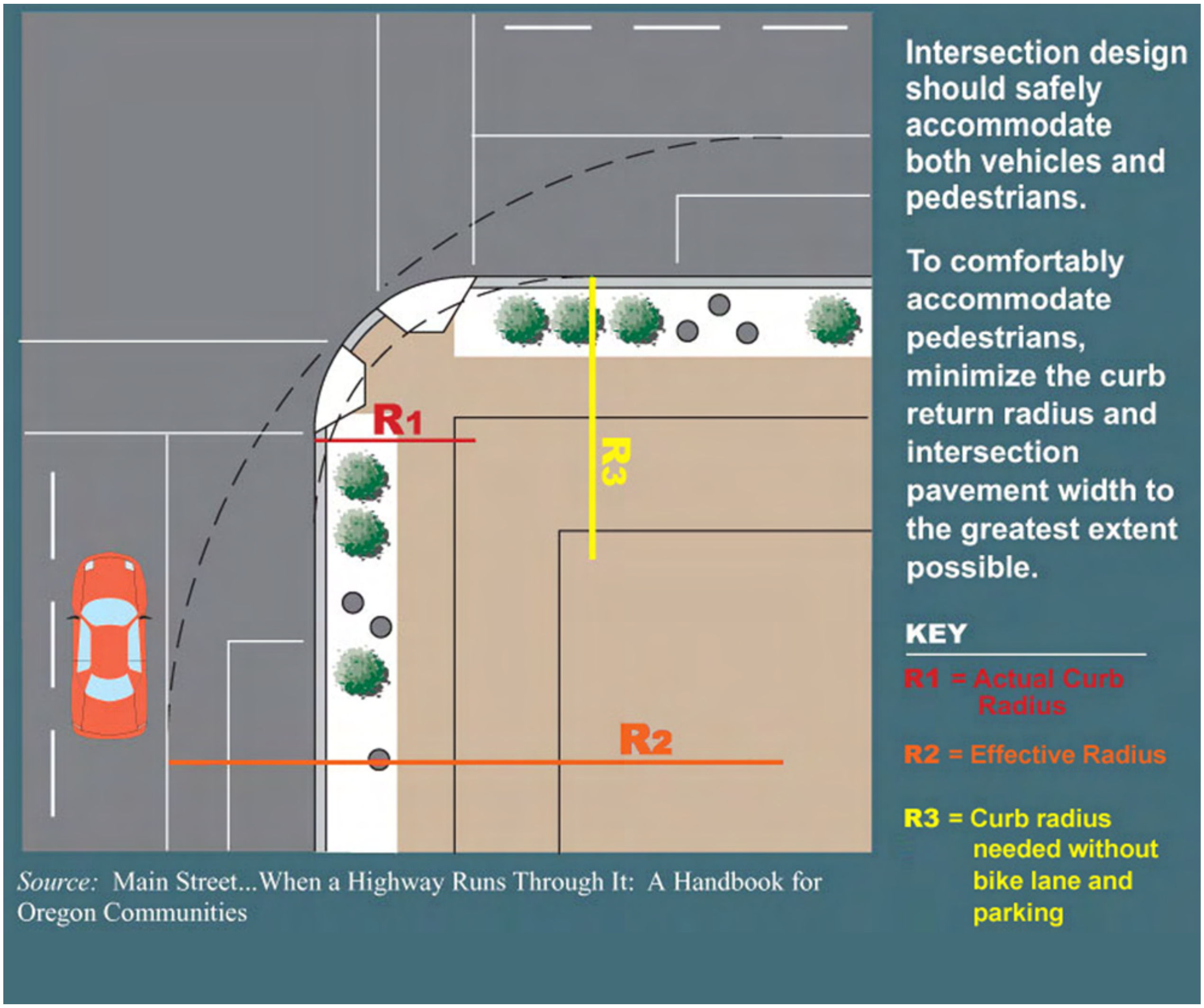


Figure 7.9 Effective Curb Radius

- Bus
- WB-40 (trailer truck with 40 ft. wheelbase)
- WB-50 (trailer truck with 50 ft. wheelbase)

In the urban core and town center contexts, where pedestrian activity is often intense, the smallest possible curb radii should be used. As indicated in the AASHTO Green Book, a curb return radius of 10 to 15 feet is used at most urban intersections, partly to minimize pedestrian crossing distances. This range is recommended here for use on most local streets, as well as collector and arterial roadways in urban areas with moderate volumes and a large percentage of passenger vehicles. Passenger vehicles can navigate curbs of this radius with little encroachment into other lanes. The relative infrequency of single unit trucks, school buses and possibly transit buses would not usually warrant construction of a larger curb radius. Curb radii of 15 to 25 ft. are recommended for these roadway types where encroachment is unacceptable.

A curb radius of 25 to 30 ft. will accommodate most turns on community collector roadways, and community arterials, particularly roads with less than 5% traffic in buses and heavy trucks. A curb radius of 25 ft. and a parking lane will permit a single-unit truck to turn without encroachment.

Radii of 35 to 40 ft. are adequate at most intersections on arterial streets where a WB-50 truck is the design vehicle. A radius of 50 ft. or larger may be considered for intersections on arterials if congestion and the percentage of larger vehicles are significant, and if there is little pedestrian activity.

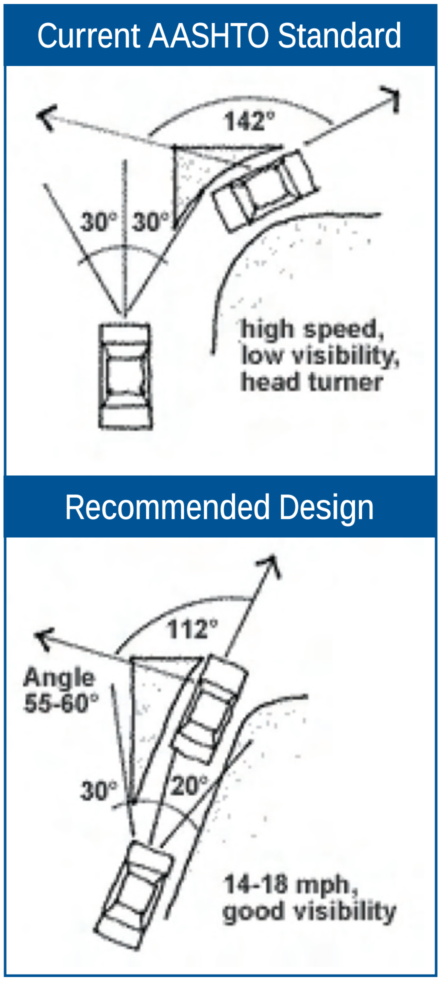


Figure 7.10. The design of channelization islands for slip lanes at intersections can be made more pedestrian friendly by changing entry angles and corner radii. Sources: Walkinginfo.org (graphic); Dan Burden (photo).

If large radii are not practicable on multi-lane roadways, it should be noted that large vehicles may encroach entirely into adjacent same-direction travel lanes. The stop line for opposed traffic can be recessed farther from the intersection if necessary. For a curb radius exceeding 50 ft., ITE *Context Sensitive Solutions in Designing Major Urban Thoroughfares* recommends investigating tapered or compound curve radii or the installation of a channelized right-turn lane with a pedestrian refuge island.

7.6.2 Signal Coordination

Traffic signal coordination reduces delay and unnecessary stops at traffic signals. Because it does so without roadway widening, it can be a useful strategy in improving traffic flow along a roadway without lengthening pedestrian crossings. Optimizing signal timing plans can result in a reduction in travel time ranging from 10 percent to 20 percent.

7.6.3 Islands

Three primary types of islands exist in roadway design: channelizing islands to direct traffic into appropriate paths, divisional islands to divide opposing or same direction traffic, and refuge islands for pedestrians. Islands can improve vehicular safety at an intersection by directing traffic and pedestrian safety by providing a safe refuge at a long intersection crossing. However, high-speed channelized right turn lanes or slips are inappropriate in urban contexts because they create conflicts with pedestrians. Principles for channelized right turns in an urban context are provided in ITE, *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities,* 2006:

- Avoid using channelized right-turn lanes where pedestrian activity is significant.
- Channelized right turn lanes should be reserved for right-turning volume thresholds of 200-300 per hour.
- When an urban channelized right-turn lane is justified, design it for low speeds (5 to 10 mph) and high-pedestrian visibility.
- It is desirable to have pedestrians crossing fully under signal control, rather than excluding the channelized right turn lane from pedestrian signalization.
- Provide a low-angle right turn, to reduce speeds and improve sight distances.

- Provide accessible islands, raised, and big enough for pedestrians to wait at least 4 ft. from the face of curb in all directions, and accommodate accessible features, such as curb ramps. A painted island is not satisfactory for pedestrians.
- If warranted, provide signing to remind drivers of their legal obligation to yield to pedestrians

7.6.4 Curb Extensions

Curb extensions (or bulb-outs) extend the line of the curb into the traveled way, reducing the width of the street. They are often used in urban core, village/town center and suburban center contexts to improve visibility of and by pedestrians, and also reduce the length of pedestrian crossings. They are installed at both intersections and mid-block locations. A common width is 6 ft., or slightly less than the width of a parallel parking lane. Their use should be restricted to streets with on-street parking. They should not be installed within a striped bike lane. They are favored by emergency service departments in many municipalities, since their presence prevents vehicles from parking too close to an intersection, or in front of a water hydrant if so positioned.

Examples of Curb Extensions

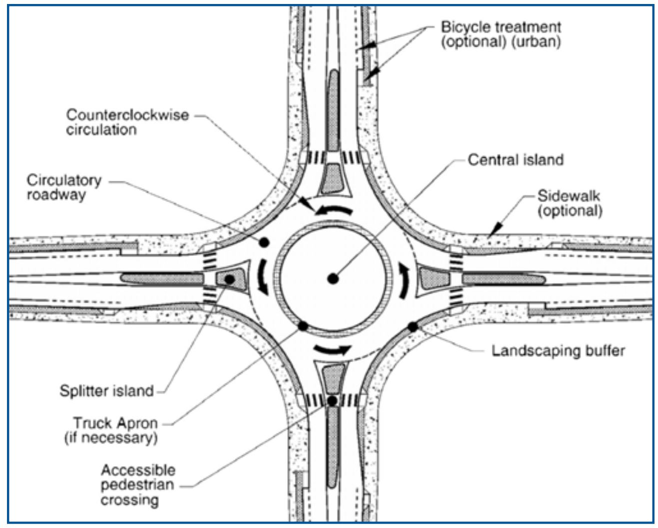


Figure 7.11. Roundabout design.

7.6.5 Modern Roundabouts

The modern roundabout, a channelized intersection with one-way traffic flow around a central island, can be used as an alternative to signalized intersections. They are increasingly accepted in the United States, and have been successfully implemented in other countries for decades. Modern roundabouts help to maintain traffic flow, while improving safety through reducing vehicular speeds and the number of vehicle conflict points (eight versus 32 at traditional 4-way intersections). A before and after study sponsored by the Insurance Institute for Highway Safety found that roundabouts produced a 39% decrease in overall crashes and a 76% decrease in injury crashes.[57]

There are six categories of roundabouts, increasing in diameter from 45 to 200 feet with corresponding increases in vehicle capacity and entry speed. Four categories are intended for urban areas, and two categories for rural areas. The characteristics of each are shown in Figure 7.2.

Roundabouts can lower vehicular delays at an intersection. However, for many communities, the deciding factors in using a roundabout are the aesthetics of a landscaped center island and the traffic calming effect provided by the horizontal deflection. Roundabouts are ideal when installed on the edge of an urban center, as all vehicles entering this area must slow down.

The ability of roundabouts to reduce vehicular crashes is well documented, but less research has been done on their effect on pedestrian and bicycle crashes. However, by reducing and simplifying interactions between pedestrians and vehicles, and reducing speeds, roundabouts have the potential to improve pedestrian safety. Steps must be taken to accommodate blind pedestrians, since they normally navigate four-legged intersections by the sound of the prevailing traffic movement, which is difficult to decipher at roundabouts. Bicycles should be directed into the flow of traffic with no bike lane markings due to the complexity of interactions with vehicles.

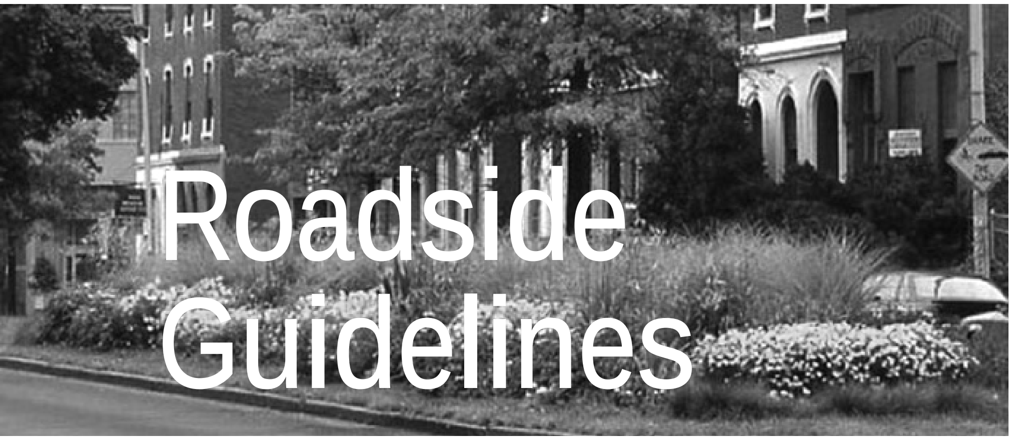
For more information on roundabouts, consult the FHWA publication *Roundabouts: An Informational Guide* (2000) and PennDOT Publication 414, *Guide to Roundabouts (2007).*

Table 7.2 Selected design characteristics of roundabout categories

Design Element	Mini roundabout	Urban Compact	Urban Single-Lane	Urban Double-Lane	Rural Single-Lane	Rural Double-Lane
Maximum entry design speed	15 mph	15 mph	20 mph	25 mph	25 mph	30 mph
Typical inscribed circle diameter	45 - 80 ft	80 - 100 ft	100 - 130 ft	150 - 180 ft	115 - 130 ft	180 - 200 ft
Typical daily service volume on 4-leg	10,000 veh/day	15,000 veh/day	20,000 veh/day	**	20,000 veh/day	**

Source: FHWA publication *Roundabouts: An Informational Guide* **(2000)**

*** Special procedures required for calculation*



8.0 Roadside Guidelines

8.1 PEDESTRIAN FACILITIES

Walkability is a critical gauge of a healthy community. Whether in an urban core or a suburban area, pedestrian activity is best accommodated by a connected network of sidewalks, complementary land uses, attractive streetscaping, regular controlled pedestrian crossings, and lower speeds of passing traffic. The most difficult environment for pedestrians is found along higher order roadways in suburban areas, where gaps occur in the sidewalk network, vehicles pass by at high speeds, and the opportunity for safe pedestrian crossings is much less frequent. However, good design can make a major difference in how comfortable and safe these roadways are for pedestrians.

8.1.1 Sidewalks

Sidewalks are desirable to support both mobility and safety. Their presence has been shown to reduce the risk of pedestrian crashes in residential areas; a 1987 FHWA study found that locations with no sidewalks were more than twice as likely to have pedestrian/motor vehicle crashes as sites where sidewalks existed.[58] The safety benefit was particularly pronounced in residential and mixed residential areas. Approximately 15% of pedestrian accidents in suburban and rural areas occur when a pedestrian is struck while walking along a roadway.[59]

The 13 ft. clear sidewalk width on this downtown street permits groups of people to comfortably walk side by side.

A basic strategy for improving pedestrian conditions is to provide sidewalks along all roadways with developed land uses. The vast majority of municipalities in New Jersey and Pennsylvania have sidewalks missing in at least some developed land use areas, in part a product of the post-World War II planning philosophy that emphasized vehicular mobility in suburbia. Unfortunately, even today municipalities in both states continue to approve retail centers and other land uses on suburban roadways with no sidewalks. Along many suburban corridors, pedestrians stitch together trips by walking through parking lots, grass lots, and in the roadway. Other people elect to forego trips by walking or by transit. However, momentum has gathered for requiring sidewalks in all roadway projects, federal, state and local. In 2000, FHWA announced that bicycling and walking facilities will be incorporated into all transportation projects unless "exceptional circumstances" exist.

Missing sidewalk links are one of the biggest impediments to pedestrian mobility, particularly in suburban areas in the two states. Pedestrians in these areas must regularly walk in the street.

In response, the states have been planning, and should continue to plan, for sidewalks in a greater share of roadway projects. At the state level, sidewalks should be considered very early in the planning process to ensure adequate funding is programmed. The final decision to incorporate sidewalks into projects may ultimately be based on program-wide fiscal considerations of the DOT.

The provision of sidewalks has usually been a local responsibility, falling under the municipality's authority to approve new land uses and supporting infrastructure. In the two states, there is only one law mandating the installation of sidewalks in conjunction with land development: the New Jersey *Residential Site Improvement Standards* (RSIS), N.J.A.C. Title 5, Chapter 21. This law applies only to residential developments. It states that sidewalk widths shall be 4 feet, with greater widths near pedestrian generators and employment centers. No state law applies to the installation of sidewalks in commercial developments in New Jersey, or commercial or residential areas in Pennsylvania.

Therefore, the most fundamental action that can be taken by any municipality to improve pedestrian facilities is to amend its land development ordinance to require the installation of sidewalks for new and redeveloped land uses. ITE's *Design and Safety of Pedestrian Facilities* recommends that sidewalks be provided:

- in commercial and industrial areas, along both sides of all roadways;
- in residential areas, along arterials and collectors, and local streets with 1 unit or more per acre;
- in residential area with less than 1 unit per acre, sidewalks may be provided along one side of the roadway.

The ITE text further recommends use of a sidewalk and curb and gutter for any local street within two blocks of a school site.

Some municipalities may wish to retain a rural atmosphere for certain areas, and exclude these areas from this requirement. AASHTO's *Guide for the Planning, Design and Operation of Pedestrian Facilities* suggests that in low-density areas, sidewalks be installed whenever the roadway changes from open swales to curb-and-gutter. The *Guide* also says that sidewalks may not be needed on some local roadways with traffic volumes less than 400 per day.

In suburban areas, developers have routinely requested waivers from sidewalk requirements, typically on the grounds that any anticipated pedestrian activity would be minimal. With few exceptions, this should not justify a waiver, given piecemeal suburban development patterns and the constant potential for redevelopment with more intensive uses.

8.1.2 Sidewalk and Buffer Widths

The Matrix provides recommended dimensions for "clear sidewalk widths," or the section of sidewalk unencumbered by street furniture and not immediately next to buildings. (The concept of clear sidewalk width is the same as "effective walkway width" discussed in the NJDOT *Pedestrian Compatible Planning and Design Guidelines*.)

This 9 foot buffer provides good separation for pedestrians from motorists. Wide buffers are especially desirable on roadways posted at 35 mph or higher.

Clear sidewalk widths of 8 to 10 feet are recommended for major roadways in town center and urban core contexts. Recommended clear sidewalk widths of 5 to 8 feet predominate in most context types. Including the street furniture area and building shy distance, total recommended widths extend from 10 to 18 ft. in most urban contexts. This represents an ideal goal; in physically constrained areas – or most existing neighborhoods in the two states – sponsoring agencies should aspire to provide the widths referenced in clear sidewalk widths.

Although developed primarily to ensure accessible routes for buildings and facilities, the *Americans with Disabilities Act Accessibility Guidelines* (ADAAG) have been pressed into service as the controlling authority for public sidewalks. ADAAG mandates an accessible route width of at least 3 ft., and a width of 5 ft. at regular intervals as passing spaces. In order to specifically address public walkways, the Access Board has released the draft *Public Rights-of-Way Accessibility Guidelines* (November 2005). These require a 4 foot wide pedestrian access route, located within a sidewalk, shoulder, shared street or street crossing. Periodic passing spaces of 5 ft. in width are also required.

Because of the requirement for periodic passing spaces of 5 ft. in width, local governments are increasingly specifying 5 ft. as the recommended minimum for sidewalks, and that standard is recommended here. In significantly constrained areas, a sidewalk width of 4 ft. may be considered. If a buffer is not provided, sidewalk widths of 6 ft. in residential areas, and 8 ft. in commercial areas is recommended.

The presence of buffers, comprised of landscaping in suburban areas, and street furniture in urban areas, is important to the comfort level and perceived safety of pedestrians. The widest buffers – at 6 to over 8 ft. – are recommended on suburban corridors since vehicular speeds are highest in these areas. Wide setbacks are not essential for pedestrian comfort in urban areas, particularly when on-street parking is available and well used, and speeds are moderate. However, wide buffers can be beneficial in this environment in providing room for street furniture and landscaping.

Along low to moderate-speed roadways in residential areas, buffers can be of minimal width. These should be at least 4 ft. to accommodate street trees. Three feet is the minimum width if a grass or planted strip is desired; any buffer less than this should be paved.

8.1.3 Medians

On multi-lane roadways, medians can be among the most desirable features for pedestrians. At signalized intersections in which the pedestrian crossing phase is the bare minimum required by the *Manual on Uniform Traffic Control Devices*, and pedestrians are unable to complete the crossing of the entire intersection, a median will permit them to safely wait until the next pedestrian crossing phase.

Along suburban corridors at unsignalized locations, medians play an even more vital role. Because of the distance separating signalized intersections in these areas, pedestrians are reluctant to cross roadways only at these locations, and many pedestrians will conduct mid-block crossings. The hazard of these crossings can be mitigated by the installation of physical medians. Further, medians reduce the time required for pedestrians to cross; delays are up to 10 times longer for pedestrians crossing undivided multilane roadways than roadways with medians.[60] Medians should always be considered when the cartway width exceeds 60 ft.

Median islands intended to serve as pedestrian refuges should be at least 6 ft. feet wide from curb to curb, although 8 ft. is preferable. In constrained conditions, median widths of 4 ft. feet curb-to-curb are acceptable. All islands should have curb ramps or cut-through ramps at street level to accommodate pedestrians in wheelchairs.

Yield to pedestrian signs mounted on the centerline of two-lane roadways have proven effective in increasing the yielding rate of motorists, and are highly recommended for urban areas.

Advanced yield markings are recommended in conjunction with uncontrolled pedestrian crossings on multi-lane roadways to reduce the possibility of multiple threat crashes.

8.1.4 Crosswalks

Crosswalks should be present on all legs at signalized intersections, unless hazardous conditions make one or two legs unsuitable for installation. Crosswalks may also be installed on the controlled legs of unsignalized intersections. The ability to install them on uncontrolled legs of unsignalized intersections depends on the same kinds of factors that are used to determine if crosswalks should be installed at midblock locations.

AASHTO *Guide for the Planning, Design and Operation of Pedestrian Facilities* recommends midblock crosswalks under the following circumstances:

- Already substantial number of midblock crossings
- Due to existing and planned pedestrian generators, pedestrians are highly unlikely to cross the street at the next intersection
- Spacing between adjacent intersections exceeds 660 feet
- Adequate sight distance is available.

Midblock crosswalks should typically not be installed within 300 feet of signalized intersections. However, on low-speed two-lane roadways in urban contexts, particularly with very high levels of pedestrian activity, mid-block crosswalks may be considered within 200 feet of signalized intersections.

Whether or not to install a midblock crosswalk can be among the most contentious pedestrian planning issues. There is a widespread perception that simply installing crosswalks will make crossings at unsignalized locations safer; studies are definitive that this is not the case. The most extensive study on this topic yet conducted (FHWA, *Safety Effects of Marked vs Unmarked Crosswalks at Uncontrolled Locations*, November 2000) concludes that there is no difference in safety between marked and unmarked midblock crosswalks on two-lane roads, and that marked midblock crossings on multi-lane roadways are actually less safe than unmarked midblock crossings. The greatest difference in crash types at the two crosswalk types on multi-lane roadways is the role of "multiple threat" crashes. In this crash type, a vehicle yields to a pedestrian in the crosswalk on a multi-lane roadway. The yielding vehicle obscures the view of another motorist heading in the same direction. The pedestrian steps in front of the oncoming vehicle, and is struck.

The report concludes that crosswalks, by themselves, should not be installed at uncontrolled crossing locations on two-lane roadways with ADTs (average daily traffic) above 12,000, and multi-lane roadways with ADTs above 9,000. More substantial engineering treatments need to be considered, including raised medians, pedestrian signals, and signs and markings.

Table 8.1 summarizes of the effectiveness of the most common crosswalk treatments, based on TCRP Report 112/NCHRP Report 562, *Improving Pedestrian Safety at Unsignalized Crossings* (2006). This report provides a comprehensive review of previous studies and evaluates several measures in the field.

As indicated, half signals are especially effective, but have seen little application in this country, and some professionals are concerned that the use of red beacons places these measures somewhere in between a warning light and traffic control light. In-street pedestrian crossing signs are very effective, but their application is restricted to two-lane roadways. A wide variety of warning lights have been tested, with in-pavement lights showing greater

Physical islands have been demonstrated to increase the safety of pedestrian crossings. Northampton, Massachusetts supplements the island with signs advising pedestrians to pay attention to oncoming vehicles before crossing.

A variety of blinking pedestrian crossing signs have shown promise in increasing the yielding rate of motorists.

yield compliance than overhead lights. Raised medians by themselves have modest effect on yielding compliance, but are highly recommended on multi-lane roadways for their ability to facilitate safer crossings.

The safest pedestrian crossings – particularly for multi-lane, higher speed roadways – often combine several different treatments. The appropriate crosswalk treatment depends principally upon roadway operating speeds and number of travel lanes. Following are recommendations for the installation of midblock crosswalks (or crosswalks at unsignalized intersections) on different roadway types:

Regional Arterial. Installation of midblock crosswalks on regional arterials should involve the most intensive treatments. These should only be used on roadways of 40 mph or less, since motorists have increasing difficulty stopping at speeds of 40 mph or more.[61] A raised median is highly recommended to accompany mid-block crossings on multi-lane roadways. Advanced yield markings, warning lights and high-visibility markings are also desirable.

Community Arterial. On multi-lane roadways, a raised median and advanced yield markings are desirable. Accompanying lights are recommended for two-lane roadways of 35 mph or above, as well as multi-lane roadways. All crosswalks installed should be high visibility. Curb extensions are recommended on any street with on-street parking.

Main Street. "Yield to Pedestrian" signs mounted on the roadway centerline are highly recommended for this roadway sub-type, along with high-visibility markings. Curb extensions are less critical, but are recommended for streets with on-street parking. They will provide better visibility of and by pedestrians, and should not reduce the number of on-street parking spaces, since parking within 25 feet of the crosswalk would be prohibited in any case.

Community Collector. On multi-lane roadways, a raised median and advanced yield markings are desirable. Accompanying lights are recommended for two-lane roadways of 35 mph or above, as well as multi-lane roadways. All crosswalks installed should be high visibility. Curb extensions are recommended on any street with on-street parking.

Neighborhood Collector. Crosswalks should be accompanied by pedestrian warning signs or "Yield to Pedestrian" signs mounted on the roadway centerline. Crosswalks may be high visibility depending on traffic volumes and speeds. Curb extensions to accompany on-street parking is also recommended.

Local Road. Crosswalks should be accompanied by pedestrian warning signs.

TCRP Report 112/ NCHRP Report 562 provides "Guidelines for Pedestrian Crossing Treatments." This report recommends installing traffic control devices only when peak hour pedestrian volume exceeds 14 per hour on roadways posted above 35 mph, or 20 per hour on roadways posted 35 mph or lower. However, these thresholds can be difficult to meet in suburban areas. If the installation of pedestrian facilities would lead to increased pedestrian volumes, and if controlled pedestrian crossings are more than 600 ft. away, consideration should be given to installing new controlled crossings.

Table 8.1 Effectiveness of Crosswalk Treatments

Treatment	Description	Results
Raised median	Physical median, preferably 6 to 8 ft. wide.	Pedestrian crash rates on multi-lane roadways are 2 to 4 times lower than on roadways without raised medians.
Advanced yield markings and signs	White triangles distributed evenly across roadway 20 to 50 ft. in advance of crosswalk, accompanied by “Yield Here to Pedestrians” sign.	Reduced vehicle-pedestrian conflicts on multi-lane roadways by 67% to 87%.
Overhead flashing beacon	Flashing amber lights installed in conjunction with, or integral within other warning signs. A wide variety of applications has been tested.	Resulted in yielding compliance of 30% to 76%; original field studies for TCRP 112 indicated 49% yielding compliance when pushbutton activated, 67% with passive activation.
Overhead lighted sign	Constantly lit sign with appropriate legend such as “Crosswalk.”	Resulted in yielding compliance of 40% to 52%.
In-pavement lights	Lights are installed in pavement similar to lights on airport runways, with lights protruding above pavement up to .5 inches.	Resulted in yielding compliance of 50% to 90%.
In-street “Yield to Pedestrian” sign	Signs are typically placed on flexible orange stanchions, mounted on roadway centerline. Studies have been limited to two-lane roadways.	Resulted in yielding compliance of 82% to 91%. This measure has achieved widespread use in both New Jersey and Pennsylvania.
Half signal	Solid or flashing red beacons are shown to major street, with stop control on minor street.	Original field studies for TCRP 112 indicate yielding compliance up to 98%.

Source: *TCRP Report 112/NCHRP Report 562, Improving Pedestrian Safety at Unsignalized Crossings.*

8.2 PUBLIC TRANSPORTATION

Transit facilities are an important component of the context-sensitive roadway. This Guidebook recommends increased use of public transportation through facilities that expedite travel, and afford a more comfortable environment for pedestrians.

The focus of this Guidebook is on providing facilities for transit vehicles that utilize surface roadways, as well as riders who walk to and from bus stops. Local governments in the two states have final authority over where to locate bus stops, but it is highly recommended that they coordinate closely with the transit operators in their area, and seek their views on bus stop design early in the process. It should also be noted that all bus stops should be designed to comply with the Americans with Disabilities Act (ADA).

8.2.1 Vehicle Types

Table 8.2 provides design characteristics for three bus types often seen in urban areas. The most common type for local service is the conventional 40 ft. bus; conventional buses can also be manufactured in lengths of 30 to 35 ft. Articulated buses have a joint in the middle which enables them to maneuver comfortably on city streets; they are normally used only in high demand situations, such as major urban areas and college campuses. Intercity buses are typically operated on longer routes with express portions and intercity service with limited stops. Small buses (25 ft. in length) are not discussed in this Guidebook since they are not commonly used in fixed route service, and can be accommodated by stops designed for conventional buses.

Vehicle width does not include both the right and left side mirrors, each of which can add another 12 inches to the vehicle width.

8.2.2 Bus Stops

Following are recommendations for the identification, placement and physical features of bus stops:

Identification – A sign at each bus stop should indicate the agency’s name and logo; bus route and destination; schedule; and the agency’s telephone number and website. Parking prohibitions should be identified by another sign (i.e., MUCTD R7-107) or pavement markings.

Bus Types

Placement - Bus stops are placed at the nearside or farside of an intersection, or at midblock locations. Below are basic factors that should be considered in bus stop placement:

- At intersections, a consistent pattern of stops (e.g., all nearside or all farside) enables transit patrons to readily comprehend where they need to board a bus.
- At intersections where more than one bus route operates, and in particular where buses operate on cross streets, consideration should be given to the ability to conveniently transfer to other bus routes.
- Stops should be located close to major passenger generators.
- Curb space should be provided to accommodate the desired number of buses, and passenger waiting areas.

Bus stops at intersections are preferred because they provide the best pedestrian accessibility from both sides of the street as well as the cross streets. They also provide for the most convenient transfers to intersecting bus routes.

In limited instances, a midblock bus stop will be suggested by the presence of major generators. Compared to conditions at proximate intersections, midblock bus stops lessen sight distance problems for pedestrians and motorists, produce fewer pedestrian conflicts, and reduces pedestrian congestion at passenger waiting areas.

A major concern with midblock bus stops is that they increase the walking distance for pedestrians who must cross at intersections, and, in so doing, can encourage people to cross the street midblock (i.e., "jaywalk"). This is problematic on high-speed roadways.

At intersections, farside bus stops are typically preferred to nearside stops, especially in urban centers or other areas with high pedestrian volumes. One study found that about 2% of pedestrian crashes in urban areas, and 3% of crashes in rural areas, are related to bus stops. A common pattern is when the pedestrian steps into the street from in front of a stopped bus. This pattern is associated with nearside stops more than farside stops.

Other considerations related to bus stops at intersections include:

- Where it is not desirable to stop the bus in a travel lane and a turn-out is warranted, a farside stop (or even a midblock stop) is preferred.

Table 8.2

	Conventional	
	30 ft.	40 ft.
Length (ft.)	30	40
Width (in.)	102	102
Height (in.)	120	120
Centerline turning radius (ft.)	31	40
Inside turning radius (ft.)	13	25
Seating capacity	23	40

	Articulated
Length (ft.)	60
Width (in.)	102
Height (in.)	131
Centerline turning radius (ft.)	38
Inside turning radius (ft.)	21
Seating capacity	65

	Intercity
Length (ft.)	46
Width (in.)	102
Height (in.)	138
Centerline turning radius (ft.)	47
Inside turning radius (ft.)	30
Seating capacity	50

- If a route requires a left turn, the bus stop should be placed on the farside after the left turn is completed. If this is not possible, a midblock bus stop is preferred, but must be located far enough from the intersection so that the bus can still maneuver into the proper left turn lane.
- If a route requires a right turn, or if there is a high volume of right turns at an intersection, the bus stop should be located at the farside location.
- If too many buses would utilize a farside stop and there is not enough room to extend the bus stop, a nearside location should be used instead.
- When an intersection is complex and has several dedicated turn lanes, farside bus stops are preferred because they are removed from the location where complex traffic movements are performed.
- At simple signalized intersections, nearside stops permit riders to discharge when they are stopped at red lights.

Geometrics – The bus stop area in which parking is prohibited must be long enough to permit buses to maneuver to and from the curb, and to accommodate the safe movement of pedestrians from the curb to the bus. The amount of distance required for a bus stop depends on four factors: (1) the type of bus stop; (2) the length of buses using the stop; (3) the number of buses using the stop; and (4) the posted speed limit of the roadway.

The dimensions in Figure 8.1 are consistent with NJ Transit Guidelines, and apply when buses are operating in the lane adjacent to the curb lane. If parking is prohibited and the bus operates in the curb lane, the bus stop length could be reduced to the length of one bus.

Curb space may be limited in some urban business districts, due to high demand for on-street parking. However, the municipality should not designate bus stops of inadequate length, since the bus will be unable to "dock" at the curb. In this situation, the driver will either "nose in" the vehicle or stop in the street, forcing passengers to step into the street, and not permitting the deployment of the wheelchair lift/ramp for disabled riders.

If space is highly constrained, the municipality may wish to forego mid-block bus stops, since they require the greatest length. The municipality may also consider the use of "bus bulbs." A bus bulb is a section of the sidewalk that extends from the curb of a parking lane to the edge of the through lane. Buses stop in the traffic lane instead of weaving into and out of the bus stop that is located in the parking lane. The bus bulb need only extend the length of the bus, and thereby saves parking spaces. However, because traffic behind is held up during passenger loading, the bus bulb is not preferred for heavily congested roadways.

8.2.3 Turn-Outs

A turn-out is desirable for roadways where the posted speed limit is higher than 40 miles per hour, at stops with a high number of passenger boardings and dwell times. These features allow buses to pull out of the flow of traffic to board and alight passengers, thus not impeding the free flow of vehicular traffic. Figure 8.1 shows the recommended dimensions.

When nearside bus stops have a turn-out, the "exit taper" length can be removed (and 50 ft. deducted from dimensions shown in Figure 8.1) since it is assumed that the bus will utilize the intersection area to merge with traffic. Similarly, if farside bus stops have a turn-out, then the "entrance taper" length can be removed. If multiple buses will use the bus stop, then the "Total Bus Stop Length" can be increased by the length of the additional buses with an allowance of ten feet for separation between buses.

8.2.4 Bus Stop Characteristics

Other desirable characteristics of a bus stop include:

- Front and rear door clearances should be 5 feet wide and 8 to 10 feet deep.
- All-weather, slip resistant surface in bus stop area.
- Slopes are not to exceed two percent in boarding area.
- Vertical clearances of 84 inches.
- No obstructions in boarding/alighting areas, and room for pedestrians to wait without entering the roadway and without impeding other pedestrian movements.
- Compliance with ADA standards, including ability to accommodate bus wheelchair lifts and/or ramps.
- Bus riders must be readily visible to satisfy traffic safety and security issues, with adequate lighting from adjacent parcels and street lights.

Spacing – Bus stop spacing represents a trade-off between providing a high number of stops (thus increasing service coverage and maximizing ridership) while still allowing the transit service to operate at reasonable speeds and trip times. Following is typical bus stop spacing for the seven context areas described in this report:

Table 8.3 Bus Stop Spacing

Context	Stops per Mile	Typical Spacing (ft)
Urban Core, Town Center	10 to 12	450
Town/Village Neighborhood, Suburban Center	5 to 10	750
Suburban Corridor, Suburban Neighborhood	4 to 6	1,000
Rural	As needed	As needed

8.2.5 Bus Stop Amenities

This bus shelter impedes pedestrian movement on the sidewalk.

Passenger Waiting Shelters – Following are minimum design specifications for shelters:

- Three walls (a rear and two sides with a minimum covered area of 48 square feet. For areas with space limitations, other types of shelters (e.g., umbrella or half-wall or canopies) may be used.
- Interior seating.
- A minimum front clearance of four feet (five feet desirable) from the shelter to the edge of the curb.
- Minimum sidewalk around shelter (i.e., sides and rear) of three feet (five feet desirable).
- Display panel for route and schedule information, if not provided on information kiosk.

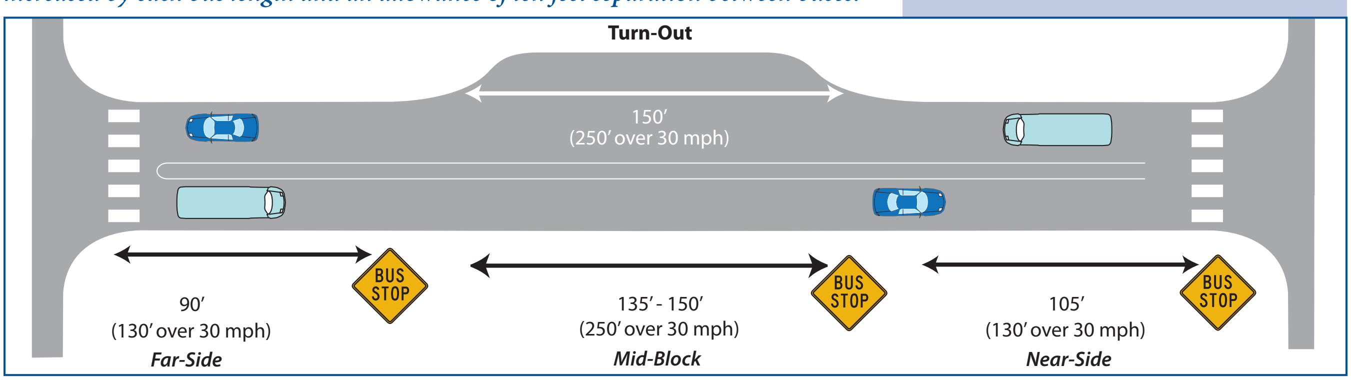
Seating - Bus stop seating increases patron comfort and reduces perceived waiting time. A bench should be at least six feet wide and placed four feet from the curb. If a four ft. space is not available from the curb, the bench may be installed with its back facing the street.

Information Kiosks/Boxes – These display schedules, maps and other information.

Other Customer Features – Trash receptacles, bicycle storage racks, public telephones, lighting and landscaping.

Specialized treatments to better accomodate buses, such as "bus shoulder" and "transit signal priority" may be considered in high activity transit corridors. For more information about such treatments, see: NCHRP Project 20-7 Task 135 report, "Geometric Design Guide for Transit Facilities on Highways and Streets—Phase I Interim Guide," prepared for AASHTO Standing Committee on Highways, July 2002.

Figure 8.1 Bus stop dimensions vary depending upon their position on a block. If two or more buses regularly load at the same time, the bus stop length would be increased by each bus length and an allowance of ten feet separation between buses.



8.3 LANDSCAPE DESIGN

More than a valued aesthetic enhancement, landscaping helps integrate a roadway into the surrounding environment. Street trees provide shade and physical definition to roadways. Landscape features buffer pedestrians from passing vehicular traffic, making them feel more comfortable. They provide an important stormwater management function by reducing runoff, and improving water quality by filtering runoff before it enters the collection system or nearby streams. Following are principles to follow in installing street trees and other plants.

8.3.1 Street Trees

Street trees are the most critical landscaping element. Historic problems with street trees (e.g., buckling sidewalks, interfering with utility poles) can be addressed by careful species selection and utility placement (on the inside of the sidewalk).

The best location for street trees depends upon area context and roadway. For curbed roadways in urban contexts or developed suburban contexts, trees should be planted next to the street. At maturity, the trunks of these trees should be at least 18 inches from the face of the curb. This distance will permit car doors to open, and is recognized by the AASHTO Green Book as an "operational offset." In suburban contexts, trees can be planted inside and adjacent to the sidewalk if sufficient right-of-way is unavailable.

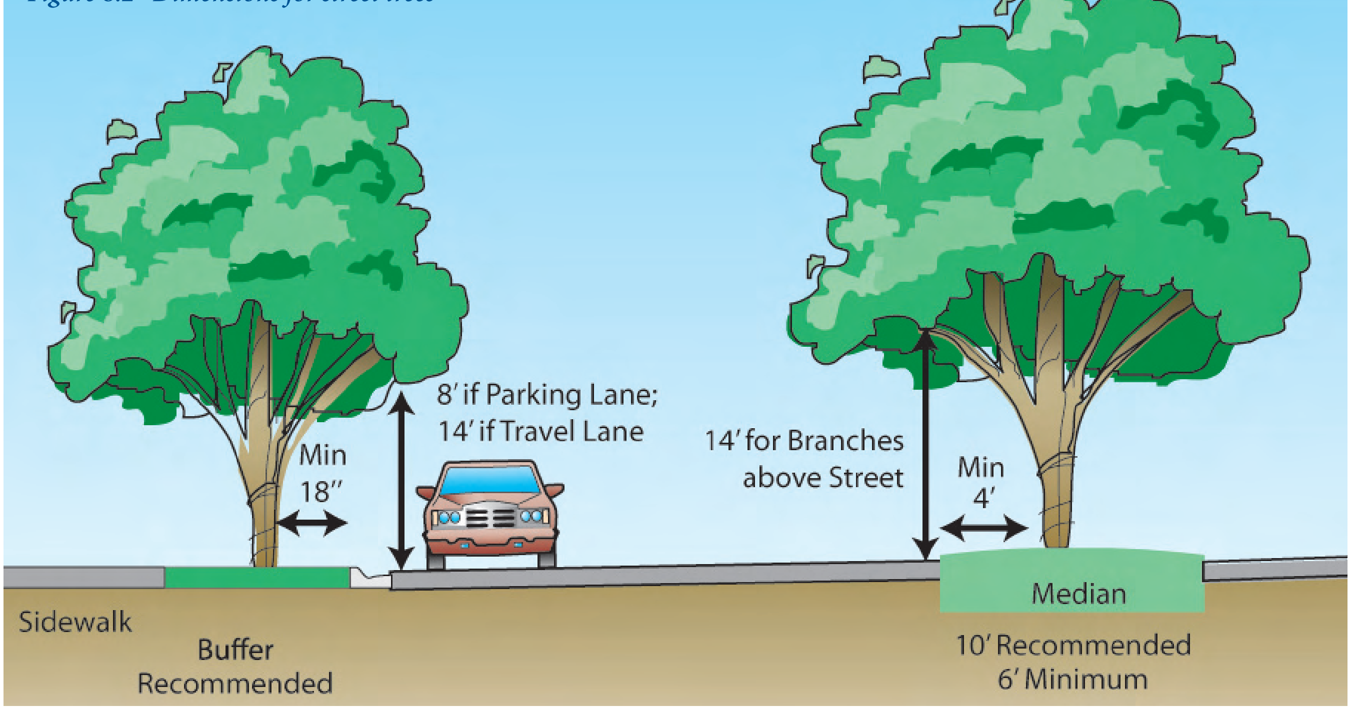
Along roadways with speeds over 45 mph, that are uncurbed or have mountable curbs in rural and suburban context areas, trees with a mature diameter of four inches or more should not be planted within the clear zone. If the street right-of-way is not appropriate for trees, municipalities should request developers to plant trees close to the front lot line.

A tree planting strip of 5 ft. in width is preferred, but 4 ft. strips are common. In constrained areas, a tree pit of 3 ft. may be used for small caliper trees.

Trees must often compete for space with utilities. In urban contexts, if overhead lines are present along the roadway, there are two options: the community should select trees that grow to a maximum height of 25 to 35 ft. at maturity, or trees with a fine branch system that can be trimmed to grow on either side of the lines.

A clear sight line should be maintained along all intersections and curb cuts, and trees should be kept trimmed around all signs and signals. Trees should provide a clear-

Figure 8.2 Dimensions for street trees



ance of 7 ft. above sidewalks, and 8 feet above parking lanes. A clearance of 14 ft. is required on PennDOT roadways if the curb lane is used for moving vehicles. Along New Jersey state roadways, vegetation that has potential to obstruct sight distance should not be planted in the clear zone.

Tree spacing typically varies from 30 ft. to 50 ft., although a minimum of 15 ft. spacing is possible with some tree species. A dramatic effect can be achieved by planting trees in close proximity. On downtown retail streets, the spacing should be at the most between 30 ft. and 40 ft. in order to create the shading and comfort that is welcome along a shopping sidewalk. Spacing can be wider in residential neighborhoods; since larger species are possible here, shade and visual interest along the street can still be maintained.

Tree species in commercial areas are chosen based on owner concerns about blocking views to retail signage and store window displays. Trees that branch up over the first floor signs, and that have an open leafed habit are desirable in these areas.

Trees in Medians

- The recommended raised median width for tree planting is 10 ft. on street segments with infrequent driveways and intersections and 14 ft. to 16 ft. on street segments with frequent driveways and intersections. The minimum median width to accommodate trees is 6 ft. with the approval of a municipal forester or arborist.
- Trees are not recommended for medians when roadway operating speed exceeds 45 mph.

A six foot wide planting strip permits more elaborate landscaping treatments.

- Trees planted within the median serve to reduce the perceived width of the street, and may have the effect of calming traffic.
- Trees in the median should have an upright profile and be high branching. Branches that extend beyond the curb into the street should be pruned 14 ft. above the pavement. Trees can be planted within 50 ft. from the ends of medians only if a high tree canopy is maintained, providing adequate sight distance.

8.3.2 Other Landscaping

Small-scale landscape planting includes shrubs, flowers, ground covers, and smaller ornamental trees. Following are guidelines for small scale plantings:

- Plant species can be used to differentiate between arterial and local streets or various context areas. Use unique plant palettes to characterize and create an identity for each design situation.
- Commercial areas typically receive landscape treatments that are low maintenance and drought tolerant. However, funding of a vigorous maintenance schedule, such as by a business improvement district, will permit more diverse and attractive landscaping treatments.
- Small-scale landscape spacing ranges from 6 in. on center for groundcover, to 6 to 8 ft. on center for large shrubs, to 15 ft. on center for ornamental trees.
- Developers should avoid installing shrubs in the public right-of-way, in the path of pedestrians. If no sidewalk is present, a clear path must still be maintained for pedestrians to walk along the frontage of all developed properties.

8.3.3 Buffering

A well landscaped buffer creates a visual barrier between traffic and pedestrians, providing comfort for the latter. Following are recommendations for the buffer area:

- Low plantings should be spaced densely enough to provide massing, plant drifts and visual interest.
- To heighten decorative effects in high-profile urban and suburban areas alike, plant a minimum 50 percent of a buffer area with vegetation other than lawn.

8.4 STREET FURNITURE

Street furniture refers collectively to sidewalk amenities that accommodate pedestrians, transit users and bicyclists. Types of street furniture include benches, trash receptacles, newspaper racks, bike racks, bollards, kiosks, transit shelters, and street lights. Following are guidelines for selection and arrangement of street furniture.

- The most important aspects of selecting street furniture are to ensure that the colors, materials, and styles make up a family of unified furnishings, and reflect the character of the context area and surrounding architecture.
- Street furniture should be placed where it can accommodate the greatest number of people, and where activity nodes are most desired. Certain furnishings such as trash receptacles and newspaper racks are often clustered near intersections where pedestrians are waiting to cross. Benches should be placed according to design intent. For example, when located at a transit stop, they should face the street for functionality, and when intended for rest and people-watching, they can be placed so that the pedestrian is encouraged to feel a sense of privacy while still connecting with the public square. Benches can be placed near popular restaurants to accommodate people waiting to be seated.
- Public trash receptacles are placed in the buffer zone.
- Bike racks should be located in the buffer zone with a 3 foot minimum clearance between bicycles parked at racks and other street furniture.
- All newspaper racks should be located in the buffer zone, but open toward the pedestrian throughway.
- Chairs, tables, planters and displays are typically located close to buildings. Communities can consider permitting these in the pedestrian throughway as long as desirable widths for pedestrians are maintained.

It should be noted that on all state projects, the cost of installing and maintaining street furniture is borne by the community.

Public art helps to enliven public spaces, as seen in this photograph of children posing with a sculpture of a dolphin on a downtown street.

8.4.1 Lighting

Lighting for the sidewalk and shopfront area is most effectively provided by pedestrian-scale streetlights (12 to 16 ft. in height) placed inside the curb. Spaced about 60 ft. apart on ornamental poles, they can also provide roadway lighting for streets less than 45 ft. wide. Wider streets will require additional illumination to meet IESNA (Illuminating Engineering Society of North America) standards. A lighting fixture with good color rendition makes for a safer, more welcoming nighttime environment – an important quality for successful commercial districts. Preferred pedestrian lighting is mercury vapor, metal halide or incandescent. Low-pressure sodium lights are undesirable because they create distortion.

9.0 Road System Issues

9.1 ACCESS MANAGEMENT

Access management is the "systematic control of the location, spacing, design and operation of driveways, median openings, interchanges and street connections to a roadway (TRB *Access Management Manual*, 2003)." Benefits include:

- **Safety.** The implementation of good access management practices on a corridor can reduce vehicle crashes by 50 percent or more.[62]
- **Mobility.** Spacing traffic signals at appropriate distances permits signals to be coordinated for optimized operation. Optimal signal spacing can reduce the need to increase a roadway's capacity by widening intersections and corridors.
- **Reduction of conflicts with non-motorized modes.** Controlling the number and width of driveways reduces areas of exposure for pedestrians and bicyclists along a roadway.
- **Aesthetics.** By providing raised medians and reducing the width of driveways, more room can be used for landscaped beds or decorative hardscape surfaces.

Access management is appropriate for all roadway types, but the techniques employed depend upon roadway functional classification and context area.

- **Roadway function.** The highest level of access management applies to high-speed regional and community arterial roadways.
- **Land use context.** Greater access control is appropriate for higher order roadways in suburban areas, where operating speeds are highest. Conversely, a higher concentration of driveways is normally found in urban contexts. However, the number of driveways should be moderated on main streets, to reduce conflicts between motorists and pedestrians or bicyclists.

9.1.1 Access Management in New Jersey and Pennsylvania

New Jersey

The State Highway Access Management Code (N.J.A.C. Title 16, Chapter 47) provides for the comprehensive regulation of access on New Jersey state roadways. The Code regulates the spacing between unsignalized access points and between traffic signals, as well as the type of access.

Controlling the number and width of driveways along a roadway improves vehicular safety and mobility, and reduces the areas of exposure for pedestrians and bicyclists.

The Access Management Code also offers the ability to prepare an access management plan for an entire stretch of state highway. The participants in creating a plan are the host municipality; the county, if a county roadway intersects the highway segment; and NJDOT.

Because NJDOT has complete authority over the design of driveways on state highways, New Jersey municipalities have little ability to influence access on these roadways. However, through the subdivision and site plan approval process, municipalities can encourage developers of properties on state highways to investigate the use of frontage roads, cross access drives, and shared driveways. An incentive (such as a reduction in the number of parking spaces) could be offered to those developers that use the desired access management techniques. It should be noted that municipalities can approve regulations governing access on county and municipal roadways.

Pennsylvania

Pennsylvania Access Management regulations are provided in the Pennsylvania Code, Title 67, Chapter 441 – *Access to and Occupancy of Highways by Driveways and Local Roads*. Chapter 441 specifies the permissible number of driveways and location of driveways for a lot. The regulations do not have spacing standards, as found in New Jersey.

Pennsylvania permits municipalities to implement access management regulations for state highways. As authorized by Chapter 441, these regulations can be more stringent than PennDOT's, provided they result in safer conditions. A number of Pennsylvania municipalities have enacted provisions regulating access on state roadways. West Fallowfield Township in Chester County adopted a highway corridor overlay district for PA Routes 10 and 41 in 1997, which limited the number of access points for developing properties, and applied design standards to new access points. In 2002, Smithfield Township and Middle Smithfield Township in Monroe County enacted access management overlay districts for US Route 209. These ordinances required owners to investigate gaining access from a joint driveway or cross access driveway if prescribed spacing standards could not be met, and encouraged joint access points through the incentive of reducing the required lot frontage and number of parking spaces by 15 percent.

9.1.2 Access Management Techniques

A variety of tools can be used to achieve access management objectives, with the most common discussed below.

Median Treatments

Both two-way left-turn lanes (TWLTLs) and nontraversable medians offer significant advantages over undivided roadways in terms of both safety and mobility. Raised medians are generally preferable to TWLTLs, but the latter are successfully used on commercial corridors with moderate traffic volumes and speeds, and high numbers of driveways. See Medians, Section 7.5.

Shared Driveways

A shared driveway (also referred to as a joint access drive) provides access to two or more properties. Municipalities can implement ordinances encouraging landowners to investigate the feasibility of shared driveways as part of the site development review process.

Cross-access drive

Cross-access drives provide interparcel circulation between two or more lots, and are highly recommended for commercial corridors (see Figure 9.1). Customers that would otherwise re-enter an arterial street to drive to an adjacent property are able to now drive (or walk) via internal connections between properties. An easement is often used to facilitate creation of the cross-access drive.

Channelization

Channelization involves the use of physical islands or pavement markings to direct traffic movements into definite paths of travel to facilitate safe and orderly movements of both vehicles and pedestrians. Common examples are changing a driveway from unrestricted access to right turn in, right turn out only.

Frontage Roads

This is an access drive that parallels a major public road between the right-of-way of the major roadway and the front building setback. It provides access to private properties while separating them from the principal roadway (TRB *Access Management Manual*, 2003).

9.2 TRAFFIC CALMING

ITE defines traffic calming as "the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior and improve conditions for non-motorized street users." This definition is consistent with the concept of "desired operating speed," discussed earlier in the document. Physical design, complementary road striping, and other strategies are key to slowing motorists to speeds that are appropriate to their contexts, thereby reducing the number and severity of collisions, and increasing the safety and comfort of pedestrians and bicyclists.

9.2.1 Traffic Calming Practice

Although traffic calming was initially implemented mostly on local roads, many cities in the U.S. are now calming collector streets and arterials as well.[63] The road diet – or removing and/or narrowing travel lanes – is one of the most common traffic calming practices for arterial and collector roads. In 2005 Ocean City, New Jersey narrowed West Avenue, an arterial, from four lanes to three lanes and added bike lanes and a wide median. Installed for a trial period on six blocks, residential response was so positive that the City extended the road diet treatment to two miles. The 85th percentile speed was reduced by 1 mph, with the number of high speed "outliers" – those traveling at more than 10 mph over the speed limit – dropping from 12% to 4% of motorists.[64]

The popularity of road diets can be explained by their ability to lower speeds, improve safety, and add room for non-motorized users. A study for the Iowa Department of Transportation of 15 road diets documented a reduction in crash rate of 19%, while a study of road diets in the Seattle area found an average crash reduction of 29%.[65] A review of 14 road diet treatments across the country indicate that eight resulted in speed reductions ranging from 1 to 5 mph, although no notable decreases were seen in six of the treatments. Road diets are particularly effective in calming aggressive motorists, since they are required to queue up in a single lane, often behind more patient motorists.

Cities are also increasingly willing to install traffic calming measures such as speed tables, curb extensions, and center islands on higher order roadways. For example, the City

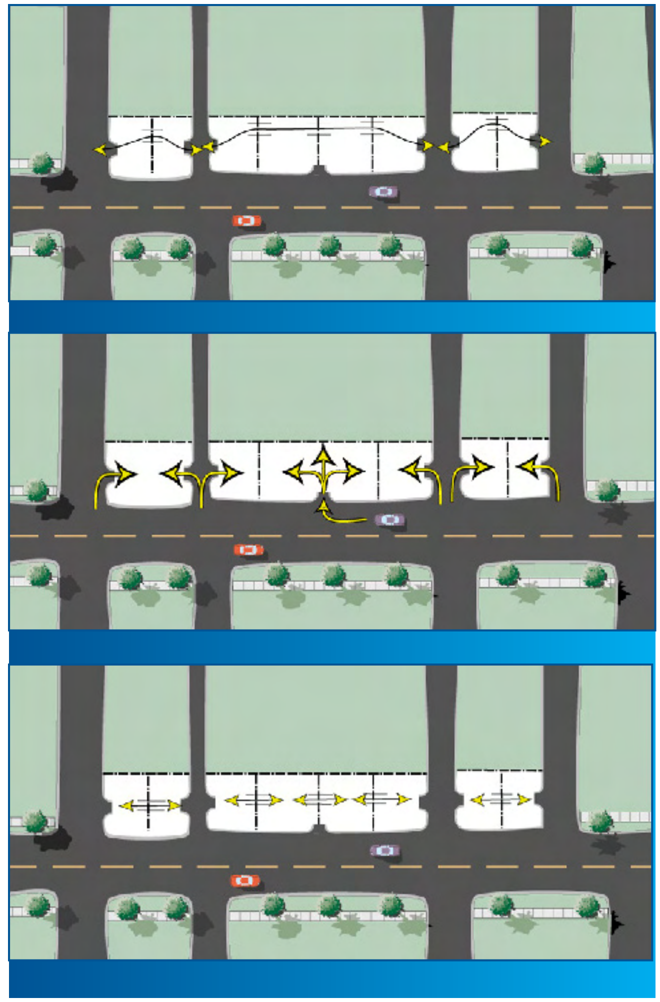


Figure 9.1 The linkage of driveways and parking lots along a corridor permits safer traffic conditions, and benefits pedestrians and bicyclists.

of Beaverton, OR, implemented speed tables, raised intersections, curb extensions(also called bulbouts), and center islands on a collector roadway lined with residential uses and schools, lowering the 85th percentile speeds from 40 to 34 mph.

Many highway calming projects do not literally "calm the highway" but, instead, replace the highway with main streets, boulevards and parkways, with traffic calming measures built into their cross-sections. These measures, known as "cross-section measures," include a reduction in lane widths, textures, medians, edge treatments (e.g. removing shoulders and adding curb and gutter) street trees, curb extensions, wider sidewalks, and on-street parking.

9.2.2 Traffic Calming Policy

The acceptance of traffic calming, on all roadway classifications, is increasingly seen. AASHTO endorsed the extension of traffic calming to higher order roadways: "Traffic calming techniques may apply on arterials, collectors, or local streets. Traffic calming aimed at reducing speeds is primarily used in lower speed urban areas and in speed transition areas such as near the urbanized limits of small towns."[66]

At the city and county levels, hundreds of traffic calming programs have existed for some time. At the state level, PennDOT issued Pennsylvania's *Traffic Calming Handbook* in January 2001, and other states have issued manuals and/or have exploited the flexibility already inherent in their guidelines.

9.2.3 Traffic Calming and Context Sensitive Design

Traffic calming and Context-Sensitive Design (CSD) are synonymous as they pertain to the design of most roadways. The ITE international subcommittee that defined traffic calming in 1996 provided a broad list of contextual considerations for design such as location, street type, land use, public transit needs, aesthetics, community preferences, budget, desired speeds and other goals for the street. These are all CSD issues.

For example, as Route 29 goes through Lambertville, New Jersey, its new context-sensitive road diet will include roundabouts, going from four to two lanes, adding on-street parking, adding street trees, and other traffic calming measures.

9.2.4 Lessons from Europe

Although a relatively new idea in the United States, calming on higher order roadways has been accepted in Europe for over thirty years. Following are examples of European traffic calming principles, and the lessons they hold for the US:

- Choose appropriate design speeds. Because functional classification schemes in Europe strike a balance between speed and other goals such as bicycle/pedestrian friendliness, speeds tend to be lower than in the

US Highway 50 in Virginia is a good example of a comprehensive traffic calming project that is aimed at producing appropriate speeds in urban and transition areas alike. The 50 mph highway passes through several small towns. The Virginia DOT, at the request of the local communities, shelved their plans to build highway bypasses around the small towns along with widening the highway to four lanes. Instead, the State is implementing a traffic calming project, leaving the highway at two lanes and narrowing an already built four-lane section back to two lanes. Highway 50 will also be changed to suit its various contexts; it will be a rural highway between the towns, a main street in the towns, and go through transition areas at the edges of the towns. The design speeds range from 50 mph in the rural areas to 25 mph in the towns. Splitter island proposed for Route 50 in Virginia (Courtesy of Lardner/Klein Landscape Architects, P.C.)

U.S. Common speeds are 50 km/h or 31 mph on traffic calmed urban arterials and 40-50 km/h (25-31 mph) on highways as they pass through towns and villages. The main lesson here for U.S. applications is to derive the desired design speed from the context, not the functional classification.

- Choose measures and spacing of features appropriate to design speed and classification. In Denmark, only entranceways, and lateral shifts are permitted at design speeds of 60 km/h (37 mph) or more. At 50 km/h (31 mph), other measures such as narrowings and raised areas are also common. At 40 km/h (25 mph) or less, a much larger menu of measures are used. The lesson here is that cross-section measures are more suitable for arterials and community collector streets, while on neighborhood collector and local streets, periodic measures are also suitable.
- Reallocate right-of-way in favor of non-automobile modes. Europeans have long restriped multilane roads to a single lane in each direction, similar to the US practice of "road diets."
- Provide ample warning on approaches to calmed areas. In Europe, entranceways such as islands and roundabouts are used to mark the transition from highway speeds to town speeds in aesthetically pleasing ways. Islands are used to enhance the effectiveness of entranceways, and roundabouts are even more effective in reducing speeds due to their horizontal displacement.
- Emphasize street edge treatments. Europeans strive to create street environments inviting to pedestrians, slowing the speeds of motorists in the process, through the qualities of human scale, visual enclosure, and complexity. Street trees, requiring buildings to be built to the back of sidewalk, and street furniture contribute to these qualities.
- Facilitate pedestrian crossings. Small corner radii and curb extensions shorten crossing distances for pedestrians and reduce motorists' turning speeds. Curb extensions at the corners and at mid-block crossings provide safe vantage points for pedestrians to see and be seen.

9.2.5 Traffic Calming and Health and Safety

Before-and-after studies, in the US and abroad, of streets which have been traffic calmed, show large reductions in the number and severity of collisions. Typically, a 50% drop in the number of collisions occurs along with

European communities have long championed the combined use of traffic calming measures on higher order roadways. This roadway in a Paris suburb uses a raised intersection along with median islands and roadway narrowing to slow motorists.

an 80 to 90% reduction in deaths and injuries. Further, traffic calmed streets encourage walking and cycling, and helps "self-enforce" speeds, reducing the burden on local police.

Although slow speeds have health and safety benefits, the needs of emergency responders should be taken into consideration. Emergency responders, particularly the fire department, are sensitive to "response time." However, if streets are designed for high speeds for the fire department, other motorists can speed as well. Consequently, a balance needs to be achieved between the competing interests of public safety.

Traffic calming measures are therefore divided into two categories: those appropriate for "framework" streets and those appropriate for both framework streets and "non-framework" streets.

- Framework streets include community collector streets and arterial streets – that serve as regular emergency vehicle routes. Traffic calming measures appropriate for framework streets include only "cross-section measures" because response times are generally unaffected by cross-section changes.

It is important to have a network of framework streets so that emergency responders can get to calls without encountering too many periodic measures. In certain circumstances, periodic measures can be used for framework streets, adjacent to heavy pedestrian generators such as schools, civic institutions, or along a main street.

- Non-framework streets include local streets and neighborhood collector roads which are rarely used by emergency vehicles. Both cross-section and periodic measures can be used on these streets. However, even on non-framework streets, the number of periodic measures should be limited, with no more than 8 to 12 measures between two framework streets. This will help keep emergency response times reasonable and increase public acceptability.

9.2.6 Application

Following are guidelines for the application of traffic calming measures on different roadway classifications:

Table 9.1. Traffic Calming Measures Appropriate to Roadway Classifications

Classification			Regional Arterial	Community Arterial	Community Collector	Neighborhood Collector	Local Street
Design speed range (mph)			30 to 45	25 to 45	25 to 30	25 to 30	20 to 25
Traffic calmed category			Framework Street		Non-Framework Street		
Transition zone to traffic calmed segment			Appropriate	Appropriate	Not Appropriate	Not Appropriate	Not Appropriate
Gateway (landscaping, archway, signs, etc.)			Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
Cross Section Measures	Reduction in number of lanes		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Reduction in width of lanes		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Long median		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Short median/refuge		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Bulbouts[1]		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Curb and gutter		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Pedestrian-scale lighting		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Street trees		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Buildings at back of sidewalk		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Lateral shifts		Not Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Bike lanes		Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	On-street parking	Parallel	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
		Back-in- angle	Not Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
		Front-in-angle	Not Appropriate	Not Appropriate	Appropriate	Appropriate	Appropriate
		90°	Not Appropriate	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate
Periodic Measures	Horizontal Measures	Roundabouts	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
		Mini-traffic circles	Not Appropriate	Not Appropriate	Appropriate	Appropriate	Appropriate
		Chicanes	Not Appropriate	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate
		Short medians	Not Appropriate	Not Appropriate	Appropriate	Appropriate	Appropriate
	Narrowings	Pinch points	Not Appropriate	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate
	Vertical Measures	Raised intersections	Appropriate in Special Circumstances	Appropriate in Special Circumstances	Appropriate	Appropriate	Appropriate
		Raised crosswalks	Appropriate in Special Circumstances	Appropriate in Special Circumstances	Appropriate	Appropriate	Appropriate
		Flat-top speed humps	Not Appropriate	Not Appropriate	Appropriate	Appropriate	Appropriate
		Speed cushions	Not Appropriate	Not Appropriate	Appropriate	Appropriate	Appropriate
		Speed humps	Not Appropriate	Not Appropriate	Not Appropriate	Appropriate	Appropriate

Key: *Appropriate* *Not Appropriate* *Appropriate in Special Circumstances*

1 Bulbouts should be used on regional arterials only in urban or suburban center contexts, with speeds of 35 mph or below. On arterials they should be no greater than 6 ft. in width.

9.3 OPERATIONS AND MAINTENANCE

Local maintenance capabilities are important to consider with designs that incorporate landscaping. A community that supports a maintenance-heavy design, such as a planted median, will generally need to provide the maintenance itself, since NJDOT and PennDOT may not be able to do so. Community and neighborhood associations may be enlisted to provide maintenance on such features. Alternatively, the cost of maintenance may lead a community to support alternative measures, such as installation of a hardscape median, or low-maintenance plants such as natural grasses.

Issues regarding maintenance of roadways differ between the two states.

New Jersey

State highways account for a relatively small percentage of roadways in the state. Offering greater flexibility in the design on state-owned roadways may become more feasible in some cases if the roadway is de-designated as a state highway and shifted to county or municipal ownership. This option relieves the state of maintenance responsibility and liability and gives localities control of the roadway design. The tradeoff is that the municipality will have to assume responsibility for maintenance of the roadway.

The report *Flexible Design of New Jersey's Main Streets* notes that a lack of money at the local level for reconstruction and maintenance is a leading hindrance to de-designation.[67] This burden may be partially alleviated through state or federal grants, through cost sharing arrangements, or through road swaps. The report contains a number of case studies offering potential funding solutions, and recommends in particular 1) removing segments that no longer function as state or county routes from their respective systems, and 2) maintenance agreements between state and local governments that will permit more design flexibility.

Raised crosswalk

Pennsylvania

PennDOT owns a greater percentage of higher order roadways than NJDOT, but PennDOT's curb-to-curb maintenance policy typically requires local control and maintenance of curbing and sidewalks. This includes sidewalks, landscaping, street furniture, gateway signage, and roadside lighting not required by PennDOT. Municipalities should understand the implications of additional maintenance on their end before undertaking the project.

9.3.1 Maintenance Operations

Snow Removal

Many communities require homeowners and businesses to clear the sidewalks fronting their property within a reasonable time after a snowfall. Despite this, public agencies must often become involved in clearing snow from sidewalks along major commercial roadways. For public works agencies, the best strategy would entail first clearing the snow from the road, and following up with the use of snow blowers and hand shovels as needed to clear pedestrian facilities. Unfortunately, even when sidewalks and roadways are cleared, a substantial wall of snow is often left adjacent to the curb, presenting obstacles to pedestrians and making pathways impassable for persons in wheelchairs. Priority should thus be given to clearing curb ramps at all intersections. Bike lanes should also be cleared; snow should not be stored there until it melts.

The buffer/ street furniture zone widths recommended in the Matrix should provide sufficient area to store snow in the immediate aftermath of a snowfall.

When snow removal is not possible, departments should consider taking measures to improve pedestrians' foot traction, such as hard-packing the snow, or using de-icing compounds.

9.4 EMERGENCY VEHICLES

Narrower lane widths, physical medians, smaller curb-return radii and traffic calming measures all have potential to increase the response time for emergency service vehicles. Even when the potential increase in incident response time is minor, the concerns of emergency service personnel should be considered. In some cases, it will be possible to build support for smart transportation solutions if emergency services understand that the improvements will result in slowing traffic to speeds appropriate to the context, resulting in fewer and less severe crashes. However, this will not always suffice to address the concerns of emergency service respondents, and the actual impact on emergency service operations will need to be evaluated in such cases.

9.4.1 Major Issues

All of the following issues should be considered in addressing emergency vehicle needs:

Response routes. Alternate response routes should be designated. A high level of connectivity for roadway networks will give more options to emergency service providers.

Classification of the roadway. The higher the classification, the more likely it is that the roadway is used as a primary response route for an emergency service company (i.e. framework streets).

Land use context. The land use context should also be an important consideration. For example, long ladder trucks need to be accommodated in downtowns with multi-story buildings. But in residential neighborhoods of one- and two-story homes, shorter or smaller fire trucks may be the appropriate design vehicle.

Design vehicle. The appropriate design vehicle should be established through coordination with the local fire company. In some areas, fire codes have additional accessibility requirements, such as minimum clear widths designed for space to deploy ladders to reach high buildings and portable ponds for water. If fire companies are located on a neighborhood collector and local streets, designers should consider the emergency vehicles housed at these companies when designing curb radii for intersections used frequently by the fire company.

Modification of design. Street designers need to reconcile emergency service objectives on public streets with a myriad of regular public safety and design objectives. The street designer can better accommodate multiple objectives if he or she is given, and employs, design flexibility.

The proposed installation of a raised median on a wide roadway is a common example of a context sensitive design that may be viewed differently by local planners and by emergency service companies. Planners may regard the median as an opportunity to provide safer crossings for pedestrians, and to slow down speeding traffic by narrowing the travel lane. Emergency service companies may see the median as hindering their ability to travel on the roadway centerline to avoid long queues of traffic when responding to an incident.

There are various means of addressing the concerns of emergency services in such a situation. Adjusting the width of the lane, or installing median islands with a flush hardscape surface are possible options. Medians could be installed with mountable curbs about 200 to 300 feet back from an intersection approach that frequently experiences queuing traffic, permitting emergency vehicles to cross the median to bypass blocked lanes.[68] Mountable medians can be super-reinforced with grasscrete pavers, soil reinforcement or concrete with added rebar.

Curb extensions could be provided with mountable (or flush with pavement) curbs, featuring bollards to protect the pedestrian area. It should also be assumed that emergency vehicles can encroach into opposing travel lanes to some degree.

9.4.2 Context Sensitive Streets and the Fire Code

An obstacle to the construction of context sensitive streets has been the adoption of the National Fire Code (NFC) in its entirety by municipalities. The NFC recommends a 20 ft. clear path on all streets. While this width is virtually always achievable on arterial and collector streets, on local streets this provision contradicts the AASHTO Green Book, ITE *Neighborhood Street Design Guidelines*, and other planning and engineering best practices. If literally applied, it would consign to obsolescence one of the most popular local street types, the 24 to 26 ft. local street with parking on both sides. There is no indication that traditionally narrow local streets have contributed to deaths or injuries from impeding emergency responses. Particularly since narrow streets enhance safety and community life by reducing the incidence of speeding,

the language on 20 ft. clear paths on local streets should not be adopted by municipalities. Instead, municipalities should rely on guidance from AASHTO or ITE.

However, a 20 ft. clear provision is acceptable for private roads and for private driveways into gated subdivisions. Often, the design standards for private streets are less than those for public streets. Furthermore, there are usually fewer redundant routes for emergency responders to use into private developments should the main driveway or private street get blocked.

9.4.3 Traditional Neighborhood Developments

Concerns about emergency response are often raised with traditional neighborhood developments, since they often feature narrow public street widths, alleys, and minimal curb radii.

As the first step in addressing these concerns, two points are in favor of traditional neighborhood developments:

- Most of the emergency responses in a typical community are to incidents such as car crashes, not to house fires. With their traffic calming effects of their roadway design, TND's are intended to reduce the frequency and severity of vehicular crashes.
- The high degree of connectivity found in TND's offer emergency service companies multiple routes to the site.

Where the above arguments do not suffice, TND's have managed to preserve the smaller geometries of streets above the classification of alleys by using the following strategies:

- demonstrating to local emergency personnel the navigability of the smaller road widths and radii using cone tests and a computer program called AutoTURN;
- putting local fire personnel in touch with firefighters in communities which already have TND's; and,
- installing flush curb returns at corners to accommodate fire trucks.

TND's have managed to preserve the small geometries of alleys through the following strategies;

- explaining that alleys are not intended to be a primary means of fighting a fire (and therefore should not be designed for the largest ladder truck); and,
- demonstrating how the alley benefits first responders by creating a new secondary means of attacking a house fire with smaller equipment.

Many of these concerns could be addressed if urbanizing communities encourage their fire departments to purchase smaller, more navigable equipment designed for the tighter spaces of smart growth communities and require installation of sprinkler systems in appropriate buildings.

Emergency Vehicles Major Issues

Response Routes

Classification of the Roadway

Land Use Context

Design Vehicle

Modification of Design

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