



Technologies for Safe & Efficient Transportation

THE NATIONAL USDOT UNIVERSITY
TRANSPORTATION CENTER FOR SAFETY

Carnegie Mellon University

UNIVERSITY of PENNSYLVANIA

Highway Corridor Transformation Research Study - Proof of Concept

FINAL RESEARCH REPORT

Stephen Quick and (PI) Donald K. Carter

Contract No. DTRT12GUTG11

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the U.S. Department of Transportation's University Transportation Centers Program, in the interest of information exchange. The U.S. Government assumes no liability for the contents or use thereof.



pennsylvania
DEPARTMENT OF TRANSPORTATION

Highway Corridor Transformation Research Study - Proof of Concept

FINAL REPORT

September 30, 2016

By Stephen Quick and (PI) Donald K. Carter
CARNEGIE MELLON UNIVERSITY

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

CONTRACT # CMUIGA2012
WORK ORDER # 06

**Carnegie
Mellon
University**



Blank Page

1. Report No. FHWA-PA-2016-012-CMU WO 06		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Highway Corridor Transformation Research Study – Proof of Concept				5. Report Date September 30, 2016	
				6. Performing Organization Code	
7. Author(s) Stephen Quick, Principal Author, with Donald Carter (PI), Christine Mondor, Patty Folan, Stephen Smith, and Tim Dawson				8. Performing Organization Report No. Not Applicable	
9. Performing Organization Name and Address Carnegie Mellon University 5000 Forbes Avenue Pittsburgh, PA 15213				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No. CMUIGA2012 – CMU WO 06	
12. Sponsoring Agency Name and Address The Pennsylvania Department of Transportation Bureau of Planning and Research Commonwealth Keystone Building 400 North Street, 6 th Floor Harrisburg, PA 17120-0064				13. Type of Report and Period Covered Final Report – 1/11/16 to 9/30/16	
				14. Sponsoring Agency Code	
15. Supplementary Notes Not Applicable					
16. Abstract Corridor Guidelines, typologies, and multimodal design recommendations for PennDOT corridor highways in Pennsylvania based on context sensitive solutions, smart transportation, and complete streets best practices.					
17. Key Words corridor, multimodal, PennDOT, highway, design, typology, roadway, guidelines, complete streets, corridor typologies, context sensitive solutions, smart transportation, civic engagement, climate change, holistic planning				18. Distribution Statement No restrictions. This document is available from the National Technical Information Service, Springfield, VA 22161	
19. Security Classif. (of this report) Unclassified		20. Security Classif. (of this page) Unclassified		21. No. of Pages 196	22. Price

Blank Page

Highway Corridor Transformation Research Study - Proof of Concept
PennDOT WO#006
September 2016

Pennsylvania Department of Transportation

CORRIDOR GUIDELINES



REPORT PREPARED BY

Remaking Cities Institute
School of Architecture
Carnegie Mellon University

Technical Advisor: Todd Kravits, PennDOT

Contract/Project Managers: Shelley Scott, PennDOT and
Courtney Ehrlichman, CMU

Disclaimer

The contents of this report reflect the views of the author(s) who is (are) responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Federal Highway Administration (FHWA) or the Commonwealth of Pennsylvania at the time of publication. This report does not constitute a standard, specification or regulation.

Copyright 2016 Remaking Cities Institute

RESEARCH TEAM AND PARTNERS

CARNEGIE MELLON UNIVERSITY

Remaking Cities Institute (RCI)

Donald K. Carter, Principal Investigator
Stephen Quick, Project Director and Lead Author
Marantha Dawkins, Researcher
Zharfa Ranjbar, Researcher
Olivia Wells, Researcher
Xuan Xu, Researcher

School of Architecture

Christine Mondor

Heinz School of Public Policy and Management

Patty Folan

Robotics Institute and Traffic21

Stephen Smith, Principal Investigator
Greg Barlow
Pranav Shah

Program for Deliberative Democracy

Robert Cavalier, Principal Investigator
Michael Arnold Mages
Casey Canfield
Tim Dawson
Selena Schmidt
Christine Shen

Funding was provided by the Federal Highway Administration, the Pennsylvania Department of Transportation and the Metro21 Program at Carnegie Mellon University

COMMUNITY PARTNERS

Economic Development South

Greg Jones, Executive Director
Lisa Brown, Saw Mill Run Watershed Coordinator
Stephanie Miller, Deputy Director
Jason Tigamo, Director of Real Estate

CONNECT (Congress of Neighboring Communities)

Kristen Maser Michaels, Executive Director
David Miller, Founder and Advisor

Technical Advisory Committee (TAC)

Dan Alwine	Office of Senator Matt Smith
Dan Barrett	Office of Councilwoman Natalia Rudiak
John Barrett	Baldwin Borough
Al Biehler	Carnegie Mellon University
Lance Chimka	Allegheny County Economic Development
Darcy Cleaver	Port Authority of Allegheny County
Dom D'Andrea	Southwestern Pennsylvania Commission
Ashleigh Deemer	Office of Councilwoman Natalia Rudiak
Deb Engler	Pleasant Hills Borough
Grant Ervin	Office of Mayor William Peduto
Tim Hindes	Fourth Economy
Greg Jones	Economic Development South
Todd Kravits	Pennsylvania Department of Transportation
Jim Leventry	Whitehall Borough
Breen Masciotra	Port Authority of Allegheny County
Stephanie Miller	Economic Development South
Ann Ogoreuc	Allegheny County Economic Development
Patrick Roberts	Pittsburgh Department of City Planning
John Rudiak	Carrick Community Council
Chris Sandvig	Pittsburgh Community Reinvestment Group
Matt Sebastian	Borough of Jefferson Hills
James Stitt	Pittsburgh Water and Sewer Authority
Dave Totten	Southwestern Pennsylvania Commission
George Zboyovsky	Brentwood Borough

Blank Page

TABLE OF CONTENTS

EXECUTIVE SUMMARY

- 1 Challenges and Transformation
- 2 Synopsis of the Report
- 4 Key Takeaways

BACKGROUND ON CORRIDOR PLANNING

- 9 Relating Corridors to Roadway Planning
- 14 PennDOT Transportation Policy and Directives
- 24 Multimodal Impact on Federal Directives
- 27 Conflicts with Existing Policy
- 34 PennDOT Project Planning
- 36 Corridor Planning Processes

NEW INFLUENCES ON CORRIDOR PLANNING

- 45 Climate and Risk
- 49 Metrics and Accountability
- 53 Holistic Project Practices
- 57 Civic Engagement

TOPIC AREA INFLUENCES

- 64 Urban Design
- 67 Economic Development
- 68 Environmental Infrastructure
- 71 Transportation
- 72 Transportation Technology

CORRIDOR GUIDELINES

- 77 Corridor Types and Comparative Matrix
- 81 RURAL CORRIDOR
- 85 SUBURBAN NEIGHBORHOOD CORRIDOR
- 89 SUBURBAN CORRIDOR
- 93 SUBURBAN CENTER CORRIDOR
- 97 TOWN/VILLAGE NEIGHBORHOOD CORRIDOR
- 101 TOWN CENTER CORRIDOR
- 105 URBAN CORE CORRIDOR

CORRIDOR PROJECT DELIVERY

- 110 Design Checklist
- 117 Right-of-Way Components
- 121 Civic Engagement Checklist

APPENDIX

- 126 Right-of-Way Components - Details
- 131 Performance Measurements - Details
- 145 Research Methodology and Approach
- 147 Case Study: Route 51 in Pittsburgh

RESOURCES

- 186 Endnotes
- 188 References
- 194 Photographs and Illustrations

Blank Page

CHALLENGES AND TRANSFORMATION

The Corridor Guidelines report is the result of a research study, Highway Corridor Transformation Research Study – Proof of Concept, commissioned by the Pennsylvania Department of Transportation (PennDOT) and the US Department of Transportation (USDOT). The objective was to provide proof of concept that a holistic approach to corridor transportation planning can be a model for mixed-use, multimodal transportation corridors that is replicable throughout the Commonwealth of Pennsylvania and elsewhere.

The study defines the primary proofs of a holistic approach to corridor planning; defines corridors as a string of functional roadway typologies that serve a connectivity need; introduces new influences that will affect future corridor planning and design; questions several current planning practices that send mixed messages toward achieving robust multimodal implementation; recommends a corridor classification system that parallels PennDOT's Roadway Typologies; recommends a set of Corridor Typologies and Guidelines, including type definitions and design recommendations; and concludes with recommendations for integrated corridor project delivery.

The report is intended to be an information source and guidebook for achieving safe, multimodal improvements for corridor facilities for transportation planners and engineers who have the responsibility of interpreting PennDOT policy and directives on Transportation Improvement Projects (TIPs). It is also a document for communities and citizen stakeholders to understand

the planning goals and design process of PennDOT in order to reach common ground between a TIP improvement project and the goals of the community it is intended to benefit.

Current transportation thinking embraces multimodal transportation as beneficial to residents, business, and industry now that road systems in urban areas are reaching their capacity and width limits. This is a healthier and more environmentally friendly perspective – and is also a more efficient use of resources and infrastructure. From the perspective of the pedestrian and bicyclist, higher density development and infill have begun to calm traffic as mass transit use increases.

With more pedestrians and bicycles occupying street systems, integrated transportation planning is now expected even if only as a means to protect those on foot and bicycle. Recently, the concept of Complete Streets has entered the transportation planning lexicon. Streets are now envisioned as public places and fundamentally multimodal, integrating street systems with activities of daily life.

Corridor planning fills the gap between long-range transportation planning and specific corridor construction projects. It provides a link between land use and transportation planning with the opportunity to direct, or even re-direct, future development within the community context of the corridor prior to construction. It also promotes stakeholder and public involvement, as well as increases interagency cooperation.

Transportation planning is in transition. Long-held beliefs and attitudes are being challenged, not only from the top but also by a different-thinking public less enamored by the automobile. Transportation planners are being challenged to think expansively and holistically. The problem is no longer how to squeeze in more traffic volume, but how to engage all parties with the task of creating an infrastructure amenity that is diversely beneficial. Citizens are demanding that transportation planning embrace the idea of “complete communities,” where streets and corridor systems contribute to the healthy sustainability of neighborhoods.

SYNOPSIS OF THE REPORT

Background on Corridor Planning

The early development of PennDOT's policies and directives focused on holistic planning and design can be traced back to the mid-1990s with the introduction of Context Sensitive Design/Solutions (CSS). This was followed by the subsequent adoption of Smart Transportation, Complete Streets, and Bicycle and Pedestrian Policy, combined with an agency-wide commitment to multimodal transportation across the Commonwealth. The section gives a brief summary of these policies, discusses conflicts with current directives, multimodal best practices, and FHWA's recent change in design criteria, and concludes with a synopsis of PennDOT's procurement, implementation and two suggested best practice processes for corridor planning and design.

New Influences on Corridor Planning

Long-range planning for infrastructure is currently experiencing fundamental changes as new concepts, technologies, and priorities rule out easy application of past standard practices. This section discusses Climate Change and the adaptation of transportation planning to mitigate its effects. The Metrics and Accountability section discusses performance measures for both the planning process and for the proposed project, including distinguishing between measured outputs and measured outcomes. Public participation in the process is discussed as an issues-based civic engagement to incorporate community values into

corridor solutions. The section includes a discussion of the interrelationship of multimodal design with design speed, level of service, and traffic calming and ends with a recent report on several cities reducing urban speed limits.

Topic Area Influences

Holistic planning encourages corridor planning and engineering teams to broaden their perspective and include topic areas of community development concern. This section discusses the disciplines of Urban Design, Economic Development, Environmental Infrastructure, Transportation, and Transportation Technology and their strategic value to corridor planning and design.

Corridor Guidelines

The Corridor Guidelines section describes seven corridor typologies by design characteristics, settings, and scales. They build on new multimodal corridor initiatives and complete street policies from the Federal government and PennDOT. Urban design, economic development, environmental infrastructure, transportation, and transportation technology are integrated into the design recommendations.

Corridor Project Delivery

This section describes the delivery and inclusion of the corridor guidelines into the planning and implementation process. Design, right-of-way

components, and performance measures are introduced to assist with project planning, as are civic engagement best practice recommendations.

Appendix

The Appendix contains detailed right-of-way design components and performance measurements to guide TIP project planning and design. The research team's approach and methodology are described along with lessons learned from the case study of Route 51 in Pittsburgh.

References

The report concludes with a listing of endnotes, references, and credits.



Figure 1 | Cycling is a form of multimodal transportation.

KEY TAKEAWAYS

Transportation Corridors are a new category of roadway classification, not just a new type of roadway.

PennDOT's comprehensive Roadway Typology provided the basis for distinction between roadway types and corridors. However, further work is needed to integrate roadway and corridor typologies.

Corridors are good candidates for best multimodal practices found with Complete Streets guidelines.

Complete streets policies and guidelines, particularly those for Philadelphia and Boston, provide clues for the inclusion of multimodal facilities in the right-of-way. However, this is far from standard practice in the United States, especially for transportation agencies that resist multimodal facilities for all but slow-speed streets. New thinking is required, including alternatives beyond the right-of-way. Fortunately, public opinion is changing to value the importance of multimodal options.

Multimodal design will require changes in standards of design speed, level of service, and traffic calming.

The first step is to acknowledge that walking and biking are major means of transportation. Planners and engineers have the responsibility to integrate and balance place-making and quality of life with efficient and effective traffic movement. Highway arterial corridors have traditionally been planned as high-speed roadways designed for high volumes

of traffic. That paradigm must shift to serve the roughly one-third of the population who do not drive motor vehicles.

- + Design Speed requires reconsideration. A community's land use policy should not be the result of accommodating design speeds, but rather an expression of community values. Place-making, aesthetics, and safety should all be acknowledged as legitimate factors of corridor (and roadway) design standards for all modes of transportation.
- + Level of Service is not an adequate measurement for a multimodal corridor because its sole focus is on the efficient and effective flow of motor vehicles, not the needs of pedestrians, bicyclists, and transit users. A better measurement is Multimodal Level of Service (MMLoS) that account for vehicles, pedestrians, bicyclists, and transit users. Not only does this standard measure the flow of all modes, but it also assesses the experiential and degree of safety experienced by each user type.
- + Traffic Calming features, such as speed humps and traffic circles, while effective and in compliance with complete streets policy on local residential streets with design speeds of 25 to 30 mph, are not permitted on faster moving corridors. Transportation planners and engineers need the flexibility to modify corridor roadbed design to calm traffic at transitions between corridor segments of different design geometries at major intersections and mid-block for the safe

accommodation of pedestrians, bicyclists, and transit users in addition to motorists.

Federal and Pennsylvania transportation policies and standards are not fully reconciled with multimodal corridor planning.

The message is clear from research and practice that achieving integrated multimodal corridor right-of-way design requires lowering traffic speeds, if for no other reason than safety. Integrating multimodal transportation means slower automobile and freight movement, the expansion of corridor right-of-ways to provide space for multimodal facilities, and, when physical conditions are too restrictive, the diversion of some multimodal facilities to adjacent roadways. It is interesting to note that the most efficient speed for the movement of the largest volume of motorized traffic is 27 to 30 mph,¹ well within the mandated design speed for local roads and streets and the most conducive for multimodal facilities and complete streets. Recently, many cities across the United States have lowered speed limits by 5 mph in response to the Vision Zero program that seeks zero traffic deaths.

Climate Change will alter how corridors will be designed in the future.

Higher temperature patterns will increase the heat island effect of roadway surfaces resulting in higher evaporation rates. The Argonne National Laboratory predicts that heavy rain events will increase by 225 percent or more within the next eighty years across most of Pennsylvania. Flooding of highway corridors from severe flash storms has already become a safety and environmental

hazard. Corridor planners and engineers must develop designs that not only fit immediate needs, but also perform adequately for decades under evolving climate conditions.



Figure 2 | Multimodal facilities should be considered for all corridors.



BACKGROUND ON CORRIDOR PLANNING

Relating Corridors to Roadway Planning
PennDOT Transportation Policy and Directives
Multimodal Impact on Federal Directives
Conflicts with Existing Policy
PennDOT Project Planning
Corridor Planning Processes

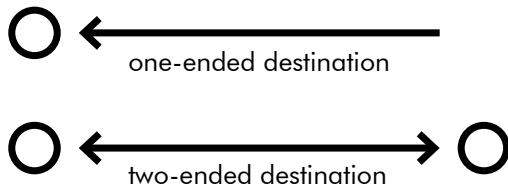
A corridor is a restricted tract of land that allows passage between two places. A transportation corridor, in its most basic definition, is a linear pathway for a particular mode of transportation that includes built pathways as well as designated pathways that involve no construction. Until recently, most transportation corridors have been defined by their modal uses, which provide the functional characteristics of the roadway.

Today there are a wide variety of definitions in literature and common language. Some are based on how the corridor is used, such as a street type, or by its geometric or geographical significance, such as a linear strip or a geographical area that connects people and goods. Corridors are also defined by uses other than traffic or transportation, such as a commercial corridor or an iconic moniker, such as the Las Vegas Strip, which is dominated by a certain type of land use that serves a neighborhood, city, or region.

What is common to corridors is a linear geometry, whether it is straight or curvy; that it connects a traffic generator to at least one predominant destination; and that it is traversed by at least one mode of transportation.

ARTERIAL CORRIDOR

An arterial corridor serves as a main route to a predominant destination. It may traverse urban, suburban, and/or rural areas to link traffic, goods, and passengers to either a one-ended or a two-ended destination. It can accommodate multiple transportation modes, although the automobile is generally the dominant mode.



COLLECTOR CORRIDOR

A collector corridor typically serves as a traffic collector to link an arterial corridor or, in some cases, to link to a predominant destination. Local destinations may also be found along a collector corridor. While mainly serving the automobile, bus or shuttle service may also use this corridor type.

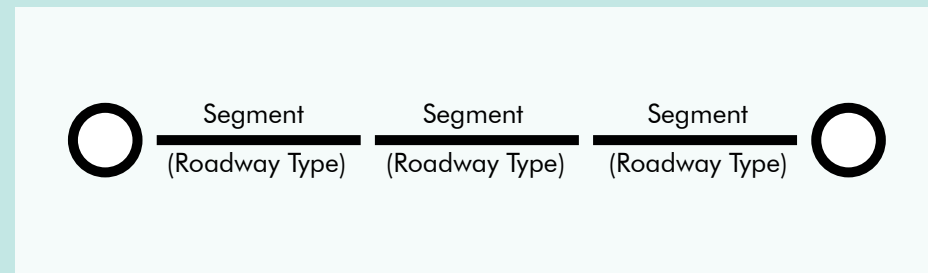
LOCAL CORRIDOR

A corridor under this category may have a series of small destinations along its path, such as retail and commercial uses that provide services to nearby communities. These are typically neighborhood-scaled streets that may also be served by bus.

WHAT IS A TRANSPORTATION CORRIDOR?

A transportation corridor^a connects people and goods to a destination by one or more conveyance modes.

Transportation corridors are combinations of roadway segments, with each segment meeting the definition of a respective roadway type.^b Typical corridors are highways that connect towns and villages to metropolitan centers as well as highways that connect the exurbs, suburbs, and outer ring urban neighborhoods to the urban core.



Corridors are not typical roadways and their sum of segments does not fully define their unique qualities. While not always intended to move high volumes of traffic to specific destinations with high efficiency, like Interstates or freeways, corridors nonetheless deliver people and goods to a destination faster and more direct than other secondary roadway types. Rather than limited access like a freeway, corridors are embedded within, and are part of, a network fabric that offers the shortest route to a destination.

^a The terms transportation corridor and corridor are used interchangeably in this report.

^b Corridors of a single roadway type are highly unusual.

RELATING CORRIDORS TO ROADWAY PLANNING

Functional Definition of Roadway Types

PennDOT had traditionally classified its road types by functional classification based on AASHTO’s 2004 publication *A Policy on Geometric Design of Highways and Streets*, (the Green Book), as follows:^a

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

The functional system differentiates between urban and rural settings, with each setting relating to its general context in terms of service characteristics. Note that there are subtle distinctions of scale within both urban and rural systems.

The problem with this system is that not all road types conveniently fit within a “one-size-fits-all” functional classification. For example, the design speed for a Principal Arterial in a suburban context may be inappropriate for a Principal Arterial in a dense, urban neighborhood. Nor does it recognize that Main Streets, when part of a Major Arterial or a Collector classification, have characteristics unlike other roadways in the same functional category.

PennDOT Redefines Roadway Types

Teaming up with the state of New Jersey, PennDOT and NJDOT adopted a more reasonable and workable system (Figure 3), which was first published in the 2008 NJDOT and PennDOT *Smart*

^a Note that PennDOT has adopted the Green Book 2004 edition, but not subsequent editions.

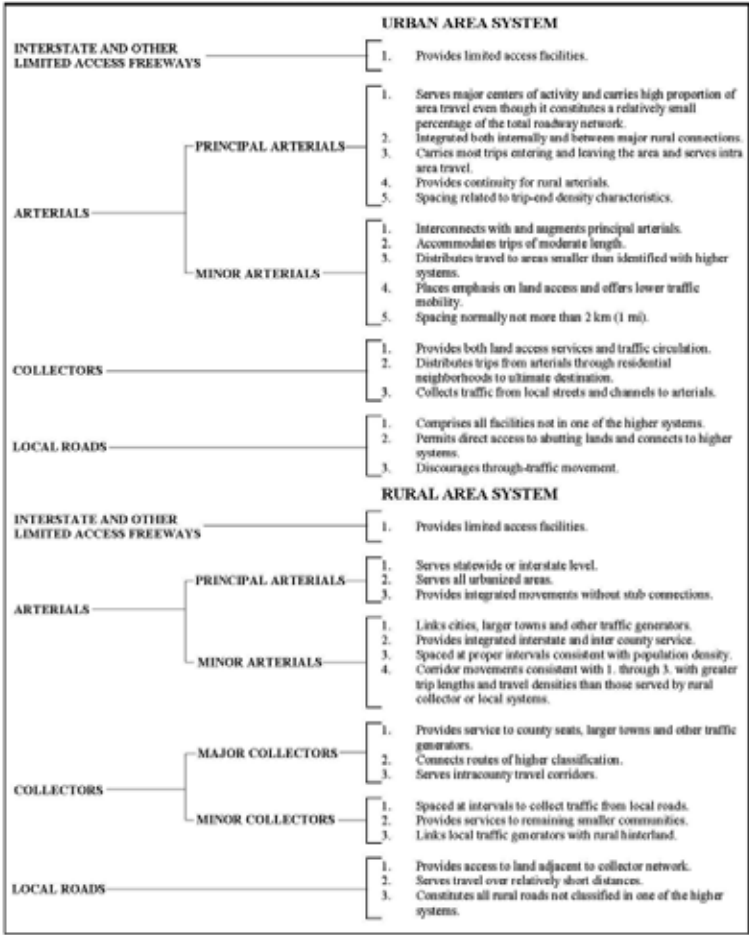


Figure 3 | Functional Classification System Characteristics that appears in PennDOT’s 2010 *Design Manual* provides useful functional information based on AASHTO’s 2004 Green Book. Although PennDOT has since revised the classification system as Roadway Typologies, the above functional description remains in effect. Note that Interstate and Other Limited Access Freeways, however, have not been carried over as road types in PennDOT’s Roadway Typologies classification system.

Transportation Guidebook (the Guidebook) as Table 5.1 Roadway Categories.²

This roadway typology classification system recognizes that each roadway type requires flexibility of definition and it provides more guidance on the characteristics of each type:

- + Regional Arterial
- + Community Arterial
- + Community Collector
- + Neighborhood Collector
- + Local

To understand the functional relationships with AASHTO’s Green Book classifications, Figure 4 makes reference to them in the right-hand “Comments” column.

The *Smart Transportation Guidebook* also recognized that a more thorough explanation of roadway typologies as a classification system was necessary to meet localized contextual needs. The Guidebook developed an illustrated matrix of these five types, which was later adopted without change in PennDOT’s 2010 *Design Manual* as Figure 1.2 Illustrated Roadway Typologies (Figure 4) and remains unchanged in the most recent 2015 edition. Note that the illustrated version also includes suburban settings, an important distinction that bridges the gap between rural and urban settings.

The Illustrated Roadway Typologies matrix identifies, by both location and scale, how the roadway types physically appear. Both Table 1.2 (Figure 4) and

Figure 1.2 (Figure 5) combine urban and rural functional types into a single classification of five functionalities that are identified by scale ranging from Regional to Local and by setting from Rural to Suburban to Urban.

PennDOT continues to use both the AASHTO Green Book (2004) and the PennDOT *Design Manual* (2015) for guidance on the design of roadways and corridors. So as not to confuse the two policy/guideline documents with respect to roadway typologies, the AASHTO functionalities are not the typology classification currently used by PennDOT.

Corridor Typologies

The Corridor Typology system framework for functionality and service is a derivative of PennDOT’s current Roadway Typology system framework (Figure 1.1, Functional Classification System Service Characteristics (Figure 3), and, for context settings and scale, Figure 1.2, Illustrated Roadway Typologies (Figure 5)). Only the roadway names have been changed to “Corridors.”

While the Corridor Typology system framework may appear as a minor adjustment to the Roadway

ROADWAY CLASS	ROADWAY TYPE	DESIRED OPERATING SPEED	AVERAGE TRIP LENGTH	VOLUME	INTERSECTION SPACING	COMMENTS
Arterial	Regional	50-90 km/h (30-55 mph)	24-56 km (15-35 mi)	10,000-40,000 veh/day	200-400 m (660-1,320 ft)	Roadways in this category would be considered "Principal Arterial" in traditional functional classification.
Arterial	Community	40-90 km/h (25-55 mph)	11-40 km (7-25 mi)	5,000-25,000 veh/day	90-400 m (300-1,320 ft)	Often classified as "Minor Arterial" in traditional classification but may include road segments classified as "Principal Arterial".
Collector	Community	40-90 km/h (25-55 mph)	8-16 km (5-10 mi)	5,000-15,000 veh/day	90-200 m (300-660 ft)	Often similar in appearance to a community arterial. Typically classified as "Major Collector".
Collector	Neighborhood	40-60 km/h (25-35 mph)	< 11 km (< 7 mi)	< 6,000 veh/day	90-200 m (300-660 ft)	Similar in appearance to local roadways. Typically classified as "Minor Collector".
Local	Local	30-50 km/h (20-30 mph)	< 8 km (< 5 mi)	< 3,000 veh/day	60-200 m (200-660 ft)	

Figure 4 | The 2010/2015 Design Manual’s Table 1.2 Roadway Typologies is a more flexible functional classification that acknowledges different contextual settings in response to AASHTO’s one-size-fits-all classification system.³

Typology system, it is not. Rather, it is a separate and stand-alone typological system that recognizes that various combinations of corridor roadway segments comprise a corridor. Likewise, the proposed Corridor Typologies system requires the greater contextual flexibility found with the current Roadway Typology system, not the 2004 AASHTO Green Book.

The Corridor Typology system framework is described in the Corridor Guidelines section later in this report. For practical purposes, this report focuses on Regional and Community Arterials as the typical corridor types because state highways are normally under the jurisdiction of PennDOT and not local communities. Interstates and freeways are also not identified as corridors.

The Corridor Typologies identified in this report align with the Roadway Typologies listed in the PennDOT Design Manual.

1. Rural Corridor
2. Suburban Neighborhood Corridor
3. Suburban Corridor
4. Suburban Center Corridor
5. Town/Village Neighborhood Corridor
6. Town Center Corridor
7. Urban Core Corridor

Locations:

8. Rural
9. Suburban
10. Urban

Scales:

11. Regional Arterial
12. Community Arterial
13. Community Collector
14. Neighborhood Collector
15. Local Road/Street



Figure 5 | The 2010/2015 Design Manual's Figure 1.2 Illustrated Roadway Typologies also includes suburban roadway settings that bridge between the earlier urban and rural locations, without changing the basic topological framework. This matrix is a useful tool for transportation planners in understanding how context and scale create identifiable, and differentiated, characteristics.

Individual and Network Corridor Patterns

Corridors assume one of two basic patterns: individual or network. They are not exclusive and many corridors share both patterns in typologically-different roadway segments.

Individual Corridors

An individual corridor is a linear corridor with intersecting roadways that typically meet the corridor at 90 degrees. They are stand-alone roadways and, as such, do not have parallel streets located a block or two off the corridor. While perceived as isolated lineal paths of a geometric grid, individual corridors can take the form of a radial pattern. Distances between intersections are usually quite long and pedestrian activity is often limited to crossings at intersections.

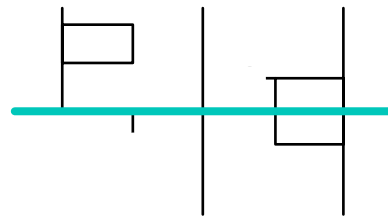


Figure 6 | Linear Individual Pattern. A primary thoroughfare continues down the center with buildings on either side. Side streets rarely parallel the main thoroughfare and may be present only on one side as determined by natural features and topography.

Individual corridors allow for a concentration of traffic on a few routes which is beneficial to auto-centric businesses and land uses that benefit from a steady volume of traffic, such as shopping centers or office districts. They are typically found in rural and suburban areas or where topographic conditions, such as valleys or ridges, limit an adjacent street network.

Network Corridors

A network corridor is a linear corridor with at least one adjacent and parallel roadway. Typically, there is a network of streets on either side of a corridor that form a web. Network corridors are found in urban and suburban areas and for short distances in rural towns and village with a street grid. Like individual corridors, network corridors can be lineal paths within a geometric grid or in radial and

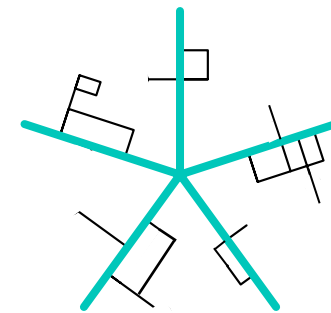


Figure 7 | Radial Individual Pattern. Primary thoroughfares radiate out from a central point. These streets may extend outwards 360 degrees around a central point or within an arc from a point along a natural barrier, such as a river's edge.

concentric patterns where the radial corridors are interconnected by a series of lateral roadways.

Network corridors facilitate circulation for all travel modes. They disperse traffic instead of concentrating it by providing facility users with more direct-route options that may reduce travel delay. Walking and biking are encouraged along these lower-volume parallel roadways. They are transit-friendly, offering transit riders the choice of walking routes to transit stops, and agency-friendly because the network's access redundancy provides an alternate route if the corridor is closed or obstructed for any reason, resulting in higher transit usage.

Compact, mixed-use areas are dependent on a pattern of highly-connected local and major roadways with shorter blocks that provide multiple routes. They support a smaller development parcel

and provide access to multiple properties. These attributes can also be seen in suburbs with a high level of street connectivity.

There is often conflict between local residents, who often advocate for character and walkability in right-of-way design, and transportation agencies, who by tradition focus on capacity and the ability to accommodate a present or future travel demand. This is best addressed in a networked context where there are more opportunities for context sensitive solutions. Connectivity, parallel routes, and corridor capacity all contribute to a dispersed transportation system that is more capable of handling projected demand for all modes of travel.

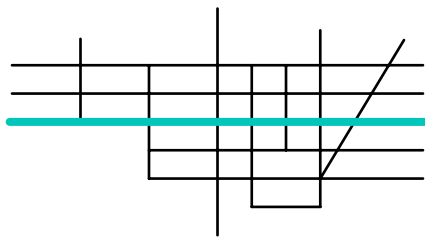


Figure 8 | Rectangular or Chessboard Network Pattern. Rectangular or Chessboard streets are grid-like, with parallel streets intersected by perpendicular or angular streets.

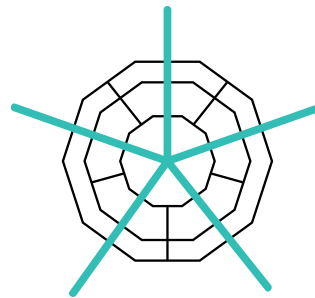


Figure 9 | Radial and Radial Ring Network Pattern. Radial patterns are surrounded and connected by successively larger loops or rings. Radial rings incorporate elements of both radial and ring/concentric designs.

PENNDOT TRANSPORTATION POLICY AND DIRECTIVES



Figure 10 | Context-sensitive transportation principles that laid the groundwork for integrating community design values and needs into current street and highway planning.

Introduction

In the 1990s, urban designers and city planners began advocating for a reinvestment in the country's urban areas as a counter to new suburban and rural development on greenfield sites. Urban flight was causing high levels of commuter frustration on congested corridors as downtowns functioned as 9:00 am-5:00 pm employment centers during the day and ghost towns at night. The recent migration to cities has reinvigorated urban center as 24-hour environments.

From the 1960s through the 1980s, the term "urban" had a pejorative connotation. Now, however, the virtues of density and the reinvestment in existing infrastructure are viewed with a new perspective.

Transportation planning has also shifted from an emphasis on motorized vehicles to a multimodal philosophy that values all users of the transportation network. The groundwork that began in the late 1990s continues to evolve with new transportation policies and directives that are in keeping with the country's movement toward equality and inclusiveness.

Understanding PennDOT's recent philosophical repositioning provides the foundation for the corridor guidelines when combined with the urban design, economic development, environmental, transportation, and transportation technology topic areas discussed later in this report.

Context Sensitive Solutions

The seeds of rethinking transportation priorities began in May 1998 at the national conference "Thinking Beyond the Pavement: A National Workshop on Integrating Highway Development with Communities and the Environment."⁴ The conference produced the following Context Sensitive Solutions (CSS) principles that are still in effect today:

Qualities of Excellence in Transportation Design

- + Project satisfies the purpose and needs agreed to by the full range of stakeholders. This agreement is forged in the earliest phase of the project and amended as warranted.
- + Project is a safe facility for both the user and the community.
- + The project is in harmony with the community, and preserves the environmental, scenic, aesthetic, historic, and natural resource values of the area.
- + Project exceeds expectations of designers and stakeholders and achieves a level of excellence in people's minds.
- + Project involves efficient and effective use of resources (time, budget, community) of all the involved parties.
- + Project is designed and built with minimal disruption to the community.
- + Project is seen as having added lasting value to the community

Characteristics of the Process to Yield Excellence

- + Communication with all stakeholders is open, honest, early, and continuous.

- + A multiple disciplinary team is established early, with disciplines based on the needs of the specific project, and with the inclusion of the public.
- + A full range of stakeholders is involved with transportation officials in the scoping phase. The purposes of the project are clearly defined and consensus on the scope is forged before proceeding.
- + The highway development process is tailored to meet the circumstances, employs a process that examines multiple alternatives, and results in consensus.
- + A commitment to the process from top agencies officials and local leaders is secured.
- + The public involvement process, which includes informal meetings, is tailored to the project.
- + The landscape, community, and valued resources are understood before design starts.
- + A full range of tools for communication about project alternatives is used.

After the 1998 conference, the American Association of State Highway and Transportation Officials (AASHTO) and the Federal Highway Administration (FHWA) adopted policies that encouraged all state departments of transportation to incorporate CSS on a day-to-day basis including:

- + 2000: AASHTO's Standing Committee on Highways passed a resolution stating, "...the time is ripe to institutionalize CSD/Thinking Beyond the Pavement principles nationwide."⁵
- + 2002: FHWA adopted three Vital Few Goals to be reached by September 30, 2007, one of which called on states to adopt CSS.

- + 2004: AASHTO published the *Guide for Achieving Flexibility in Highway Design*.
- + 2004: AASHTO published *A Policy on Geometric Design of Highways and Streets*, known commonly as the *Green Book*.

A Context Sensitive Solution (CSS), sometimes referred to as Context Sensitive Design (CSD), is generally defined as a transportation project that is collaboratively designed by an interdisciplinary team, including community and regulatory agency stakeholders, that fits its contextual physical setting by supporting community values and preserves the scenic, aesthetic, historic, and environmental resources while simultaneously maintaining safety and mobility. Making CSS work requires state departments of transportation to gain a broader perspective of the issues surrounding any transportation planning and design project. CSS requires transportation professionals to use their knowledge and expertise as a resource in the support of the collaborative development of the most creative and holistic solution to the problems, opportunities, and needs of a project area or corridor.

Since 2001, PennDOT has emphasized context sensitive solutions in conjunction with the agency's compliance with Federal ADA requirements. These two instruments have been key to revising PennDOT's design guidelines to accommodate pedestrian access.

Context sensitive solutions rely on a comprehensive Needs Assessment. Often referred to as a Problem and Opportunity Definition or a SWOT Analysis of strengths, weaknesses, opportunities, and threats,

a Needs Assessment is the starting point for any PennDOT project in order to define the scope of the problem. The Needs Assessment is the basis for performance measurements that evaluate a project's process and outcome, the basis for post-construction evaluation.

Performance measures can help project managers and project teams maintain a focus on the whole range of customer and CSS needs. The Performance Measures for Context Sensitive Solutions – A Guidebook for State DOTs provides a number of compelling reasons for considering the use of performance measures:

- + Helps make CSS a "state of the practice," not a state of the art" to create employee buy-in and accountability needed to achieve strategic objectives.
- + Strengthen agency leadership support for CSS principles as the CSS process is helpful in developing more predictable project schedules and preparing more complete documents with the idea of reducing costly redesign and the number of change orders.
- + Maintains a focus on the strategic CSS goals by continual reinforcement of leadership priorities through communication to agency employees and project teams.
- + Strengthens trust with stakeholders and customers by communicating agency priorities and gaining trust by demonstrated results.

CSS performance measures apply to both the agency processes that guide the projects and the project outcomes themselves.



Figure 11 | PennDOT integrates pedestrian and bicycle transportation needs into the planning process.

Bicycle and Pedestrian Checklist

PennDOT policy was revised again in 2007 when the 2004 *Bicycle and Pedestrian Checklist* (Checklist) was made part of the project development process. It mandates that highway and bridge projects must evaluate access and mobility needs of pedestrians and bicyclists during the planning process in all of its phases:

- + Phase 1 Planning and Programming: The Checklist ensures consistency with existing bicycle and pedestrian planning documents, evaluates current and future usage by bicyclists and pedestrians, considers safety needs, and takes into account community development, land use patterns, and the availability of transit.
- + Phase 2 Scoping: The Checklist provides design specifications to determine which pedestrian and bicycle features will be needed based on the Phase 1 findings and guides field-checking to note any site constraints.
- + Phase 3: The Checklist provides a “cookbook-style” matrix of various bicycle and pedestrian design elements to assist in creating project plans.

While it has generally been effective, some issues have arisen from its usage:

- + Implementation varies from project to project, which is often attributed to differences among project teams and the strength of PennDOT leadership.

- + Implementation at the local level has been inconsistent as not all municipalities are prepared to accept the added costs of the directive.
- + ADA compliance is mandatory, and the cost of ADA compliance adds costs to projects. When these costs are not planned for from the beginning, they can require projects to be scaled back, resulting in less desirable end results. When compliance is incorporated into a larger multimodal project and built into its budget/process the ADA costs can be more easily accommodated.
- + When design changes are made early in the process, the process works well. If they are made late and added to an ongoing project, the local municipality may have to provide the additional funds.
- + The Checklist works well when sidewalks are built into PennDOT projects from the beginning. Local municipalities resist doing so because they often do not have sufficient maintenance funds and will oppose a complete streets solution
- + Local municipalities may also oppose reducing lane capacity for bike lanes or sidewalks.

The Checklist laid the groundwork for PennDOT’s development of the *Smart Transportation Guidebook*.

Smart Transportation

In 2008, PennDOT and New Jersey DOT (NJDOT) jointly developed the *Smart Transportation Guidebook* (Guidebook), which enabled PennDOT to consider the needs of all users of all transportation modes. With this publication PennDOT took a proactive approach to Complete Streets in conjunction with its 2004 *Bicycle and Pedestrian Checklist*. The goal of the Guidebook was 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. Since transportation needs increasingly outweigh available resources, Smart Transportation incorporates financial constraints, community needs and aspirations, land use, and environmental constraints for efficient use of available funding.

The Guidebook incorporated a new roadway classification system that expanded the traditional roadway types from the four defined in the AASHTO Green Book (Principal Arterial, Minor Arterial, Collector {major and minor}, and Local) to a broader and more flexible classification that better relates context to scale and speed. The new classification system included new design standards that focused on the characteristics of access, mobility, and speed more suited to the variety of roadway types and scales rather than to a one-size-fits-all approach. The Guidebook also recognized that different segments of the same roadway could have more than one classification.

The *Smart Transportation Guidebook* was subsequently incorporated into PennDOT's *Design Manual Part 2: Highway Design*, (Publication 13M – August 2009), the precursor to the current 2015 edition.

Two documents currently guide PennDOT's smart transportation and multimodal policies: *Design Manual Part 2: Highway Design*, (Publication 13M, March 2015); and AASHTO's *A Policy on Geometric Design of Highways and Streets*, (2004). *Publication 13M* is fundamental to PennDOT's project planning and programming, scoping, and final design processes. As a complete streets-type directive, it ensures that pedestrian and bicycle accommodations are considered from the beginning of a project under the overall umbrella of PennDOT's smart transportation policy.

As explained earlier in this section, the roadway typology system used today is an expanded and slightly modified version of the *Smart Transportation Guidebook's* roadway categories. It recognizes seven different contexts or settings (rural, suburban, and urban) and five scales (from regional to local) of the five roadway types. (See Figure 5)

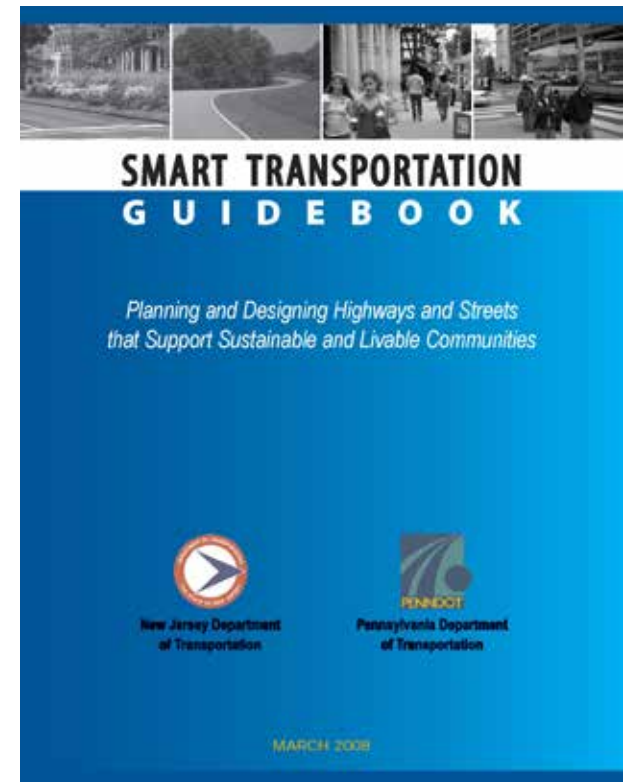


Figure 12 | PennDOT and NJDOT collaboration that considered the needs of all users of all transportation modes and introduced a new roadway typology classification system.



Figure 13 | Recognition that pedestrians, bicyclists, and transit users are also modes of transportation.

Complete Streets

Complete Streets is the next iteration of the multimodal evolution. Beginning as early as the 1990s the idea of combining bicycles with automobile traffic was introduced with great skepticism and early initiatives were largely ignored by local officials. After the adoption of CSS and Smart Transportation measures, the idea of pedestrian-friendly multimodal streets began to gain traction. In 2007, the Seattle City Council passed a Complete Streets ordinance, which directed the Seattle Department of Transportation to design streets for pedestrians, bicyclists, transit riders, and persons of all abilities while promoting safe operation for all users, including freight. In 2009 the city of Philadelphia established its Complete Streets Policy, which was followed by the *Philadelphia Complete Streets Design Handbook*. In 2013 Boston released the *Boston Complete Streets Design Guidelines* as did the city of Chicago in the same year with its *Complete Streets Chicago* publication.

The *Boston Complete Streets Design Guidelines* aims to improve the quality of life by creating streets that are both great places to live and ensure sustainable transportation networks. Boston's complete streets approach places pedestrians, bicyclists, and transit users on equal footing with automobile users, embraces innovative designs and technologies to address climate change, and promotes healthy communities. Boston's *Guidelines* establish standards for street design and reconstruction projects. While respecting Boston's historic past and responding to contemporary

values and needs, the standards adhere to these imperatives:

- + Multimodal: Streets are designed for pedestrians of all ages and abilities, bicyclists, transit users and motor vehicle drivers. Multimodal designs ensure all of the city's streets are safe and shared comfortably by all users.
- + Green: Streets are energy efficient, easy to maintain, and include healthy trees, plants, and permeable surfaces to manage stormwater. Design features encourage healthy, environmentally friendly, and sustainable use of the city's street network.
- + Smart: Streets are equipped with the physical and digital information infrastructure required to move all modes of transportation more efficiently, support alternatives such as car and bicycle share, and provide real-time data to facilitate trip planning, parking, and transfers between modes of transportation.

Chicago's complete streets policy states: "The safety and convenience of all users of the transportation system including pedestrians, bicyclists, transit users, freight, and motor vehicle drivers shall be accommodated and balanced in all types of transportation and development projects and through all phases of a project so that even the most vulnerable – children, elderly, and persons with disabilities – can travel safely within the public right-of-way."⁶

To create complete streets, the Chicago Department of Transportation adopted a pedestrian-first modal

hierarchy. All transportation projects and programs, from scoping to maintenance, favor this order:

1. Pedestrians
2. Transit riders
3. Cyclists
4. Automobiles

Another way to describe complete streets is “completing the street” – transitioning an auto-oriented street to one compatible for all modes. Complete streets are not new; they worked in the past to create communities that have sustained themselves over time. They are a contemporary return to the early twentieth century when streets were the living room of the city, accommodating everyone and all modes of transportation. They are also a recognition that complete streets comprise the safest form of street types due to the harnessing of vehicle speed and the caution it imposes on the motorist.

Urban design objectives include scaling blocks to land use and creating a well-connected network of streets that support dense development. Transportation objectives should be to increase transportation choices by providing more connections across the network and adding other modes to existing streets. Complete streets should also encourage new thinking about transportation planning, such as level of service. For example, it may be wiser to change from a 1-hour peak congestion period to a 2-hour period and accept congestion for a longer period of time as a tradeoff for better multimodal service throughout the day.⁷

Acceptance should not be assumed. Both engineers and the public tend to be skeptical about complete streets. Public reaction to new bicycle lanes in older cities, such as Pittsburgh with its narrow streets, is highly mixed with many residents opposed. Local jurisdictions may not agree when it comes to acceptance of PennDOT design guidelines and corridor planners should expect disagreement on design items such as lane width, turn lanes, curb radii, bicycle lanes, and on-street parking. By applying complete street designs to PennDOT’s own projects, the agency can create real-world examples and demonstrate best practices to educate skeptical constituents.

PennDOT has not adopted a complete streets policy, per se. PennDOT’s *Bicycle and Pedestrian Checklist* (2007) began an internal discussion of complete streets issues and the 2008 *Smart Transportation Guidebook* that followed laid the groundwork for PennDOT’s current multimodal emphasis. This was strengthened in 2016 by the Pennsylvania Transportation Advisory Committee’s issuance of the *Bicycle and Pedestrian Policy Study*.



Figure 14 | Pedestrian and bicycle integration within the street right-of-way.

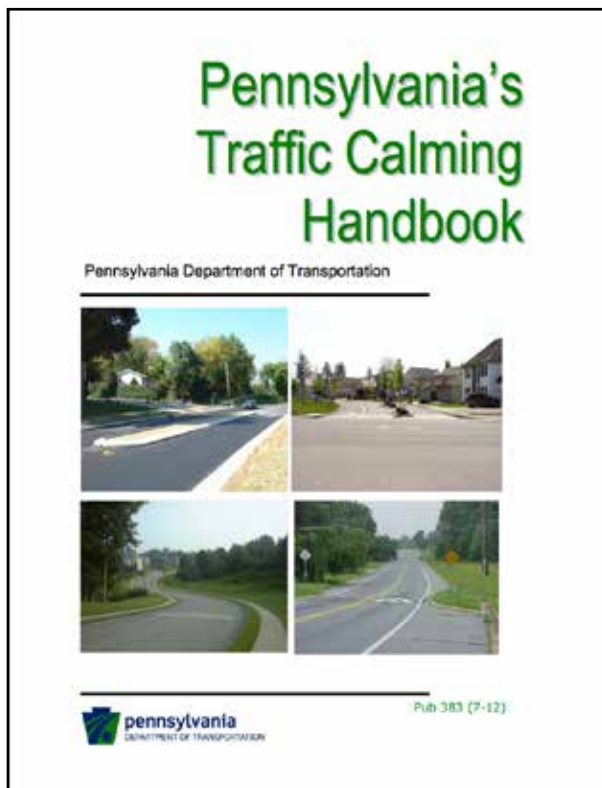


Figure 15 | Measures to slow traffic and reduce neighborhood cut-through traffic that enhance multimodal accommodation.

Traffic Calming

In 2012 PennDOT published *Pennsylvania's Traffic Calming Handbook* (the Handbook) to illustrate how to slow traffic and reduce cut-through volumes in urban areas. Other cities have adopted similar measures with the result that traffic calming programs have often evolved into complete streets for enhanced multimodal accommodation.

Functional roadway classifications and land use are the primary criteria for determining whether traffic calming measures are appropriate for any given street condition. Those most appropriate for calming measures include:

- + Local residential streets
- + Collector streets with predominantly residential land uses
- + Arterial roads and corridors within downtown districts or commercial areas with posted speeds of 40 mph or less

PennDOT's Handbook stresses, though, that traffic calming is not appropriate for all streets, particularly those intended for higher design speeds.

Speeding problems on arterial and collector corridors with state-mandated speed limits can be calmed by applying a three-step process known as the "three E's" for education, enforcement, and engineering. PennDOT's Traffic Calming Study and Approval Process identifies each step in the process to identify when and where traffic calming measures are appropriate on higher-speed corridors. Only when the education and

enforcement steps have proven to be ineffective may physical changes be considered.

Physical solutions apply to three conditions: those within the roadway right-of-way with mandated speed limits, those within the right-of-way without mandated speed limits, and a roadway's local side streets accessed for cut-through activity.

- + Roadways with Mandated Speed Limits: Physical changes within the curb-to-curb right-of-way are severely limited to non-physical modifications, such as striping to narrow lane widths or create center turn lanes. Outside the curb line, physical changes can be made to perceptually modify the visual context by installing street trees and bus pull-outs to "message" a higher degree of enclosure and/or pedestrian activity and, consequently, the need to slow down for greater safety.
- + Roadways without Mandated Speed Limits: These conditions generally apply to urban sections that are designated local streets where lower speeds are expected and sometimes mandated. Changes to the curb-to-curb right-of-way are encouraged to enhance multimodal activity and implement complete street design measures.
- + Roadway Side Streets: Cut-through activity occurs when there is congestion on the main arterial or collector. Motorists and truck drivers will divert onto local residential streets to by-pass the congestion, often speeding up to make up for lost time. Physical traffic calming measures that deflect and/or limit access, such as speed

humps and stop signs, are appropriate.

It is important to understand the relationship between traffic calming by perceptual methods (more appropriate for higher speed corridors) and those where calming measures rely on psychological and physical interventions. Most highway corridors with posted speeds of 35 mph and above have fixed curb-to-curb rights-of-way limiting the use of physical traffic calming methods. However, for corridors that traverse town centers, neighborhoods, and urban cores where there are high volumes of pedestrian and bicycle activity, a combination of lowering design speed and introducing traffic calming measures should be used thoughtfully to accommodate safety measures in harmony with complete street improvements while encouraging the smooth flow of traffic.

Traffic calming can increase the real and perceived safety of pedestrians and bicyclists, as well as improve the quality of life within a corridor's adjacent neighborhoods. Physical changes are generally "self-policing," such as speed humps and curb extensions. Public enforcement items, which include weight limits and one-way streets are not as effective because dependence is placed on the degree of police enforcement and the willingness of motorists to comply with the posted restrictions.

PennDOT supports the use of traffic calming measures, particularly when in conjunction with smart transportation principles and complete streets. PennDOT uses these basic criteria, ranked by importance, for considering traffic calming measures:⁸

- + Speed: particularly the extent to which the 85th percentile is exceeded
- + Volume: in increments of 120 cars per day
- + Crashes: the number recorded within the past three years
- + Schools: measured by the number of school crosswalks on the project street
- + Pedestrian Generators: parks, recreation spaces, and schools within the project area
- + Pedestrian Facility: the presence of sidewalks and other pedestrian features

Physical traffic calming measures consist of three types:

- + Horizontal Deflection: Curb extensions and bulb-outs, on-street parking, etc.
- + Vertical Deflection: Speed humps, raised crosswalks, raised intersections, etc.
- + Physical Obstruction: Dividers that partially or fully block the street, raised medians at intersections, etc.

Traffic calming can create controversy for both neighborhood residents and motorists and should be applied judiciously. It is important that traffic engineers work closely with affected communities because one neighborhood's selection may not be appropriate for another. For example, changing residential street patterns by diverting traffic at an intersection or closing off a street may be warranted because of high volume cut-through traffic; however, it may just move the problem elsewhere,

inconvenience local residents, or delay emergency vehicle access and response time. PennDOT recommends that traffic calming measures begin with simple solutions, such as pavement markings, and transition to physical solutions such as medians, raised intersections, or speed humps before escalating to street closures.



Figure 16 | Bump-outs help to slow traffic and reduce the roadway width for pedestrian crossing safety.



Figure 17 | Pennsylvania’s State Transportation Advisory Committee in 2016 reiterates the seriousness of multimodal planning for all PennDOT projects.

Bicycle and Pedestrian Policy

Pennsylvania’s State Transportation Advisory Committee (TAC), an advisory committee to the State Transportation Commission (STC) and the PA Secretary of Transportation, issued the *Bicycle and Pedestrian Policy Study* in May 2016 to strengthen the policy for bicycles and pedestrians and to establish new methods for policy implementation and follow-through. Walking and bicycling modes now comprise more than 4 percent of commuter traffic.

The TAC, while conducting the study, found that there are several limitations of current PennDOT bicycle and pedestrian policy and its implementation:

- + Lack of sufficient transportation funding
- + Inconsistencies in the completeness of bicycle and pedestrian checklists
- + Challenges with local coordination
- + Lack of clearly defined targets and metrics
- + Inconsistent education and awareness regarding bicycle and pedestrian planning and design standards
- + Staffing support

Recognizing that existing transportation funding is insufficient to fulfill all transportation needs of the Commonwealth, the proposed policy recommends that bicycle and pedestrian facilities shall be considered with all modes of transportation; reiterates the importance of making accommodations for bicycling and walking as a routine and integral element of planning, project

development, design, construction, operations, and maintenance; and that, on an annual basis, performance measures and targets should be established by PennDOT to ensure that some level of funding is directed to these initiatives in all Districts. Local MPOs and RPOs are to identify and prioritize bicycle and pedestrian projects and/or corridors to which local funding is to be directed, and for PennDOT to consider, when making project and facility inclusion decisions.

The seriousness of the policy recommendations is conveyed in the list of identified initiatives and proposed accountability measures:⁹

1. Initiate a phased project funding approach
2. Establish performance measures and targets
3. Build awareness and training
4. Develop an annual policy evaluation framework
5. Leverage regional bicycle and pedestrian plans
6. Update the bicycle and pedestrian checklist
7. Develop standard planning, mapping, and database templates
8. Provide county maintenance guidance
9. Update PennDOT publications
10. Publicize and promote funding operations and innovative approaches
11. Define staff roles and evaluate staffing needs
12. Develop unit cost data for various bicycle and pedestrian improvements
13. Promote education on bicycle and pedestrian laws
14. Continue state benchmarking

The need for these additional measures is indicative of the difficulty in changing mindsets and philosophy. While the multimodal direction has been around since the late 1990s, expecting immediate adoption and compliance is unrealistic. The Federal Department of Transportation, the Federal Highway Administration, and most state DOTs have consistently expressed their importance in publications and directives on planning, implementation, and design guidance. It will take a continued effort to realize large-scale change so that multimodal planning and design becomes commonplace.

Transit Oriented Development

While not necessarily PennDOT policy, transit-oriented development (TOD) is sympathetic to CSS, Smart Transportation, Complete Streets, and Bicycle and Pedestrian Policy as TOD seeks to create higher density, mixed use, and pedestrian-friendly development within a 1/2-mile or 10-minute walking distance of transit stops. The premise is that residents and other occupants within the TOD zone will rely more on transit than the automobile for daily activities. When development is compact and uses are nearby, people can access most of their needs within a small area such that walking and taking public transit becomes convenient.

Transit-oriented development embodies several principles that compliment multimodal corridor design:¹⁰

- + Accessibility: A pedestrian-friendly environment encourages a diversity of ages and physical abilities.

- + Sustainability: There are a number of benefits due to the clustering and high density of uses and resources that impact a triple bottom line: social, environment, and economic. Automobile usage is lower, energy consumption is lower, pollution levels are lower, and road congestion is lower. Generally, there is increased resident/employee comfort and productivity and the outflow of residents to the suburbs is reduced by offsetting cost-beneficial transit access without the need for a car.
- + Affordable Housing: While most TOD development provides market-rate housing, lower income residents can benefit by not having a car. Many cities and communities are aware of the need for economic diversity and may offer development subsidies for the inclusion of affordable housing.
- + Public Health: Increased walking and bicycling typically results from TOD development.
- + Mode Priority: TOD development is complementary to Complete Streets efforts that prioritize pedestrians, bicyclists, transit, auto drop-off/ride sharing, and park-and-ride facilities in suburban locations.

Transit-oriented development has numerous benefits, including:

- + Increased transit ridership
- + Economic development
- + Diverse transportation choices
- + Stable or increasing property values
- + Reduced air pollution
- + Revenue generation from transit rental space

- + Private contributions to infrastructure and other shared costs
- + Efficient land use
- + Reduced distance between transit stops and other activities
- + Improved transit connectivity

While many TOD locations occur around fixed guideway transit stops and offer more infrastructure and amenities than typical on-street transit stops, it is not unusual to witness clusters of higher density development at major intersections along corridors. While they are more appropriate in urban locations where the infrastructure supports walking, TOD derivatives are appropriate in suburban locations where intermodal transportation exchanges occur.



Figure 18 | Mixed use transit-oriented development in tandem with bus rapid transit improvements in the East Liberty neighborhood of Pittsburgh. The TOD and station improvements were completed in 2016.

MULTIMODAL IMPACT ON FEDERAL DIRECTIVES AND LOCAL GOVERNMENT INITIATIVES

Federal Highway Administration Revisions of Design Criteria

In May 2016 the Federal Highway Administration published revisions to the controlling criteria for design and how they are to be applied in different contexts on the National Highway System (NHS), updating FHWA's 1985 policy.¹¹ The FHWA found that, while all the 1985 criteria are important, not all affect the safety and operations of a corridor or roadway to the same degree and, therefore, should not require the same level of administrative control.

The FHWA no longer requires eight of the ten design criteria for corridors and roadways to be mandatory for the NHS where the design speed is less than 50 mph. The two controlling design criteria that remain are:

- + Design Loading Structural Capacity
- + Design Speed

However, except for compelling exceptions, the ten controlling design criteria are to remain in place for high-speed interstate highways, freeways, corridors, and roadways with design speeds greater than or equal to 50 mph:

- + Design Speed
- + Lane Width
- + Shoulder Width
- + Horizontal Curve Radius
- + Superelevation Rate
- + Stopping Sight Distance (SSD)
- + Maximum Grade
- + Cross Slope
- + Vertical Clearance
- + Design Loading Structural Capacity

Smart Growth America followed the Notice with the below interpretations for corridors and roadways with design speeds of less than 50 mph, the majority of which are candidates for complete street and multimodal facilities.¹²

- + The new criteria recognize that corridors running through urban and suburban areas need to be designed differently than higher-speed rural highways connecting towns or cities. The FHWA found that removing almost all of the controlling design criteria in low-speed environments is supported by research and provides additional flexibility to better accommodate multimodal transportation. There is strong public support for the revisions which indicates, in Smart Growth America's opinion, that the changes will further encourage agency and community efforts to develop transportation projects that support community goals and are appropriate to a project's context.
- + The FHWA reiterated that the FHWA does not have regulations or policies that require specific minimum Level of Service values for projects on the NHS and that the recommended values in AASHTO's Green Book are regarded by FHWA as guidance only. This comment supports communities who want to implement a complete streets approach by making clear that there is no Federal LOS requirement as well as implying that transportation agencies should consider more than just traffic speeds when planning projects.
- + While the new criteria currently conflict with

USDOT measures of congestion and that compliance remains a local decision, the new interpretation is intended to remove the penalties associated with congestion such that vehicle speed and delay are no longer the primary factors in facility design. The intention is to make it easier to get around on transit and by foot or bike.

This Notice reiterates the Federal government's strong support for multimodal facilities and raises the threshold for transportation agencies and local communities to broaden the range of options for multimodal facilities and physical design improvements. Instead of focusing multimodal improvements on local corridors and roadways in locations with posted speeds of 25 to 30 mph, the range for serious multimodal facilities has been expanded to include locations where the posted speed is 35, 40, or 45 mph.

Cities Adopt Vision Zero Safety Measures Including Lower Speed Limits

Since 2012 more than seventeen US cities have either adopted or are considering lower speed limits with the intention of decreasing traffic fatalities to zero.¹³ Among them are Boston, New York City, Washington DC, Chicago, San Francisco, Los Angeles, Portland, and Austin who are following previous resolutions undertaken in Canada, the Netherlands, Sweden, and Britain. While each city's resolutions are different, the realization that speed kills is resulting in cities taking their own actions to provide safer conditions for pedestrians, bicyclists, and motorists. Most seek zero fatalities within five to ten years after adoption.

Vision Zero, a multi-national road safety project with an objective of no fatalities or serious injuries in road traffic, started in Sweden when their parliament adopted the original Vision Zero program in 1997.¹⁴ The original program was based on four principles:¹⁵

- + Ethics: Human life and health take priority over mobility and other objectives of transportation systems
- + Responsibility: Providers and regulators of transportation systems share responsibility with the system's users
- + Safety: Traffic systems need to account for human fallibility and minimize opportunities for errors and the harm caused when they occur
- + Mechanisms for Change: Providers and regulators must do their utmost to guarantee safety of all citizens; they must cooperate with roadway users; and all three must be ready to change to achieve safety.

Since then, four more principles have been added:¹⁶

- + Traffic deaths and injuries are preventable; therefore, none are acceptable
- + People will make mistakes and the transportation system should be designed such that those mistakes are not fatal
- + Safety is the primary consideration in transportation decision-making
- + Traffic safety solutions must be addressed holistically.



Figure 19 | Vision Zero initiatives, including lowering traffic speeds in multimodal situations, have been adopted by local officials in some cities to reduce traffic injuries and fatalities to zero within the next decade. With state-mandated speed limits on many of Pennsylvania's roadways and corridors, local speed-reduction actions are not possible.

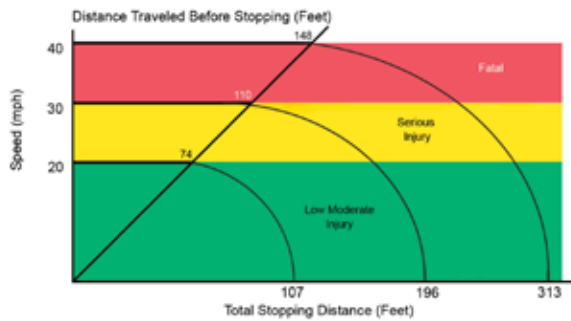


Figure 20 | Reducing vehicle speed in multimodal conditions reduces the potential for injuries and fatalities.

These actions trace back to accident statistics, both in this country and abroad, that have consistently shown that both pedestrian and motorist fatalities increase as traffic speed increases. Pedestrian survivability is highest when automobile speeds are less than 20 mph. Motorist survivability from side impact decreases at or below 30 mph and head-on-collision survivability decreases at or below 40 mph. Motorist fatalities that occur at speeds greater than 60 mph are typically caused by collisions with roadway infrastructure on freeways, such as barriers separating opposing traffic.

In the United States city governments have taken the lead in reducing speeds from 30 mph to 25 mph on major corridors and from 25 mph to 20 mph on residential streets. City programs include engineering roads for safer mobility, increasing traffic enforcement, and educating pedestrians, bicyclists, and motorists. Engineering solutions, under the direction of local government, have involved traffic calming measures, including speed humps and road diets, and separating pedestrians and bicyclists from autos and autos from buses when the speed limit exceeds 25 mph.

Note that these actions are not being implemented by state transportation agencies. They are local, community-driven resolutions and directives where communities are resisting motorist-centric transportation practices and design criteria. While not explicitly aimed at lowering design speeds for multimodal activities, these actions parallel current best practices for complete streets (see the above FHWA design criteria update) and address future needs as multimodal facilities become commonplace for all roadway and corridor types. PennDOT and the MPOs and RPOs may want to consider similar actions for Pennsylvania.

CONFLICTS WITH EXISTING POLICY

Design speed, level of service, and traffic calming raise fundamental questions over the conflict between the automobile and personal and mass transportation. European and other world cities have intermixed movement modes for some time and can show encouraging accident statistics. American cities remain automobile-centric. Cities and neighborhoods need to demand more holistic solutions and be willing to invest in infrastructure. Transportation agencies, such as PennDOT, need to take the lead in placing multimodal values above those that have traditionally driven the transportation industry.

Design Speed

In multimodal conditions where pedestrians and bicyclists are integrated into corridor and roadway design, a logical interpretation of PennDOT's complete streets policy would be that design speed's priorities and philosophy are in conflict with pedestrian-safe and design-conscious principles.

Design speed is the single most influential operational decision that affects a roadway's geometric design and configuration. It dictates horizontal alignment, superelevation, stopping sight distance, and lane widths. It also influences the flexibility of a roadway to incorporate certain geometric features, such as street trees, on-street parking, raised medians, a curbed section with sidewalks, placement and setbacks of buildings, as well as amount of curb cuts.

Posted speeds are traditionally based on either the actual observed speeds of vehicles, in which case the 85th percentile is the determinant factor, or by

an engineering and traffic study. Design speed is mandated by the Commonwealth in Title 75 of the PA Vehicle Code, Section 3362, where PennDOT is required to observe the following design speeds when there is no posted speed limit:

- + 55 mph in rural areas and divided roads
- + 35 mph in urban districts
- + 25 mph on non-numbered local roads in residential areas

AASHTO's publication titled *A Policy on Geometric Design of Highways and Streets* states that the design speed should be a logical one with respect to the anticipated operating speed, topography, the adjacent land use, and the function classification of the highway. In the selection of design speed, every effort should be made to attain a desired combination of safety, mobility, and efficiency within the constraints of environmental quality, economics, aesthetics, along with social and political impacts. Design speed should reflect the travel desires and habits of a majority of motorists expected to use the facility. If a community would like an adjacent future roadway to operate at a specific operating speed, then the design speed of the facility should be developed to match the desired operating speed, and the desired operating speed should be reinforced by adjacent land uses.

AASHTO is clear in its priorities regarding the relationship between design elements and design speed. The Green Book states, "The first step in the design process is to define the function that the facility is to serve."¹⁷ The level of service fulfilling this function for the anticipated volume and for the selection of design speed and geometric criteria are

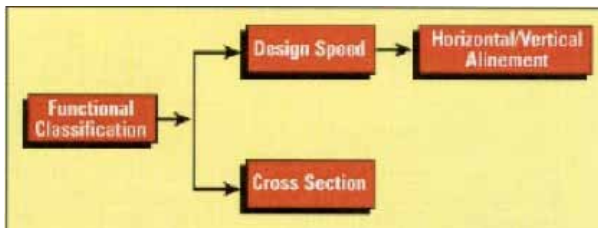


Figure 21 | A determination of functional classification establishes the basic roadway cross section in terms of lane width, shoulder width, type and width of median areas, and other major design features.

within the range of values available to the designer for the specified functional classification. The use of functional classification as a design type should appropriately integrate the highway planning and design process.

The flexibility available to a highway designer is limited once a functional classification has been determined. However, there is some flexibility (depending on respective state design speed standards) by allowing roadway type geometric features to apply over a variety of design speeds. For instance, the design geometry for a collector roadway for 20 mph might, depending on state regulations, also apply for a local roadway at 40 mph.

The PennDOT *Design Manual* (2015), in agreement with AASHTO policy, advises that the “selected design speed should be consistent with the speeds that drivers are likely to expect on a given highway facility. Where a reason for limiting speed is obvious, drivers are more apt to accept lower speed operation than where there is no apparent reason. A highway of higher functional classification may justify a higher design speed than a lesser classified facility in similar topography, particularly where the savings in vehicle operation and other operating costs are sufficient to offset the increased costs of right-of-way and construction. A low design speed, however, should not be selected where the topography is such that drivers are likely travel at high speeds. Drivers do not adjust their speeds to the importance of the highway, but to their perception of the physical limitations of the highway and its traffic.”

“For projects in new locations or projects where the desired operating speed differs from the posted speed on the roadway, PennDOT advises that “the design speed should be selected with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the roadway. The geometric features should be designed respectfully, consistent with the established design speed, to encourage the appropriate operating speed. To that end PennDOT requires that every effort should be made to use the most practical design speed to attain a desired degree of safety, mobility, and efficiency within the constraints of environmental quality, economics, aesthetics, and social or political impacts. Once the design speed is selected, all of the pertinent highway features should be related to it to attain a balanced design.”

“(For projects maintaining existing speed limits) of 45 mph or less the selected speed should equal the posted speed limit unless the analysis of safety, mobility and efficiency warrants setting the design speed 5 mph greater than the posted speed limit.”¹⁸

Historically, roadways have been designed with a design speed 5 to 10 mph above the posted speed. The effect of this is that drivers usually drive as fast as they believe the roadway can safely accommodate, which may encourage speeds higher than the posted speeds. PennDOT’s recent mandate that design speeds less than 45 mph match both the design and posted speed is a better interpretation of this policy as it begins to recognize the importance of bringing design

speed into congruence with complete street, traffic calming, and context sensitive design. Street and corridor design speed determination is a perceptual determination. For instance, corridors with heavier pedestrian volumes require more scrutiny of design speed and posted speed, including consideration of lowering both.

What is not clear, though, is who is governing speed limits. Is it the motorist or best design practices? Both AASHTO's and PennDOT's policies leave that decision to the motorist as the key determinant and, furthermore, ask that the "desired operating speed should be reinforced by adjacent land uses."³⁰ In terms of land use and urban design, this means that building setbacks, heights, landscape, on street-parking, and other design features should be set to reinforce design speeds of 45 mph and greater, including the tolerance of 5 to 10 mph above the posted speed. While on the open highway this is appropriate, but in urban contexts where crash rates are higher and where pedestrian and bicycle usage is heavier it is inappropriate.

Requiring setbacks on heavily traveled corridors encourages faster driving, as does the absence of street trees and bumpouts. As speeds increase, buildings are set back farther and spacing between buildings increases. With the design speed philosophy proportionally tied to land use, transportation decisions will transform an urban fabric into a suburban fabric: likewise, a city's broad ceremonial streets and corridors become faster-moving parkways because their buildings

are often set back. Good urban design, though, recognizes the importance of enclosure, pedestrian scale, and multimodal functionality to achieving good public realm design and safe environments.

Context sensitive design requires that roadways are designed with a consideration for more closely aligned posted speeds and design speeds. Designing a roadway to achieve a desired operating speed is not a one-size-fits-all approach, nor is it necessarily appropriate. Elements other than roadway geometry affect the perception of a roadway, including adjacent land use patterns, commuter patterns, and access along the roadway. Decisions regarding roadway design need to include elements both inside and outside the right-of-way and involve transportation, land use, and urban design issues. Each roadway will have unique characteristics that require special attention and, ultimately, these individual circumstances require innovative ideas and tailored approaches to achieve a safe operating speed that is amenable to all users and transportation modes. It usually means that traffic movement needs to be slowed in multimodal conditions and that alternative design strategies, including traffic calming, are needed to achieve a holistic solution.

In terms of the design process, the philosophy for design speeds of 55 mph and less on all corridor and roadway types should be:

First determine the need for *multimodal* safety where pedestrians, bicyclists, and transit users are desired and expected to encounter the facility. Then determine the functionality of the *place* for design speeds under 45 mph. Then determine

which roadway functionality and design speed are supportive of achieving the health, safety, and welfare of pedestrians, bicyclists, and transit users for each *segment and intersection* of the corridor or roadway.

An important question needs to be addressed when designing for multimodal situations: Is the design speed supportive of the desired role of the corridor or roadway, or not? Considerations for reducing speed include changing the geometry of both land use and transportation configurations, such as:

- + Safety Features: Buffer non-motorized from motorized traffic, shorten crosswalk lengths, provide pedestrian-assisted signalization, warning lights and signs.
- + Place-Making Features: Reduce setbacks, increase building heights, activate ground floor spaces, encroach tree canopies over the roadway, and buffer curb lines with shrubbery no higher than 30 inches.
- + Transportation features: Introduce urban standards where reductions in design speed are desired, including signal density and adaptation, medians, on-street parking, curbs, street trees, lane widths, curb return radii, horizontal offsets between the inside travel lane and median curbs, and other traffic calming measures, including changes to the right-of-way.

Level of Service

The traditional performance measure for street design is Level of Service (LOS), which is calculated based on the 2010 version of the *Highway Capacity Manual* (HCM) published by the Transportation Research Board. The measure is a function of the ratio of the number of cars on a road to the road's carrying capacity and is expressed by assumed delay for each vehicle. Its purpose is to move the highest volume of vehicles. It is not a useful measure for the complete streets goal of providing a safe and convenient environment for all users.

The LOS standards range from A to F, with A being the best.

- + LOS A Free Flow: Traffic flows at or above speed limit with complete mobility between lanes. Motorists have a high level of physical and psychological comfort.
- + LOS B Reasonably Free Flow: LOS A speeds are maintained, with maneuverability is slightly restricted. High level of physical and psychological comfort.
- + LOS C Stable Flow: Ability to maneuver through lanes is noticeably restricted and lane changes require more driver awareness. Roads remain safely below but

efficiently close to capacity. Target LOS for some urban and most rural highways.

- + LOS D Approaching Unstable Flow: Speeds slightly decrease as traffic volume slightly increases. Limited freedom to maneuver within the traffic stream much more limited and driver comfort levels decrease. LOS D is a common goal for urban streets during peak rush hours.
- + LOS E Unstable Flow, Operating at Capacity: Flow becomes irregular and speed varies rapidly due to little usable gaps to maneuver. Speeds rarely reach the posted speed limit. Any disruption in traffic flow will affect traffic upstream. Driver comfort level approaches poor. The common standard in large urban areas, where some roadway congestion at peak periods is the norm.
- + LOS F Forced or Breakdown Flow: Congestion. Every vehicle moves in tandem with vehicle in front of it, with frequent slowing required. Travel times are unpredictable with generally more demand than capacity. LOS D or LOS E roads may experience LOS F levels at some times.

Bicycle, pedestrian, and transit multimodal measures (MMLOS) attempt to evaluate the quality of the travel experience, such as tradeoffs of street

designs on the perceptions of multimodal travelers, rather than just vehicle throughput. The measures account for features that influence the safety and comfort of pedestrians and bicycles, such as crossing distance, crosswalks, bike lanes, corner radii, and traffic-signal timing and placement.

In urban areas where multimodal complete street conversions are becoming more frequent, achieving a high level LOS is unrealistic and not necessarily a good objective. Urban areas typically adopt standards of LOS C to E, depending on context, and LOS F is sometimes allowed in areas with improved multimodal alternatives. More stringent LOS standards widen roads for more travel lanes, which is counter-productive to achieving a complete streets policy. In locations where multimodal traffic is desired and accommodated, a more practical bicycle, pedestrian, and transit multimodal MMLOS should be the governing factor, not LOS.



Figure 22 | Level of service performance measures address only the efficiency of traffic flow, not safe environments for pedestrians, bicyclists, and transit users.

Traffic Calming

Traffic calming is intended for municipal or state-owned local residential streets, collector streets in predominately residential areas, and arterial roads within downtown districts or commercial areas with posted speed limits of 40 mph or less. The intention is to discourage cut-through traffic from higher speed corridors and arterials from migrating to local streets to avoid congestion in the primary roadway. Traffic calming measures are not encouraged on corridors and roadways with mandated speed limits of 55 mph or higher, or on heavily trafficked corridors and arterials where the goal is to move large volumes of traffic.

For corridors and arterials with speed limits between 35 and 55 mph, physical changes to the roadway and the right-of-way are difficult to achieve because of a complicated approval process, the mandatory transfer of maintenance

and funding of improvements on state-owned roads to local municipalities, restrictions on what can be done within the curb-to-curb roadbed, and restrictions on the use of the curb-to-property line space. Although sympathetic to the complete street philosophy and in compliance with almost all of PennDOT's design manuals and directives, multimodal measures for these corridors are not implemented because of safety concerns for pedestrians, bicyclists, transit riders, and motorists. Changes within the curb-to-curb roadbed are limited to non-physical modifications, such as striping, narrowing lanes, and installing center turn lanes without medians. The roadbed is mostly off limits for multimodal use. The space between the curb line and the right-of-way line (property line) may only be utilized to perceptually "narrow" the visual field to create a sense of enclosure so that motorists will reduce speed.

As a result it is difficult to provide multimodal access at intersection crossings or along the length of corridor segments between intersections. Pedestrians, bicyclists, and transit users are discouraged from crossing at intersections because the crossing distance cannot be shortened. Signalization is typically set to move vehicular traffic, not slow it down by adding a pedestrian sequence. It is dangerous to cross on the green light when cross traffic is also moving quickly or turning onto the corridor. Pedestrians and bicyclists are discouraged from traveling the length of a corridor segment unless the curb-to-property line dimension is large enough to accommodate a sidewalk, bicycle path, and street trees — accommodations that make these modes of travel safe. Local communities do not have the funds to construct these accommodations when funding from the state is limited.

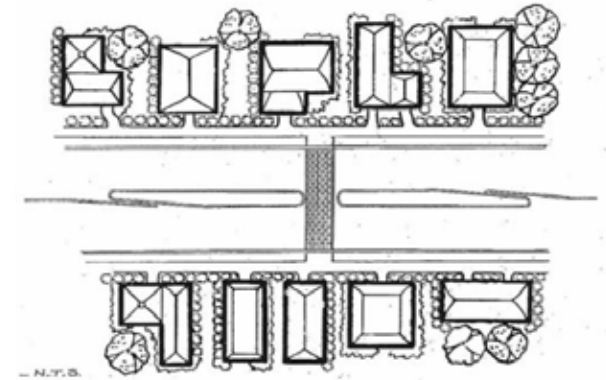


Figure 23 | Medians can calm traffic by narrowing the roadway and alerting drivers to the presence of pedestrians at mid-block and intersection crossings.



PENNDOT PROJECT PLANNING

PennDOT's Transportation Program Development and Project Delivery Process (TIP and STIP)

PennDOT's *Design Manual* lays out the responsibility of PennDOT, the state's lead agency responsible for developing, maintaining and enhancing the Commonwealth's transportation system. As land use and community needs became even more integrated with transportation, PennDOT implemented the Transportation Program Development and Project Delivery Process for internal evaluation of projects identified in the local region's Transportation Improvement Program (TIP) and the State Transportation Improvement Plan (STIP). TIP projects are mandated and are in compliance with federal law (ISTEA, TEA-21, SAFETEA LU, MAP-21, and the FAST Act). The TIP Program is the regionally agreed-upon list of priority transportation projects that lists all projects that intend to use federal funds, along with all non-federally funded projects that are regionally significant. (Note that the term TIP is applied to the regional Program, Process, and Projects.)

The Program and Process for all approved TIP projects are set to ensure that limited transportation funding is prioritized as follows:

- + To maintain existing infrastructure
- + Applied in a manner that requires smart land use decisions
- + Focused on better use of existing capacity, rather than adding more capacity
- + Programmed based on realistic project cost estimates
- + Projects are designed to these estimates

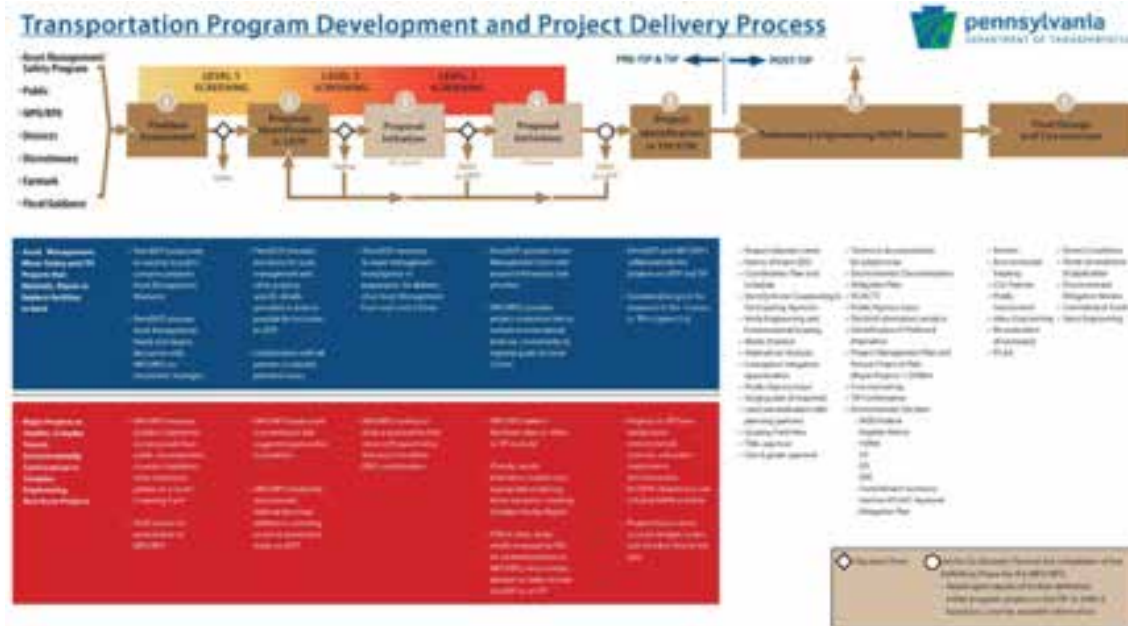


Figure 24 | Diagram of the Transportation Program Development and Project Delivery Process illustrating the Pre-TIP and Post-TIP process of bringing a project to fruition and construction. The Pre-TIP portions defines a project's needs and develops a proposal for funding. Once approved, the Post-TIP process defines the design and construction delivery.¹⁹

PennDOT's initial planning phases are closely aligned with the Metropolitan and Rural Planning Organizations (MPO/RPO), who jointly take responsibility for identifying potential transportation problems. The MPOs and RPOs work with PennDOT to create fundable transportation proposals that meet the State's needs and priorities. Once the proposals become projects, information from the Pre-Transportation Improvement Plan and the TIP Project Delivery Procedures will be carried through to the Post-TIP Project Delivery Procedures. During the Post-TIP project planning and design phases, PennDOT will work to assure that the projects incorporate CSS, Smart Growth, and other adopted policies as well as the principles of Complete Streets. The expectation is that all partners in the planning and delivery process will adhere to these principles and concepts.

PennDOT's responsibilities also include coordinating the Commonwealth's goals and objectives for the transportation system, which set Pennsylvania's transportation direction for a twenty year period. These goals are supported in the Transportation Program Development and Project Delivery Process, which defines the regional roadmap for their achievement. Transportation problems being considered for inclusion in the TIP/STIP must support these goals as the projects evolve into completed installations. The Process defines the steps needed to develop the proposals, convert proposals to projects, and carry projects through construction. The Plan and Process were developed to provide a sustainable transportation system and adhere to the Core Principles that underlie the State

Transportation Improvement Plan. Proposals that are not funded are not necessarily dismissed and may go through several iterations before being put on the TIP as a project to advance to construction.

The Core Principles of the Transportation Program Development and Project Delivery Process are:

- + Money counts
- + Choose projects with high Value to Price ratios
- + Enhance the local network
- + Look beyond Level of Service (LOS)
- + Safety first and maybe safety only
- + Accommodate all modes
- + Leverage and preserve existing investments
- + Build towns, not sprawl
- + Understand the context; plan and design within the context
- + Develop local governments as strong land use planners

As a guide for PennDOT personnel, its MPO and RPO Partners, consultants, and contractors the following primary objectives for the Process are to:

- + Focus available funds and resources on the most necessary transportation needs
- + Improve cost estimating for potential projects
- + Increase the accuracy of project scheduling and improve the predictability for project delivery
- + Develop better and more accurate project scopes
- + Better reflect PennDOT's goals in project selection
- + Improve communications, coordination,

- and cooperation within and between PennDOT, the MPO/RPOs, the Federal Highway Administration (FHWA), Federal Transit Administration (FTA), other transportation planning entities, tribal nations, and the resource agencies
- + Promote early public participation and public involvement

The core principles of the local/regional TIP process are driving decision-making. Safety plays a major role and, if budgets are restrictive, may be the only impetus for an improvement project. Multimodal integration within the transportation system, community impact, and civic engagement appear at or near the end of the various priority listings.

Given limited funding for transportation, this is not unexpected; however, the message to the public, local communities, and highway corridor planning teams is mixed. Federal policy, reflected in Pennsylvania's various policies, requires that multimodal integration, holistic transportation planning and projects reflect community plans, and that public outreach be integral to all TIP projects as appropriate.

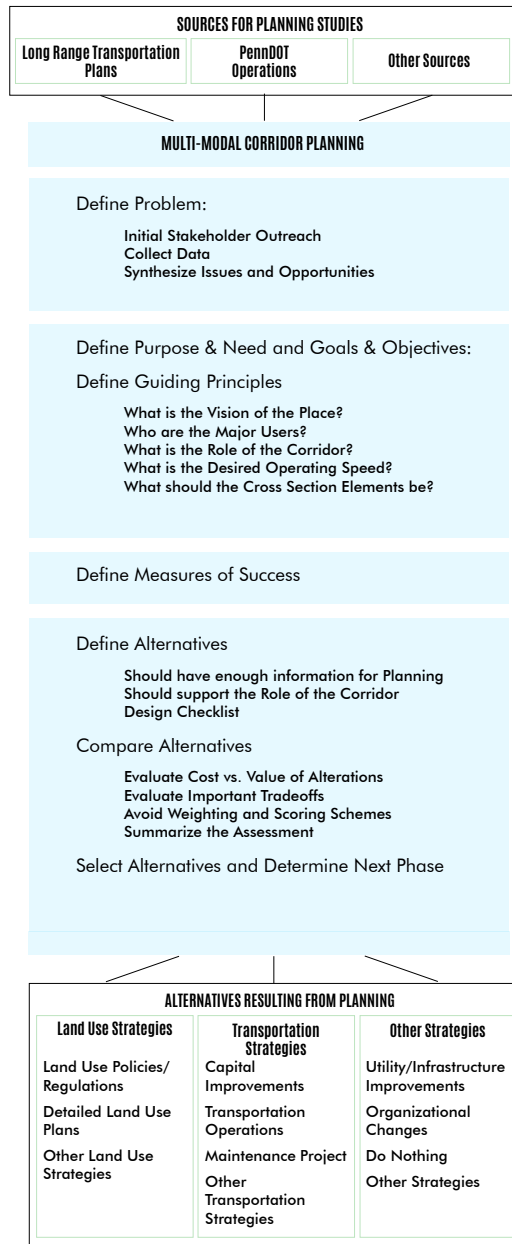


Figure 25 | Example of a three-phased planning process through the second phase.

CORRIDOR PLANNING PROCESSES

Introduction

Two Planning Processes are appropriate for corridor planning: The first, a more traditional Three-Phased Process, is well-suited for complex corridors comprised of several segments that cross municipal boundaries. This process is typically used for projects that involve a number of consultants and a long timeframe. (Figure 25) The second, a more intense and fast-moving Charrette Process, is particularly applicable for projects of limited scope and complexity or those with a short timeframe. Both types are explained below; however, aspects of each are interchangeable and many corridor projects would benefit from combining them at appropriate times during a project’s tenure.

Facilitated Systems Integration introduces a new methodology for project teams to fully engage their consultants in the design process.

Three-Phased Process

In essence, there are three phases:

- Phase I Understanding: Base Data and Analysis
- Phase II Exploring: Alternatives
- Phase III Deciding: Final Plan

In a typical highway corridor planning process, the Department of Transportation will appoint a Project Manager who will work day to day with the consultant team, who will also appoint a Project Manager. The two project managers will organize the project; form the planning team and determine and engage outside consultants as needed; prepare and manage the schedule; and determine committee and public meeting dates and venues.

The process should begin with the appointment of an Advisory Committee, often referred to as a Steering Committee (SC) or Technical Advisory Committee (TAC) of ten to fifteen members. The membership should be diverse and include PennDOT staff, local government officials, citizens, business persons, and non-governmental organizations with expertise in environmental issues, historic preservation, and universal accessibility. The Committee’s role is to advise the Department of Transportation, and should meet periodically throughout the process, typically twice in each of the three phases, for planning team feedback and advice.

Phases of the Process

Phase I Understanding: Base Data and Analysis

- + Data Collection: The planning and design team will collect existing data and generate new data as applicable. Examples include land use, zoning, GIS information, building coverage, traffic counts, environmental conditions, demographics, economic data, historic resources, comprehensive plans, redevelopment plans, public budgets, transportation improvement plans (TIPs), and other resources as needed.
- + Public Outreach: Working with the Advisory Committee and DOT, the planning team will conduct stakeholder interviews and civic engagement forums, as well as focus group meetings with interest groups or organizations, to gather subjective data about people's perceptions of the corridor – good things, bad things, what needs to change – and the issues and values held by the community(ies).
- + Analysis and Synthesis: The planning team will analyse the collected data and findings from public outreach and prepare a Phase I report to document the process to date and summarize the key issues to be dealt with in Phase II. Often this report will primarily consist of a Needs Assessment or Analysis, supplemented by reports from the team's consultants.

Phase II Exploring: Alternatives

- + Develop Alternatives: The planning team will prepare alternatives for the corridor transformation based on findings from Phase I and direction from the Advisory

Committee and the DOT. Typically, the alternatives should explore a range of interventions from modest to aggressive.

- + Review Alternatives with the Advisory Committee and DOT: The Advisory Committee, DOT, and the planning team meets in a workshop format to review the alternatives, including revising them or developing new alternatives. Two or three alternatives will be chosen to present to the public.
- + Public Outreach: Working with the Advisory Committee and DOT, the planning team conducts a public forum (or series of public forums) to gather feedback on the alternatives.

Phase III Deciding: Final Plan

- + Preferred Alternative: Draft Plan: The planning team, based on input from the Advisory Committee, the DOT, and the public meeting(s) will prepare a draft plan with the preferred alternative. The report will include a summary of Phases I and II and an implementation plan that will include plans, budgets, and schedule.
- + Review Draft Report with the Advisory Committee and DOT: The Advisory Committee, DOT, and the consultant team will review the draft report and make revisions as necessary.
- + Public Outreach: Working with the Advisory Committee and DOT, the planning team will conduct a public forum (or series of forums) to gather feedback on the Draft Plan.
- + Final Plan: The planning team will prepare the Final Plan based on input from the public forum(s) and working meetings with the Advisory Committee and DOT.



Figure 26 | The charrette process is design-driven to arrive at solutions in a timely manner.

Charrette Process

The Charrette Process is not phase-oriented; it proceeds through a series of stages of completion, each more complex and detailed than the previous to arrive at a final plan.

Where the Three-Phased Process gathers data during the upfront portion of the planning process, the Charrette Process, otherwise known as the Concept/Test Method, uses design as the basis of the planning process. Design ideas (concepts) are developed and evaluated (tested) and the knowledge gained during each iteration directs data collection.

The approach is holistic throughout the entire process as the full scope of the project is brought to bear at each iteration; at the beginning of the process the designs are sketchy and conceptual and often do not address the full scope, but as the stages progress so does the breadth of design. The resulting evaluation and supporting data becomes the basis for the next design iteration, and so on. Throughout the process, alternative solutions are deliberately sought so that the breadth of the design investigation is rigorous. Alternatives are continuously tested; it is rare that an initial concept remains in its original form at the end of the process.

This process is systematic like the Three-Phase Process, however its approach to data collection is the opposite. Data collection is directed toward idea evaluation, which keeps it focused throughout the process. However as the design alternatives

narrow, data collection progressively increases to support more rigorous testing.

Three Phased Process

The Three-Phased Process begins by collecting a variety of data, from precedents, best practices, and former studies as well as more detailed information, such as GIS, census, and survey information. The data is analysed for pattern recognition developed through the analysis process and the data is sifted for relevant facts, and synthesized to support the project's goals and objectives. The system process is additive, aggregately composing the data into supportive alternatives until the end-stage solution is reached. The Three-Phased Process takes longer than the Charrette Process; however, this is a benefit when the project is complex and a number of stakeholders are involved — it lengthens the time between iterations to allow for all parties to reach similar conclusions. It builds stakeholder ownership as all parties are witness to the information and the aggregation of it into physical design.

The Charrette Process is particularly useful when the timeframe is short and design decisions are needed quickly. The planning team can proceed at a faster pace than the stakeholders and it provides more control over the process. Its advantage is that design solutions arise at every stage or phase of a project, which in its own manner builds collective ownership of the physical design.

A more dynamic process can occur when the design team intermixes the two processes when

either is more advantageous; proceeding with one alone for a period of time, and selectively engaging the Charrette Process to boost design development. The Charrette Process and the Three-Phased Process both include an Advisory Committee.

Stages of the Charrette Process

Initial Design Iteration

- + Design: After becoming familiar with the project area through tours and discussions, the planning and design team prepares a series of initial, holistic design ideas based upon what they have seen and heard, as well as their inherent professional knowledge and prior experience.
- + Data Collection: Site tours and initial discussions with key stakeholders. The only detailed information at this time is accurate site information to prepare base maps.
- + Public Outreach: Conduct initial design discussions with the Advisory Committee and DOT, particularly with those from the community who will be instrumental in the approval and implementation of the project.
- + Analysis and Synthesis: The planning team will rigorously evaluate and discuss the design, with the expectation that the boundaries of the project will be challenged. The boundaries may be budget, scope, identified community issues, time, etc. Comparative cost/benefit analyses are performed for each design and the planning team makes the first cut of the alternatives.

Later Design Iterations

- + Design: Continue with developing design alternatives based upon evaluations of previous iterations. Narrow the alternatives to a set of three for communication with the Advisory Committee and Public Outreach initiatives. As the project matures, the design iterations will begin to slow down as decisions are made and as the focus narrows to a single direction and its derivatives.
- + Data Collection: Enrich data collection with each design iteration and expand breadth in stages, with each successive iteration adding new subjects. In the early stages it will be necessary to expand the data collection beyond that needed for the first design iteration to satisfy the Needs Analysis and other requirements of the TIP process, and as community issues and concerns become more apparent.
- + Advisory Committee and DOT: Begin working with the Advisory Committee and DOT in a workshop format to review alternatives, including revising iterations or developing new alternatives. Select two or three conceptual alternatives that represent clear design directions to present to the public at the first public forum. Continue to work with the Advisory Committee in the workshop format during design development and through the final design. Keep the Advisory Committee abreast of community and data findings, design issues and the designs' interpretation of community needs and issues.

- + Public Outreach: After the first design iteration the planning team will conduct stakeholder interviews and public civic engagement forums, as well as focus group meetings with selective interest groups and organizations, to gather community perceptions, issues, and values held by the community(ies). Working with the Advisory Committee and DOT, the planning team will conduct a series of public forums to gather feedback on the design progression and the project's overall progress. During the second public forum the planning team will present two or three conceptual alternatives that represent clear design directions for feedback, then in subsequent public forums present more specific designs, including alternatives or derivatives, that progressively address community issues and concerns and incorporate community values as they are understood.

Final Plan

- + Preferred Alternative: The planning team, based on input from the Advisory Committee, the DOT, and the public meeting(s) will prepare a draft plan with the preferred alternative. The report will include a summary of the prior stages' milestones and decisions, along with an implementation plan that will include plans, budgets, and schedule.
- + Review Draft Report: The Advisory Committee, DOT, and the planning team will review the draft report and make revisions as necessary.

-
- + Public Outreach: Working with the Advisory Committee and DOT, the planning team will conduct a public forum (or series of forums) to gather feedback on the Draft Plan.
 - + Final Plan: The planning team will prepare the Final Plan based on input from the public forum(s) and working meetings with the Advisory Committee and DOT.

Facilitated Systems Integration

Not all planning teams, irrespective of discipline, are successful with integrating consultants or even members of the same agency to achieve the results expected of a holistic process. Pioneering work with integrating planning team members, particularly when many disciplines are represented and the planning team is large, has recently achieved positive results with a modified planning and design process termed “facilitated systems integration.”

Developed by the Regenesi Group, facilitated systems integration introduces two changes to the typical planning and design process.²⁰ The first is a deep analysis of the project’s context, which Regenesi terms the Story of Place. It identifies the underlying contextual patterns that shaped the environmental, economic, and social dynamics the specific location where the project is located. The Story of Place explores how and why the context is what it is, including the forces that shaped it and the values it represents. Its findings are used to inform all the team members, consultants, and major stakeholders about the context and historical

roots of place they are about to change. The second is the facilitation itself. Each work session is designed to reach an outcome appropriate to the project’s phase; however, rather than continuing with what a team member or consultant may feel is the next step, the planning team rewrites the team’s and consultants’ scope of work for the next work session that challenges the last work session’s conclusions to push the thinking forward. Respective team members and consultants are encouraged to collaborate among themselves as they “solve” their challenge. This process is iteratively repeated as the breadth of the project’s outcome becomes more focused toward implementation.

While not recommended for all transportation planning projects because of its time-consuming nature, facilitated system integration is appropriate for projects with multiple stakeholders, involving multiple disciplines, and the need for complex problem solving. For example, Regenesi successfully brought together over thirty competing interests to solve a new waste treatment facility’s integrated design. While taking longer than a typical project’s planning and design, the project outcome resulted in all parties reaching a consensus solution that introduced a new form of waste processing and new operational procedures to the business of waste management. While the design phase took more time and expense, construction was completed faster than expected and significantly under budget such that the savings more than paid for all the project’s design fees.

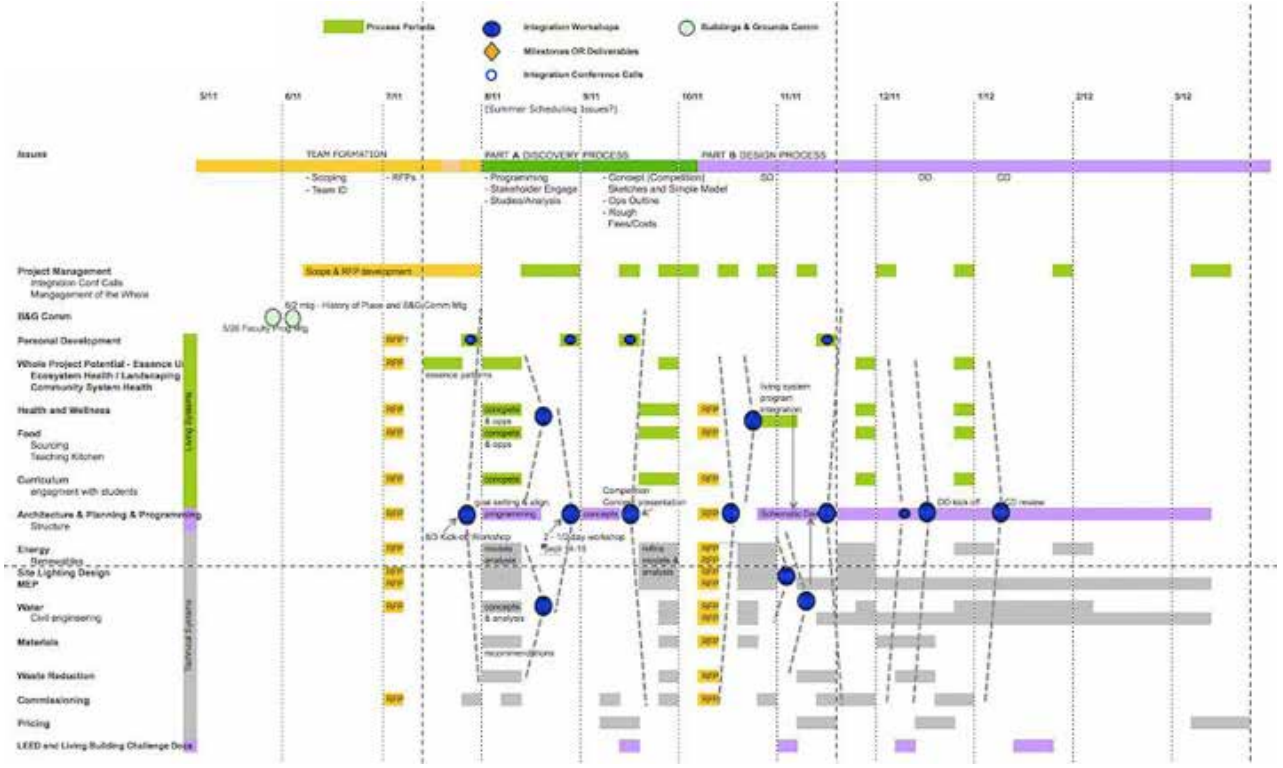


Figure 27 | Facilitated systems integration process. The blue dots along the purple line are full-team facilitated work sessions, while the other blue dots represent subsidiary work sessions among select disciplines. The disciplines are represented on the left side of the diagram and the stages of Team Formation, Discovery Process (Understanding: Base Data and Analysis), and Design Process (Exploring: Alternatives and Deciding: Final Plan) follow the project timeline.



NEW INFLUENCES ON CORRIDOR PLANNING

Climate and Risk
Metrics and Accountability
Holistic Project Practices
Civic Engagement

CLIMATE AND RISK

Climate change is presenting new risks and level of accountability that create a more complex agenda for any project.

METRICS AND ACCOUNTABILITY

New ability and level of accountability have led to an emphasis to “manage what you measure.”

HOLISTIC PROJECT PRACTICES

Project delivery methods and software connect teams and communities in ways not yet fully adopted in all projects.

CIVIC ENGAGEMENT

The authentic involvement of the community helps to define project goals and the ultimate success of a project.

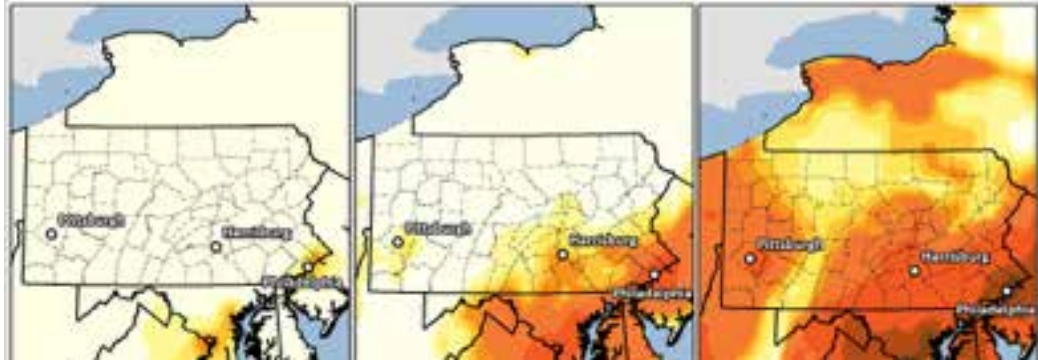


Figure 28 | The figure shows projected changes in the number of heat waves across Pennsylvania per decade. Although increases in heat waves are not widespread by mid-century, a significant increase in the number of heat waves is projected by the end of the century across the entire State. While ANL defined heat waves as two consecutive days with temperatures above 90°F, the trends shown in the figure may actually indicate prolonged periods where temperatures remain above 90°F.²¹

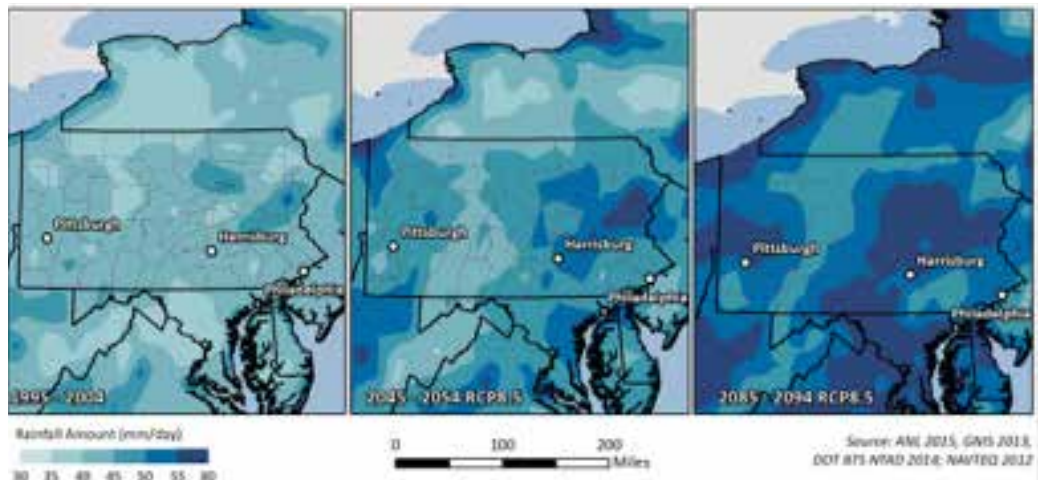


Figure 29 | Heavy precipitation is projected to increase across Pennsylvania. The figure shows the heaviest (greater than 99th percentile) daily precipitation projections under the RCP8.5 (high) scenario.²²

CLIMATE AND RISK

Climate Change

Since the beginning of the Industrial Revolution, scientists estimate that the earth's naturally occurring greenhouse effect has been enhanced by additional concentrations of carbon dioxide (approximately 30 percent), methane (estimated to have doubled), and nitrous oxide (approximately 15 percent). The effect has increased the heat-trapping capability of the planet's atmosphere. Scientists estimate that the United States contributes approximately 25 percent of the Earth's total greenhouse gases and that transportation produces 28 percent of that contribution.²³

The US Department of Transportation has been studying the situation for more than ten years and has concluded that transportation is the largest source of greenhouse gas (GHG) emissions after electricity generation, thus identifying transportation's important role in climate change policy and program decision making.

Since 1990, transportation in the United States has been one of the fastest-growing sources of greenhouse gases, representing 48 percent of the increase in total GHGs attributed to the United States. Although vehicles have become more efficient, the number of vehicles on the road has steadily increased, effectively outpacing efficiency efforts.

Over the past decade Pennsylvania has experienced new record temperatures almost every year and

scientists are now estimating that the average global surface temperature could rise between 1.6 degrees to 6.3 degrees Fahrenheit by 2100, with significant regional variation. With hotter surfaces, evaporation will increase and heavier precipitation is expected along with an increase in flooding and sea level rise. Although regional predictions are much less reliable than global ones, the projections for Pennsylvania by the Argonne National Laboratory predict a substantial increase in both temperature and precipitation across the Commonwealth.²⁴

The impact of an increasingly volatile climate is that transportation planners can no longer rely on tried and true engineering norms. The norms are changing because predictability is changing. Transportation planning is entering the age of risk management where costs and benefits must be weighed more carefully.

New planning techniques such as adaptation planning involve responding to the impacts of climate change, both proactively and reactively, and should include preventative measures to slow down the progressive effect of climate change and provide mitigation measures to reduce its impact.

Adaptation Planning

Transportation planning has been highly predictable in the past and has been codified in standardized procedures and construction details. Designing for the next fifty to one hundred years,

however, will require different strategic thinking, as predictability will no longer be standard operating procedure.

Climate change is not the only unpredictable item requiring attention. Homeland security, a national concern since 2001, is now a fact of life. Societal evolution, community preference changes, emerging opportunities and threats, both natural and man-made, all contribute to unpredictable change. Does one plan for worst-case scenarios, average the risks, or discount their influence? These are serious questions that require different thinking.

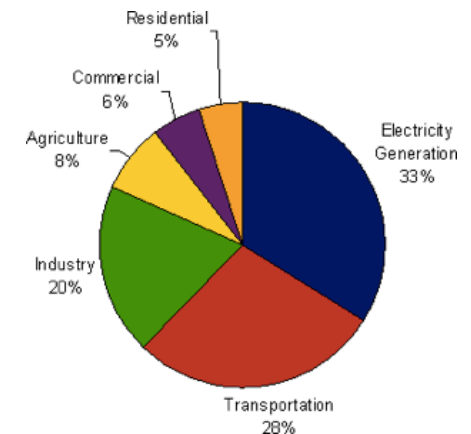


Figure 30 | Percentage of US Greenhouse Gas Emissions, 2006 (all gases, in Teragram [Tg] CO₂ equivalent)

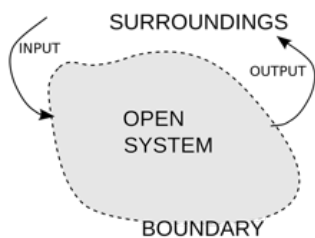


Figure 31 | Adaptability planning is an open system with fluid boundaries that responds to its context by adapting its boundary and responds as inputs change either by shock or stress.

The only thing constant about the future is change ... and change is risky.

Change can occur in a continuum of speeds, from fast to slow. Current resilience knowledge recognizes this by classifying external changes as two types: shock and stress. Shock changes occur randomly and are unexpected. Natural disasters, such as major earthquakes or Category Five hurricanes, are shock changes requiring immediate action. Stress change is slow, insistent and unrelenting, yet over the long-term is more devastating than natural disasters. They are systemic and their appearance is almost imperceptible, yet their impact is wide-spread. Climate change is an example of stress change even though it may be the source of many natural disasters. Infrastructure deterioration, energy scarcity, and water shortages are other stress changes.

Adaptation planning becomes necessary when the future is unpredictable. It is based on the idea of intentionally allowing for change – on being able to adjust the approach or action(s) in response to external change. This means planning for the unexpected. Anticipating change or future problems can be an exercise in futility, but one can establish a standard method or system to respond to change. Businesses have responded by incorporating risk management techniques into their everyday operations with detailed plans and procedures in place for how to respond to an emergency. Fast-evolving businesses, such as those in technology, have learned to transform quickly to customer demands or a competitor’s new product. Smart businesses back-up sensitive intellectual property

and keep it off-site, along with contingency plans in place should their premises be shut down.

Adaptation planning offers not only methodological and systems-based approaches, but also represents different strategic thinking. Consider both opportunity-based adaptability and alternative-based adaptability.

Opportunity-Based Adaptation Planning

Whether caused by climate change or not, natural disasters are extraordinarily costly yet provide opportunities to rebuild and rethink while doing so. As Rahm Emanuel said while Chief of Staff to President Obama, “You never let a serious crisis go to waste. And what I mean by that it’s an opportunity to do things you think you could not do before.” If prepared beforehand, transportation planners can take advantage of emergency, one-time funding to test new adaptive technology and techniques while rebuilding transportation infrastructure as the means to cover higher initial capital costs, or leverage the funds to expand proven adaptable infrastructure’s influence beyond the localized area.

Alternative-Based Adaptation Planning

While related to opportunity-based planning, alternative-based adaptation planning places the planner in a proactive position to solve a problem from different perspectives. It is about expanding opportunities. For example, to solve a congestion problem the solution may not lie with the corridor itself, but with alternative routes for other modes of transportation to better balance the transportation network. Often having atypical members on

the planning team, such as an economist or a political advisor, can help provide that alternative perspective or, alternatively, the planning team could utilize the civic engagement process to elicit different ideas.

Adaptation planning is holistic planning. Conceptualizing it as a networked engineering system of systems, or a Complex Adaptive Systems of Systems (CASoS) as shown in the accompanying diagram (Figure 32). Perturbations represent the unpredictable inputs of shock and stress. Aspirations represent the goals and visions, such as minimize risk or maximize health, and CASoS represents engineering applications. Figure 31 places CASoS at the center in a leadership position, similar to that of a transportation planning team capable of drawing on outside expertise.

One of the keys to thinking strategically about adaptation planning is the ability to learn experientially. Everybody makes mistakes. Recognizing and recording them, whether they be with decision-making, communication, or other processes builds knowledge and allows for correction over time.

The Federal government will soon mandate that climate change must be accounted for in all Federal projects and those funded by the Federal government, including those of the Department of Transportation. The US Federal Interagency Climate Change Adaptation Task Force published the following principles for adaptation:²⁵

- + Adopt integrative approaches:
 - Adaptation should be incorporated into core policies, planning, practices

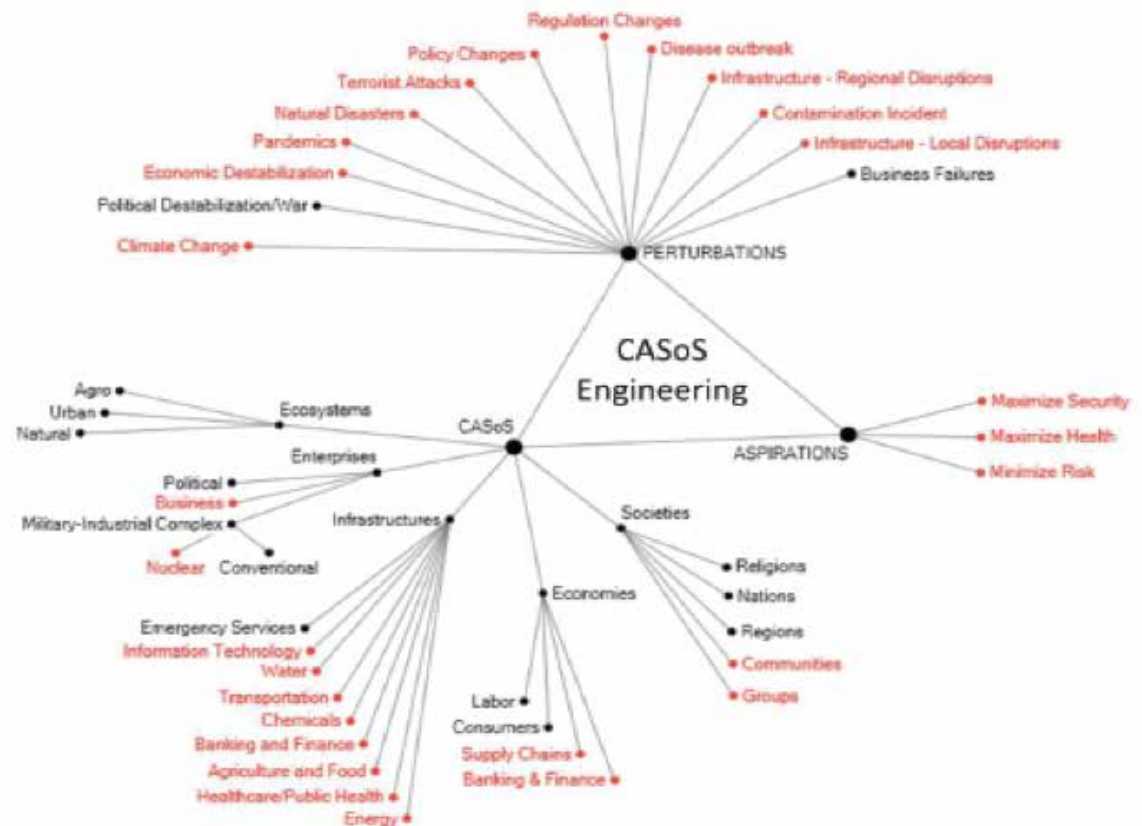


Figure 32 | Simplified diagram developed at Sandia National Laboratories of CASoS engineering application space as a simplified network. The diagram illustrates how CASoS engineering considers the relationships of the CASoS, the goals of engineering (termed aspirations), and the elements that can influence the system (perturbations). Items in black represent existing applications for a specific CASoS and those in red represent those in development.

- and programs wherever possible.
- + Prioritize the most vulnerable: Adaptation plans should prioritize helping people, places and infrastructure to be designed and implemented with meaningful involvement from all parts of society.
 - + Use best available science: Adaptation should be grounded in the best available scientific understanding of climate change risks, impacts and vulnerabilities
 - + Build strong partnerships: Adaptation requires coordination across multiple sectors and scales and should build on the existing efforts and knowledge of a wide range of public and private stakeholders.
 - + Apply risk management methods and tools: Adaptation planning should incorporate risk management methods and tools to help identify, assess and prioritize options to reduce vulnerability to potential environmental, social and economic implications of climate change.
 - + Apply ecosystem-based approaches: Adaptation should, where relevant, take into account strategies to increase ecosystem resilience and protect critical ecosystem services, thereby minimizing vulnerabilities of human and natural systems to climate change.
 - + Maximize mutual benefits: Adaptation should, where possible, use strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management and reduce greenhouse gas emissions, including the development of cost-effective technologies.

- + Continuously evaluate performance: Adaptation plans should include measurable goals and performance metrics to continuously assess whether adaptive actions are achieving desired outcomes.

Transportation engineers build long-lived infrastructure. The right-of-ways and footprints of the infrastructure have even longer-term influences. Planning and design of new infrastructure should account for the climate of the future even though there is significant uncertainty about the spatial and temporal distributions of the changes over the lifetime of infrastructure designs and plans. The uncertainty does not mean that climate change should be ignored.

Infrastructure designs and plans, as well as the institutions, regulations, and standards to which they must adhere, will need to accommodate a range of future climate conditions. Secondary effects from a changing climate, such as changes in land cover and land use, resource availability, and demographics will be similarly uncertain and will require flexibility in infrastructure location and design. The standards, codes, regulations, zoning laws, etc. that govern infrastructure are often finely negotiated or delicately balanced, which often makes them slower to adapt. In addition, stakeholders may exploit the uncertainties associated with climate change to argue for positions they prefer.

The Committee on Adaptation to a Changing Climate of the American Society of Civil Engineers makes the following recommendations:²⁶

- + Engineers should engage in cooperative research involving climate, weather, and life scientists [sic] to gain an adequate, probabilistic understanding of the magnitudes and consequences of future extremes. This cooperation can lead to a better understanding between the professions, the limits of scientific knowledge understood, and the uncertainties of climate effects become fully recognized for engineering design purposes.
- + Practicing engineers, project stakeholders, policy makers and decision makers should be informed of the uncertainty in projecting future climate and the reasons for the uncertainty, as elucidated by the climate science community. Considerable engineering judgment to balance the costs of mitigating risk through adaptation will be needed as well, and should be transparent in the planning and design processes.
- + Engineers should develop a new paradigm for engineering practice in a world in which climate is changing, but unpredictable. When uncertainty prevails, engineers use low-regret, adaptive strategies such as the observational method to make a project more resilient to future climate and weather extremes and seek alternatives that do well across a range of possible conditions.
- + Critical infrastructure that is most threatened by changing climate in a given region should be identified and evaluated in terms of strategies for resilience, and decision makers and the public should be made aware of this assessment.

METRICS AND ACCOUNTABILITY

Accountability - Performance Metrics

Performance metrics gauge the performance of transportation agencies and are a management tool to help achieve a variety of strategic goals and objectives, among them the holistic, multi-disciplinary, community-driven nature of today's transportation projects.

PennDOT's Transportation Program Development and Project Delivery Process places a high value on a thorough and rigorous evaluation of every potential project to assure that it will meet the goals of the agency, produce a high-quality product, and do so in the most efficient and effective manner.

Also important are evaluations of the Process, such as focusing funds and resources on the most necessary transportation needs; improving cost estimating; increasing accuracy in scheduling and predictability for project delivery; developing more accurate scopes of work; improving PennDOT's goals in project selection; improving communications, coordination, and cooperation within and between PennDOT and other agencies; and promoting early public participation and public involvement. PennDOT values performance in both the Project Delivery and the Process.

Evaluating Complete Streets Projects: A Guide for Practitioners, by Seskin, Kite, and Searfloss, provides sound advice regarding performance measures and how they should be used. Detailed examples are included in the Appendix. Their advice is relevant for corridor planning and execution. The following is excerpted from their publication.²⁷

What are Performance Measures and How Should They Be Used?

Performance measures generally can be interpreted to mean the data inputs used when:

- + Undertaking long-range planning efforts
- + Selecting projects to fund
- + Performing an alternatives analysis
 - an evaluation of all reasonable options for a transportation project
- + Considering specific elements when finalizing a project's design
- + Evaluating the outcomes of a built project
- + Displaying the current state of a system, as with a dashboard

Scale

It is important to apply the right performance measures at different scales within a corridor:

- + A specific location (such as an intersection)
- + A corridor segment
- + A corridor with multiple segments and intersections

Think holistically when selecting performance measurements. Not considering broader impacts can lead to uncoordinated results.

Distinguish Between Measured Outputs and Measured Outcomes

Outputs are countable factors such as the change in a crossing's distance at an intersection or the amount of stormwater filtered via new plantings.



Figure 33 | Measurement Framework: Relationship between Process and Outcomes measurements for Project-level and Organization-wide objectives or goals.

They are generally tangible evidence of a project’s impact and directly caused by an agency’s choices.

Outcomes include measures such as rates of fatal or injurious crashes or changes in economic activity. Jurisdictional collaboration and shared responsibility for influencing outcomes is necessary. Outcomes are more difficult to directly relate to transportation investments. However, they are more meaningful to the public and non-transportation agencies because they relate to the condition of the environment and the quality of life.

Lessons Learned from Performance Measurement

1. Data alone can be misleading, it requires context.
2. Transportation investments can support community objectives, but cannot solve community issues, such as boosting the economy or employment.
3. Keep metrics simple. Complexity often obscures positive results.
4. Cost-benefit analysis can prioritize successful improvements and support further investment, however it can overlook the actual needs.
5. While outcomes are important, don’t forget outputs as they make the outcomes possible.
6. Don’t expect immediate results. Use the data to question whether action was implemented correctly or whether the right items were being evaluated.
7. Results may be hampered by internal issues, such as a belief that multimodal improvements cause more problems than solutions and thus lead to a pared-back TIP that will further support the belief.

Basic Steps in Project Evaluation

1. Agree in advance to goals and objectives of the project. Consensus among stakeholders is critical to establishing the evaluation tools.
2. Determine the best ways to measure goals. Seek a variety of measurement considerations from stakeholders and utilize information collected by others.
3. Implementation measures. Take baseline measurements before implementation, establish a set timeframe for evaluation information, use a variety of techniques to record data, and consider both quantitative and qualitative measures as appropriate measures.
4. Share results. Communicate findings to stakeholders and share lessons learned within the agency.

Process and Outcome Measures

TransTech Management, et al, in their *Performance Measures for Context Sensitive Solutions – A Guidebook for State DOTs*, suggests both Process and Outcome measures for both the Project and the Agency. The framework diagram (Figure 33) shows their relationships. The descriptions developed by TransTech Management of each of the four quadrants provide helpful descriptions of measurement foci and content measures. The evaluation method is holistic and inclusive.

Project-Level PROCESS Evaluation

In Project-Level Process Evaluation, the focus is placed on enhancing the project delivery process to achieve policy and mandated directives. These evaluations stress comprehensive considerations of project needs and their impacts; community outreach to identify common interests and build consensus on approaches; the use of interdisciplinary teams; and the integration of National Environmental Protection Act (NEPA) requirements. Emphasis is placed on each project's demonstration of how the project delivery process supports the holistic integration of CSS, multimodal, and other valued principles.

Below are key components of the process:

- + Use of Multi-Disciplinary Teams: The focus should not be just having the right team members, but ensuring that they work together to achieve the desired project vision.
- + Public Engagement: The project should be tailored to meet local needs; engagement frequent and ongoing, inclusive, educational, supported by strong leadership; and stakeholders should include the public, local jurisdictions, resource agencies, various interest groups, highway designers, environmental professionals, and project managers within the sponsoring agency. Focus should be on the quality of the public engagement.

- + Consensus on Problems, Opportunities, and Needs
 - ◇ Transportation: Current or future capacity concerns; better system linkages; multimodal options; Federal, State, or local governmental mandates for action, safety problems, and roadway deficiencies.
 - ◇ Community: Social demands; concerns about community character and appearance; livable community issues; health issues such as walkability; economic development such as tourism potential.
 - ◇ Environmental: Protection needs; impact on sensitive habitats, wetlands, rivers, and streams.
- + Consensus on Vision and Goals: How the project will operate and look ten to twenty years into the future; how it supports community values or aspirations; how it creates environmental benefits. The focus should be on building a common understanding and expectations about project outcomes.
- + Alternatives Analysis: Alternatives should reflect stakeholder values and the problems and opportunities; how they reflect the creativity and expertise of team members working collaboratively; and how they address safety.
- + Construction and Maintenance: Construction and maintenance staff should be included in the process for determining construction issues and long-term maintenance of the proposed alternatives.

Project-Level OUTCOMES Evaluation

These measurements focus on how the completed project met its goals and objectives. However, it is important that they should ultimately focus on stakeholder satisfaction. Outcome-related measures should be applied upon project completion and re-evaluated in future years.

- + Achievement of Project Vision or Goals: Focus should be on measuring project outcomes against expectations. This requires careful documentation of project baseline conditions during project development, including issues identified in the needs statement
- + Stakeholder Satisfaction: Stakeholder satisfaction can be gauged using surveys, focus groups, or debriefing charrettes with the project team and stakeholders. A general survey of citizens can be effective, particularly on corridor projects spanning several municipalities.
- + Quality Assurance Review: A quality assurance review can be conducted to determine how well needs and vision or goals have been met and whether the process requires modification. This review may be conducted by the planning and design team through a collaborative self-assessment approach, by a team of agency leaders, or through evaluation by a peer group of experts outside the agency.
- + Implementing Project-Level Measures: These are generally conducted by the respective project team with assistance of an internal expert.

Implementing Project-Level Measures

Designing, tracking, and reporting project-level measures will most likely be the responsibility of individual project teams, led by their project managers. An agency-wide champion for CSS and complete streets will be of help in preparing an initial template of evaluative measures. Project teams should select project-specific measures in some or all of the focus areas described and review the list with the local agency leadership. For most project-level measures, collection of measurement data is likely to occur at project completion. Data can be collected via surveys of team members and stakeholders. Feedback is valuable for team members to strengthen project delivery. The agency may collect project-level measurements to track performance for the overall agency.

Organization-Wide PROCESS Evaluation

Strong leadership and agency-wide training and guidance are necessary.

- + Training: Training increases awareness about organization-wide policies and expectations. These are most successful when focused on developing skills for interactive and interdisciplinary teamwork.
- + Manuals: These communicate the agency's vision, policies, and guidelines for use by agency staff and consultants. Manuals are evolutionary documents that will require revisions as completed projects are evaluated and new policies emerge.
- + Policies: As agency values and attitudes evolve, policies should be amended to meet new objectives and goals.
- + Motivation: Performance measures can be used to create awards and individual performance plans to motivate employees, build awareness, encourage new thinking, and reward staff initiatives. Successful individual and team efforts and often agency-wide best practices recognition are often more important than monetary rewards.

Organization-Wide OUTCOME Evaluation

Three outcomes to measure that are closely related to CSS, complete streets, and these corridor guidelines are timeframe, budget, and stakeholder satisfaction.

- + Timeframe and Budget: Incremental costs for new approaches should be wholly integral to overall project costs and timeframe. Keeping separate records of extra costs undermines the holistic nature of the project delivery process. Macro-level analysis of trends across multiple projects may be valuable.
- + Stakeholder Satisfaction: Project teams should be encouraged to include project-level measures of stakeholder satisfaction in all projects.

Implementing Organization-Wide Measures

Implementation of these measures will require a leader or champion within the agency or a staff specialist with expertise in performance measures related to CSS or complete streets. Organization-wide measurement data should be collected on a regularly scheduled basis. External stakeholders, such as the Federal Highway Administration, may also become part of a broader agency- or organization-wide effort to measure performance.

HOLISTIC PROJECT PRACTICES

Projects and Practice are Connected in Many Ways

The word “holistic” means relating to or concerned with wholes or with complete systems rather than with the analysis of, treatment of, or dissection of parts. Holistic can also be defined as comprehension of interconnected parts of something explicable only by reference to the whole. A transportation corridor is part of a larger system and to plan and design a corridor means to understand the communities it serves.

This section describes the components of a holistic corridor planning and design process. It builds on PennDOT’s history of continuous innovation and adoption of multimodal and integrated transportation design.

Sustainable Practices

Holistic project practices are sustainable practices. The term sustainability, originally coined by environmental and ecological professionals, has become an essential feature of best practice by businesses, policy-makers, and economic development practitioners.

The clearest definition is embedded in the “triple bottom line” concept, an accounting framework that incorporates three dimensions of performance:

Triple Bottom Line

- + Economic
- + Social
- + Environmental

Developed for the accounting industry to assure comprehensive investment results with respect to performance along the dimensions of profit, people, and planet, triple bottom line has become an important tool in reaching sustainability goals.

Sustainability is embedded in Federal and PennDOT transportation policies and directives. While not stated directly, the evolution of TIP project planning, design, and evaluation incorporates sustainability qualities and values.

While subtle and difficult to measure, sustainability is now embedded in holistic project practices and evaluated by performance measures. This study supports triple bottom line sustainability practices and adds the term “physical” to the other three measures in order to achieve physical designs that are context-sensitive and holistic.

Sustainable Practice

- + Economic
- + Social
- + Environmental
- + Physical

Integrated Design Process

Transportation planners and engineers are familiar with integrated systems planning. Overlay planning tools, such as GIS, CAD, and BIM-based programs, are based on the idea of integrating systems into a comprehensive framework (Figure 34).

Systems integration planning recognizes that a diverse team of experts (representing a variety of disciplines) could individually solve the problem at hand and do so in a credible manner, but by

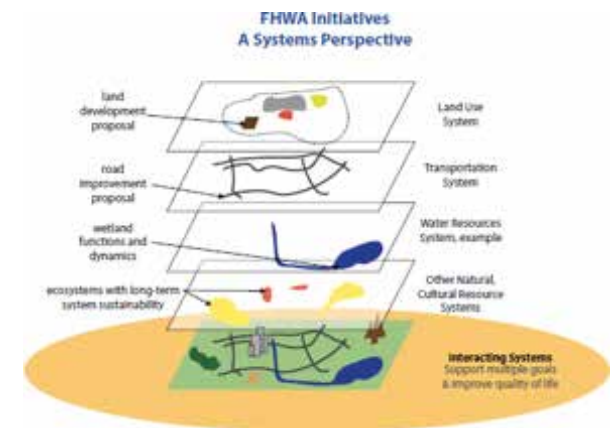


Figure 34 | Integrated systems planning is holistic by its very nature of integrating disparate systems by bringing together design specialties usually considered separately.



Figure 35 | The iterative process repeats the idea of concept-test where requirements are analyzed, developed, tested, and evaluated several times before deployment.

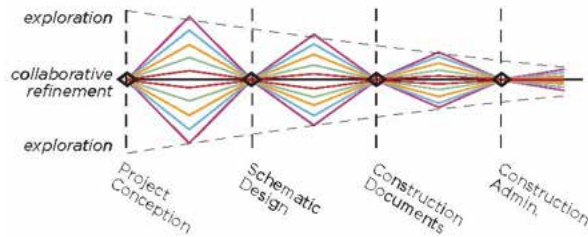


Figure 36 | The ongoing iterative cycle of systems integrated planning is illustrated for a typical planning and design project as it proceeds through the design phases to implementation. Work sessions occur where the lines representing different disciplines converge. (source: Evolve:EA)

working together and integrating their expertise can achieve higher-quality and more-accountable results. As each discipline develops its contribution the process moves forward by repeated iterations, the solution benefits by accountability from multiple perspectives.

Bringing multidisciplinary expertise and knowledge together in collaboration stimulates thinking that can lead to new solutions. It is the different perspectives that experts bring to the integrated process that enriches the solutions. Each iteration, a rigorous process itself, tests the ideas several times in a powerful and integrated process. (Figures 35 and 36)

Highway corridor planning, at least in terms of mandated Federal and PennDOT policy, has evolved from the safe and efficient movement of vehicles to the expectation of a holistic and multi-dimensional process without diminishing the need for safe and efficient movement. While integrated systems planning is familiar to transportation planners and engineers, adding the requirements of multimodal integration, community land use planning, and robust civic engagement, can be daunting for those accustomed to a more singular and traditional design process.

More integrative thinking will be demanded of planning teams as new responsibilities and more

demanding accountability are placed on planning teams and project outcomes.

The Guiding Principles for Integrated Planning lay the groundwork for a more robust and holistic process.

Guiding Principles for Integrated Planning

A holistic approach can be best achieved by the following six guiding principles.²⁸

1. **Public Participation:** This is listed first because of its prime importance. Public participation is not just calling a public meeting that has characterized highway planning in the past. It must be more inclusive and authentic. The first step is to have a diverse Advisory Committee, sometimes called a Steering Committee and/or a Technical Advisory Committee, that will work with the planning team throughout the project's tenure, provide liaison assistance with public officials and citizens, and give feedback on all proposals before they are presented to the public. This broadens the base and provides informed insights that might have been overlooked. The second step is to make the public meetings accessible to all and highly interactive. Focus groups directed at specific populations and interest groups, such as transit riders or bicyclists, may prove valuable and are recommended.

2. *Engagement of Major Stakeholders:* Outreach to elected and government officials, major employers and business interests, faith-based organizations, institutions, and economic development organizations may require individual interviews to obtain initial perceptions of the corridor and community issues and later, after alternatives and the draft final plan are ready for review.
3. *Multi-disciplinary Teams:* Highway corridors are complex systems that involve more dimensions than transportation and civil engineering disciplines have covered historically. A highway corridor planning team should include some of the following depending on the complexity of the corridor: urban designers, planners, traffic experts, ecologists, economists, attorneys, landscape architects, public outreach specialists, historic resources experts, and others as may be needed. The lead consultant could be an engineering or planning firm, but the other disciplines need to be represented in-house or as sub-consultants. A holistic solution will not emerge without a multi-disciplinary team.
4. *Understanding the Context:* Fortunately, the concept of Context Sensitive Design for highways and corridors is now both USDOT and PennDOT policy with attendant guidelines and regulations. The planning process detailed in the Integrated Corridor Project Delivery section and the commitment to a multi-disciplinary team will insure that the unique context of each corridor will emerge and be respected.
5. *Sustainable Design:* Carbon emissions, stormwater, and land use always must be dealt with in transforming highway corridors. Lowering carbon emissions, either by more efficient traffic control or the use of alternative modes (transit, biking, walking) is a core goal. Best management practices should be followed in solving stormwater issues. Best zoning practices and urban design guidelines can address development density and efficient use of land.
6. *Implementation as a Focus:* Good planning and engineering are irrelevant if there is no funding or the will to implement the plan. From day one it is important to identify and involve those participants who have access to funding, control the regulations, or have approval authority. Ideally, these agencies should be represented on the Advisory Committee. When the Final Plan is published it should include funding sources, implementers, commitments, and early action projects.

PRINCIPLES OF DELIBERATIVE DISCOURSE

- + Engages a group of citizens reflective of the diversity of the communities impacted by the outcomes of the deliberation.
- + Involves citizens in structured discussions.
- + Provides citizens with the opportunity to compare values and experiences, consider a range of policy options, and engage relevant arguments and information.
- + Activities aim to produce tangible actions and outcomes.

ELEMENTS OF A DELIBERATIVE FORUM

- + Organizers recruit a diverse group of participants.
- + Participants receive background materials offering basic information and a balanced overview of various perspectives on issues.
- + Participants engage in small-group discussions facilitated by trained moderators.
- + Participants' questions are addressed by a resource panel of experts.
- + Participants return to small groups to reflect on information provided by resource panelists.
- + Participants complete an exit survey.

BENEFITS

- + Participants develop an opinion informed by relevant facts, expert information, and an understanding of how issues and policies affect others in their community.
- + Participants enrich their understanding of their own perspective.
- + Participants develop understanding of new or alternative perspectives.
- + Participants develop a more comprehensive knowledge about the issues.
- + Participants practice skills of civil deliberation.²⁹

CIVIC ENGAGEMENT

Importance of Different Perspectives

The integrated system process is designed to elicit different perspectives. This rich planning process thrives on reaching resolutions that combine the best practices of all the involved disciplines. The outcomes are typically holistic and often innovative. Strong teams of experts produce better results as each member challenges one another in a design environment that questions and confronts conventional wisdom to test its relevance to the job at hand.

Not every project results in superior results because effective planning, team leadership, and the willingness of consultants to push themselves are key to successful projects. However, following an integrated systems approach will have better results. It is the integration that is holistic.

The agency and project team are but two thirds of the integrated systems process. Collaboration with community stakeholders completes the holistic system triad. As partners with the community, the planning team benefits from the variety of opinions and interpretations of needs and inspirations. Civic engagement, though, increases the planning team's and agency's leadership and management responsibilities. Successful civic engagement is a good test of a collaborative and responsible project.

Civic engagement is not just participatory planning, preferential opinion solicitation, or attending public information meetings, although all of these are involved. Civic engagement brings the public into the planning process in dialogue with the planning team to uncover community values and aspirations.

With this knowledge, and by incorporating it into the project's development and recommended solution, the planning team will have demonstrated that it heard, learned, and respected the community. It is a process that builds respect and, ultimately, community ownership of the final plan. It is a sustainable practice that contributes to the social significance of triple bottom line thinking.

Customary Civic Engagement Process

A typical civic engagement process consists of three public outreach or civic engagement sessions over the course of a planning project:

1. The first occurs during the initial research phase where citizens are asked to contribute ideas and express their desires for what program or design features they would like to see in the final outcome, typically conducted as a "charrette" or brainstorming session.
2. A review and feedback session about halfway through the planning process where the planners present alternatives to gauge citizens' opinion regarding desirable or undesirable features of the presented alternatives. The selection of a preferred alternative or an agreement to combine the desired features from several alternatives into a single solution is usually the end result.
3. A final engagement near the end of the planning phase where the planners present the preferred plan for final comment and feedback. While the intention of an engagement process is to build citizen ownership of the process and the final corridor plan, the typical project-based

Public participation, public outreach, citizen engagement, and other similar terms are used interchangeably throughout this document to describe civic engagement in one form or another. This section discusses civic engagement as an important aspect of holistic planning and describes how civic engagement can, and should, be used differently to achieve transformative corridor planning projects.

civic engagement is more participation than engagement. Most are structured as “preference” sessions where planners are soliciting answers to questions such as, “What would you like to see included in the design?” or “Which of these alternatives do you believe works better and for what reasons?”

While these questions solicit individual preference, they do not necessarily support public deliberative interaction among citizens or between citizens and planners. A holistic planning process needs to engage the public

in meaningful dialogue that is informative for the design team and fulfilling for the public.

Deliberative Discourse Model

Deliberative discourse is a model of civic engagement that is dialogue-based with a focus on learning about community issues and the underlying values of its citizens as the basis for information exchange and discussion. At the deliberative discourse’s core is the goal to learn from others who hold different values and to acquire new knowledge that can be shared to benefit others and the project.

The process offers a more informative approach, yet with the same ownership goal of the customary participatory process. Deliberative sessions, called forums, seek to discover what people think about an issue after they have engaged alternative perspectives in a substantive dialogue process. A deliberative engagement is not conflict resolution; it is about taking ownership. Its purpose is to provide project planners with the community’s perspective on a number of issues embedded in community values. It directs the engagement to the discussion and collaborative consideration of issues and the weighing of options rather than on preferences and



Figure 37 | Problems, preferences, and solutions are typical outcomes of citizen brainstorming sessions. Expectations of the participants’ solutions being incorporated into the final plans are often heightened by preferential sessions. This can lead to discouragement and resentment of time wasted by the civic engagement process.

brainstorming of ideas. Citizens are asked for their preferences after the issues have been discussed and deliberated.

The underlying purpose for this type of engagement is for the project team to learn and understand the concerns and values that are shared among the citizenry. It is not intended to raise expectations that participants will be making project decisions or that their ideas will be seen in the final plans.

The Program for Deliberative Democracy at Carnegie Mellon University has developed a set of principles and benefits that describe the deliberative discourse model and process (see "Principles of Deliberative Discourse" on page 56). Deliberative forums provide the resources citizens need to develop an opinion informed by relevant facts, expert information, and an understanding of how issues and policies affect others in their community.

Deliberative Discourse Engagement Process

The engagement process is a joint effort of the facilitation and planning teams and intended to integrate the two so that the engagement is an informed process. The integration typically consists of:

- + Working closely with community partners from the beginning of the process, as they will be key in helping to recruit citizens and issue experts, provide timely advice and feedback, and help advocate for the process throughout the project's tenure.
- + Participation in developing an issues paper that is sent to citizens and public officials prior to any engagement session.

- + Participation in developing a survey questionnaire and orientation documents, such as a map of the project area, regarding how citizens in the local area relate to, interact with, and regard the project as a factor in their daily lives.
- + The preparation of a PowerPoint or other visual material that provides an overview of the project to bring the citizen participants up to speed with the ongoing project. The facilitators prepare the final material, mail the briefing document to citizens who have agreed to participate, locate and brief the table moderators and scribes on how to conduct their respective small table deliberative discussions (seven to eight persons), and locate and brief a panel of experts familiar with the issues and who can provide various viewpoints and perspectives on the subject(s) as a response to citizen questions.
- + Participation by the project team in the public forums as table monitors, expert panel participants, and panel monitors. Facilitators sign in the public, hand out materials including the exit survey questionnaire, participate as table monitors if needed, debrief the table monitors immediately after the forum to learn of any issues or unintended consequences, and later tabulate the survey questionnaires and prepare a written report that summarizes the forum's outcomes and questionnaire results.

Civic engagement sessions are discussion forums, not workshops or charrettes. Participants are community residents and stakeholders, including



Figure 38 | Civic engagement formed around a discussion of issues is more productive than sessions focused on preferential opinions.

government leaders and business persons. Moderators ensure that the discussion considers the issues from multiple perspectives rather than seeking individual preferences. A resource panel of experts includes persons knowledgeable on the subject(s) being deliberative who also represent different points of view on the subject(s).

A forum procedure consists of the following:

- + Citizens who reserved a seat at the forum(s) are sent the issues briefing document prior to the meeting date and are expected to have read the document. Copies are also available at the forum.

The three-hour forum consists of the following:

- + Citizens check in and receive a copy of the briefing document to use as a reference. They take seats at tables, preferably round ones, with a table monitor. Introductions are shared.
- + Introductions are made of the facilitators, table monitors, and panelists, and the audience is briefed on the sequence of events during the forum.
- + Discussions begin at the tables over the issues presented in the briefing document. Table monitors seek dialogue by asking questions to gain different perspectives to each of the issues. Notes are taken by a scribe. The first 45-minute segment ends with each table preparing a list of questions to ask the panel of experts. The questions are intended to elicit additional information from the panel.
- + After a break the second 45-minute segment

begins with each table asking one question of the panel in turn and responses are exchanged. Depending on the number of participants, several question rounds can be covered. Note that it is important for the panelists to represent a broad range of perspectives so that the citizens can hear "expert" responses representing a range of interests, some of which are in conflict with one another.

- + The third 45-minute segment is spent with the table participants and monitors discussing what was heard from the panel and deliberating the inherent conflicts as well as consensus elements of the issues.
- + The forum is called to a close and each participant is asked to fill out the survey questionnaire, which are collected before people begin to leave the facility.

After tabulating the questionnaire results, the facilitation team prepares a short report containing the survey results that is mailed to all of the participants.

Depending on the size of a planning project, the deliberative discourse facilitation team may conduct identical forums in a number of locations to gain a larger number of responses for the statistical analysis. As the planning project progresses the planning team may want to learn additional information and receive feedback on proposed planning alternatives or final recommendations. The same engagement procedure is repeated, but with different issues raised and deliberated,

for as many iterations the planning team needs. Typically, conducting deliberative engagements during the research, alternative development, and final stages of the planning process offer a good range of feedback for planning decision-making and citizen ownership for a successful project outcome. Engagement forums do not have to occur at all planning stages and can be effective at any stage in the planning process so long as the issue discussion is pertinent to the need.

Effective Use of Deliberative Discourse

Deliberative discourse engagement is especially effective early in the project. At a project's inception citizens typically have an open mind to discussing issues, be they large or small, and if the engagement is handled properly firm positions will not have yet formed.

At mid-point when the project becomes more detailed and the planning team produces an initial set of alternatives, deliberative discourse can uncover whether the planning team understood

the values and issues of the participants. The discourse can also be used as an evaluation tool to ferret out the opportunities and challenges posed by the alternatives. Although there may be a consensus favorite, the planning team should take all comments into consideration as the team determines which alternative or combination of alternatives is best suited for final development.

By the time the planning process reaches the end the public should be eager to learn the details of the final plan and whether their issues have been addressed. Construction phasing and implementation issues are important for citizens, institutions, and businesses that will be affected by the construction.

Appropriateness for Corridor Planning

The deliberative discourse model and process is a preferred civic engagement approach for corridor planning, particularly for those projects that cross municipal boundaries. Each municipality has its own culture and identity that must be respected

throughout the planning and design process and this recommended model and process seeks to engage in issues that span municipal boundaries yet respects each community's values in the process.

There are several opportunities within the PennDOT project planning structure where deliberative discourse may be effective: at the TIP/STIP level when projects are being evaluated on strategic value vs. budget restraints; at the MPO/RPO level where the process would be helpful to bring cross-municipality interests together to strategize and prioritize regional transportation projects; and at the State Transportation Improvement Plan level where strategic, long-range planning decisions are made.



Figure 39 | The Deliberative Discourse Process. Thorough pre-forum preparation is necessary for a successful engagement.³⁰



TOPIC AREA INFLUENCES

Urban Design
Economic Development
Environmental Infrastructure
Transportation
Transportation Technology

URBAN DESIGN

Urban Design seeks to structure the public realm to create place and memorable settings for the enjoyment and benefit of all citizens. This is accomplished by using buildings and landscape to define the edges of enclosed space, by distinguishing the public and private domains within the public realm, and by increasing the quality of life within the public realm. Transportation corridors provide the opportunity to combine land use planning, site planning, streetscape and sidewalk design, and landscape design to accomplish these ends.

Using the tools of planning and design, zoning, place-making and streetscape design, physical components in the right-of-way, and way finding and landscape, urban design envisions the setting between the corridor edges and the connectivity that integrates a corridor into the community. The strategic value of urban design to corridor planning is its holistic and comprehensive understanding of the built environment and its disciplined approach to integrating complex multimodal transportation, corridor facilities, and visions and goals of the community. Several instances occur where urban design is important to the planning and design process.

Context

Context sensitive solutions expand the design process to better integrate corridors with their surroundings. The result will be beneficial for multimodal safety and mobility, providing support for the activities and land uses that line a corridor.

Planning for pedestrians, bicycles, and transit users works best when planned with a focus on context.

Planners need to look beyond the documentation of current physical conditions, topography, and natural features to also understand the location's sense of place and character of experience to understand the present context. With this background knowledge, formulating design ideas and multimodal goals that seek to improve the context will lead to an integrated right-of-way design. There should be a reciprocal benefit for both the corridor and its setting.

Land Use and Design Speed

There is a close relationship between land use and transportation systems. Land use and the roadway system should work in concert to support a safe multimodal environment. As there is a close relationship between design speed and driver-perceived levels of safety (higher perceptions of danger occur and speeds lower when drivers feel enclosed by buildings, somewhat similar to entering a tunnel).

The components and tools of urban design can be strategically used to create safe conditions while also creating streetscapes that are pedestrian-friendly. Mixed-use development, including residential, retail, and office commercial uses with their high degree of pedestrian activity, benefits from slower traffic, higher visibility, and safer speeds. Traffic can be slowed by narrowing lane widths; eliminating shoulders except for bicycle lanes; channelizing right-turn lanes; using on-street parking to create friction; using smaller turning radii; using paving materials with texture; and installing warning and advisory signage and lighting.

Creating Place and Enclosure

Well-designed and well-scaled streets invite pedestrians and bicyclists into places that were originally designed for the efficient movement of vehicles. Urban design solutions can provide the social activity, diversity, and variety that occurs when there is a mixture of movement modes and a streetscape designed for walking, sitting, and gathering.

Site design and urban form are key ingredients to composing human-scaled places. Buildings oriented toward the roadway, with entries and sidewalk activities, form a continuous built edge that is conducive to pedestrian activity. On-street parking, appropriate even in suburban settings, signals there are popular uses nearby and protects pedestrians.

Building height and landscape are important for creating place. Buildings more than one-story high begin to enclose space, the basis of place-making. Where buildings are not present or when there are gaps in the built edge, street trees provide a good substitute, particularly when planted close together so their canopies overlap. Native, deciduous street trees, if planted properly, will grow to heights above 60 feet, provide shade in the summer, create an allée beneath their lower branches, and transpire stormwater into the atmosphere. Walkable corridors do not require tall buildings, but will benefit from mature street trees.

Building scale, variety, and width contribute to creating place, enclosure, and a pedestrian-friendly streetscape. Scale and the variety of buildings help to define and reinforce the pedestrian environment.



Figure 40 | Street trees, curbside parking, and distinctive storefronts contribute to traffic calming in commercial areas and a pleasant pedestrian experience. The sense of enclosure creates place and slows traffic.



Figure 41 | Auto-oriented corridors without multimodal facilities and street trees are often not visually attractive or friendly environments.

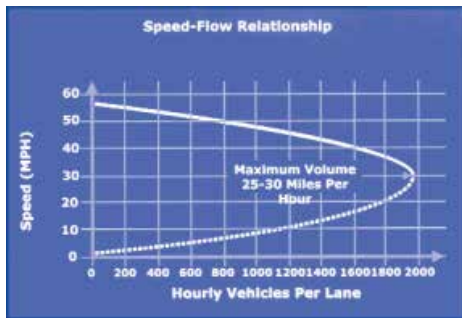


Figure 42 | Traffic movement efficiency peaks between 25 and 30 mph.



Figure 43 | As vehicle speeds increase so does the risk of serious pedestrian injury or fatality. Slower traffic speed is conducive for multimodal facilities.

On the other hand, vehicle-oriented building scale that caters to the motorist hinders walkability. Building widths are important considerations in two aspects: diversity is highest when storefronts change every 25 to 30 feet, whereas when spaces between buildings exceed 30 feet walking is discouraged.

The above principles contribute to reduced vehicle speed when applied strategically along walkable commercial segments, nodes of public realm activity, major intersections, and transitions between corridor segments.

Multimodal Accommodation

Multimodal design, traditionally a transportation concern, takes on another perspective when approached from an urban design viewpoint — walking and biking are also transportation.

A project of the Local Government Commission determined that in 1999, roughly one-third of California residents did not have a driver’s license.³¹ Those 13 million included the working poor, the state’s 8 million children who were increasingly isolated in suburbs, persons with disabilities, and a growing elderly population. The elderly population in California is projected to increase from 3 million in 1990 to 10 million in 2040, and many of them will live in auto-dominant suburbs. It is easy to understand why state and Federal transportation agencies have adopted multimodal policies.

Studies by the Transportation Research Board determined that the capacity of a lane of vehicle traffic is at its maximum at about 30 mph (some

argue that the number should be 27 mph), which has since been updated to 40 mph.³² However, Walter Kulash, a noted transportation engineer, supports the lower speeds. Pennsylvania’s Local Road/Street typology, with a design speed of 25 to 30 mph, is an acceptable road type for multimodal facilities.

The issue becomes how complete streets can be accommodated within limited right-of-way space. Rather than viewing corridors as a combination of arterials, collectors, and local streets, consider them to be boulevards, avenues and streets designed for the enjoyment of pedestrians, bikers, and motorists. Rather than viewing sidewalks, bicycle lanes, medians, street trees, etc. as impositions to be squeezed into corridor roadway system, conceive of them as layers of space in an automotive and pedestrian tapestry where trees define perforated edges, medians suggest zones, shoulders and curb travel lanes are places for mixed modes, and all users feel that their presence has been acknowledged and valued.

Urban design is a powerful tool to create an inclusive public realm. As corridors evolve over the next fifty to one hundred years, the concept of inclusive multimodal transportation spaces and a higher quality of life will also evolve if the public’s perception of corridors also changes to an enjoyable and visually stimulating experience. If the journey takes a few minutes longer to accommodate non-drivers in a pleasant and safe environment, it will be the journey that becomes memorable and not just the destination.

ECONOMIC DEVELOPMENT

Increasingly, jurisdictions are working to accommodate a variety of modes of transportation (including walking and cycling) along various corridors. If fixed-line transit is integrated, various tools can be utilized (e.g. overlay zoning, public purchase of land near transit stations, parking ratio adjustments, funding incentives) to encourage mixed-use development, leveraging ridership and access to jobs and housing. In many cases, transit stations will stimulate new development as developers take advantage of increased property values, otherwise known as value capture. The result is more compact, pedestrian-friendly, mixed-use development along the multi-modal corridor.

While mixed-use development is encouraged, and often desired, in some cases higher density mixed-use development can be difficult to implement given unique physical configurations among users and differing development economics among land use types. Increasing desirability for transit-oriented development has changed the way developers approach design near transit. In some cases, capital is more readily available near transit locations as projects near stations can generate higher rents and absorption.

According to the United Nations Department of Economic and Social Affairs, 54 percent of the world's population lives in urban areas, and is expected to increase to 66 percent by 2050.³³ This trend is particularly evident in the United States. Urban areas (defined as densely developed residential, commercial and other non-residential

areas) are home to 80.7 percent of the United States population, up from 79 percent in 2000. Although the rural population grew by a small amount from 2000 to 2010, it continued to decline as a percentage of the national population. Proximity to central business districts and significant employment centers continues to drive development. This includes a growing demand for downtown/urban area housing and the amenities desired by downtown residents.

Investments in urban areas and along urban corridors depend upon several variables, including available infrastructure, land ownership patterns, and previous uses (e.g. former industrial sites with unique challenges). Strategic investments in pedestrian connections, streetscape, and other infrastructure can help transform these corridors to more desirable locations for transit-oriented and multi-modal development.

New technologies such as driverless vehicles will also impact certain development patterns. Their influence will depend to some extent upon future policy decisions. For example, jurisdictions will have to decide if vehicles should be required to have a driver and other policies regarding how their use should be regulated. Until their potential uses are better understood (e.g. will driverless cars provide transportation to employment centers, requiring alternative parking options during the day?), it is difficult to predict the impact on future development. According to the National League of Cities, among the sixty-eight largest American

cities, only 6 percent of transportation plans consider the potential effect of driverless technology and only 3 percent consider the impact of ride-sharing services.³⁴ Ride share programs present their own unique opportunities. North American car sharing programs average forty-nine members to every vehicle, reducing the overall number of cars on the road and decreasing the need for parking spots. This can have implications in urban areas where ride share programs operate, leading to reduced parking demand in areas where land is highly valued.

ENVIRONMENTAL INFRASTRUCTURE

Corridor planning and environmental issues are integrated at a variety of scales from effects on the immediate project area to influences on climate change and risk management. Transportation engineers consider the potential impacts of a road on natural systems, such as habitat disturbance and water flow. Urban corridors may seem less disruptive to their context because the natural systems are not as visible, but they can be hazardous to human health as a source of pollution. When designed well, corridors can contribute positively to ecosystem health by integrating strategies that improve environmental performance, such as integrated rainwater management and improved biotic systems, along with the ability to move more efficiently with multimodal transportation options. In addition, corridors are a key component in climate change resiliency, helping to offset the risk associated

with extreme weather events through climate preparedness and disaster management.

Corridor design has a direct impact on ecological conditions. Corridors directly affect the local conditions of soil, topography, water, and plant communities that are ecologically connected to larger systems. Roads also affect the immediate site during construction, with equipment emissions, noise, and management of water and soil resources. Lastly, the ongoing maintenance of a corridor has direct impact on a site. Plant selection may introduce unwanted invasive species or require intensive maintenance protocol.

A well-designed corridor can actually improve the ecology in a highly urbanized environment. Street trees that are designed for traffic calming or pedestrian friendly areas can decrease the urban heat island effect and be part of an integrated

rainwater management strategy. Even in less dense areas, careful placement of pedestrian paths and the integration of areas for planting and water control can help contribute to ecosystem regeneration and ensure that natural patterns are continued.

The design of the corridor system helps to lessen activity that leads to climate change and to increase our preparedness for climate emergencies. Designing for multimodal transportation options, even if the implementation is years in the future, allows road investment to carry more passengers per paved mile. The efficient connection of existing destinations and strategic alignment with land use policy can reduce sprawl and encourage reinvestment in existing infrastructure.

Corridors are a key component of climate readiness, allowing for the efficient movement of people to safety in the case of emergencies. Places like Copenhagen, New Orleans, and other flood-prone cities have begun to design roads for “cloudburst” conditions where passage is contiguous and intentional places of refuge are provided in a partially submerged condition. These designs encompass not just the road and shoulders but the surrounding land use to create an integrated system of climate preparedness.

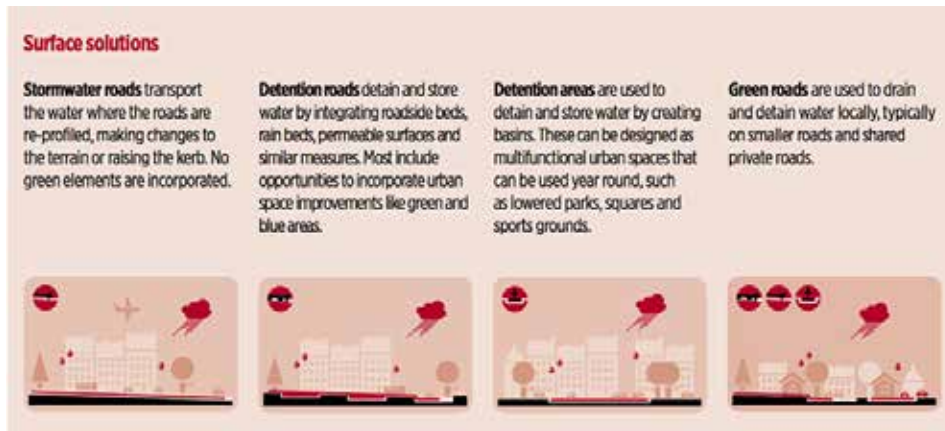


Figure 44 | Stormwater management combines effective flood mitigation with a greener and attractive roadway environment.

PennDOT Community Impact Assessment Tool

PennDOT has a history of addressing environmental concerns. PennDOT's *Community Impact Assessment Handbook* (Handbook) is focused largely on social and economic impact, but the *Handbook* also has two categories that encourage planning teams to consider environmental impact, Ecological Context and Land Use and Land Management.³⁵ The document was created to help teams "to identify, analyse, and document potential impacts of transportation projects on communities while meeting both the spirit and letter of the National Environmental Policy Act (NEPA) and other applicable federal and state laws, regulations, and policies."

The Handbook recommends a six step process that defines the project understanding, establishes baseline conditions, identifies impacts and their significance, identifies solutions, and documents findings. It is intended to be part of a planning process, but also continue into maintenance and operation as a mode of continuous learning. The process also identifies three categories of community indicators, including human environment (cultural and governance), physical environment (place-making and infrastructure), and natural environment (land use and ecology).

Ecological Context poses the following questions for design:

- + Would the project improve or impair natural resources valued by the community (e.g. trout stream water quality)?
- + Would the project alter the relationship between the community and the natural environment?

As framed in the supporting documentation, the Land Use and Land Management category is less directly related, as it deals primarily with development availability with only minor references to the deleterious effects that such development may have on the surrounding land use. Indeed, roads are often planned with the explicit purpose of spurring development, which will almost certainly change the ecological context of the road. The following land use/land management questions can be helpful to better understand ecological contexts and systems:

- + Would changes to land use occur as a result of the project?
- + Would the project be compatible with local growth management policies and adopted land use plans?
- + Would the project eliminate land uses that have unique or special characteristics not likely to be re-established in the community?

The INVEST Tool

The Handbook framed the questions generally — more updated criteria and modeling tools have recently been developed to help teams quantify and think holistically about the impact of their projects. One such tool, the Infrastructure Voluntary Evaluation Sustainability Tool (INVEST) was developed by the USDOT’s Federal Highway Administration in 2012 as a web-based self-evaluation tool with sustainability best practices that cover the full lifecycle of transportation services, including system planning for states and regions, project development, and continuing through operations and maintenance. The tool is voluntary, and some transportation agencies are using the tool to supplement their existing policies and programs.

The INVEST tool is clear in its quantification and documentation requirements and many of the issues are applicable at the corridor scale of this study. INVEST’s Project Planning Scale is most appropriate and has thirty-three criteria which span a broad range of sustainability concerns, from safety to tracking environmental commitments. All of the criteria address holistic environmental impact.

INVEST Environmental Criteria

Criteria pertaining to the improvement or preservation of Biotic Systems:

- PD-07 Habitat Restoration
- PD-08 Stormwater Quality and Flow Control
- PD-09 Ecological Connectivity
- PD-18 Site Vegetation, Maintenance and Irrigation

Criteria related to Materials, Construction, and Operational Sustainability:

Most of these criteria apply to all corridor types in this study, but five categories have unique needs in corridors

- PD-17 Energy Efficiency
- PD-26 Construction Equipment Emissions Reduction
- PD-27 Construction Noise Mitigation
- PD-32 Light Pollution
- PD-33 Noise Abatement

Criteria that apply across all corridor types:

- PD-22 Long Life Pavement
- PD-23 Reduced Energy and Emissions in Pavement
- PD-25 Construction Environmental Training
- PD-28 Construction Quality Control Plan
- PD-29 Construction Waste Management
- PD-31 Infrastructure Resiliency Planning and Design

TRANSPORTATION

The development pattern in Pennsylvania is increasingly one of strategic infill, redevelopment, and densification. Suburban and ex-urban sprawl will continue, but at a reduced rate. These development trends are market-driven by demographics and consumer preferences. The impact on transportation investments in the next thirty years will be profound.

Public demand will increasingly be to improve the existing road and bridge infrastructure rather than to build new roads and expand the network. Densification and migration to central cities will also bring citizen pressure for better public transportation and enhanced infrastructure for pedestrians and bicyclists. European cities are role models for how the American transportation system should evolve with fewer trips by individual automobiles and more multimodal trips.

Technological and logistic advances such as Uber, Lyft, ZipCar, and micro-management of traffic signals are also influencing transportation investment, not only for less investment in new roads, but also in reduced demand for parking facilities. Shared vehicles, autonomous vehicles, and more efficient traffic flow will take pressure off road building and widening and will inevitably steer public investment to support non-automobile transportation. The same holds true for truck and other commercial traffic. Reduced congestion, increased air quality, and a safer environment for transit riders, pedestrians, and bicyclists will result.

Intelligent Transportation Systems (ITS) are also a trend influencing the future of transportation. Investments are being made in vehicle-to-roadside communications via Dedicated Short-

Range Communications (DSRC) devices that can convey safety warnings and traffic information. This Internet of Things (IoT) provides direct communication between the computer on a vehicle and roadside sensors.

Mixed-use development will influence future transportation investments. New form-based zoning techniques and creative development financing have allowed for co-location of housing, retail, and offices in the same development (new or infill), thus

affording many people the option of not having a personal vehicle at all, thus reducing the demand for parking.

The underlying goal of transportation is connectivity, especially from home to work. If this can be achieved by means other than personal vehicles, such as transit, walking, or biking, then not only will quality of life be enhanced, but the impact on the environment also will be reduced.



Figure 45 | Intensive use of the right-of-way will benefit from technological advances in communication, accident avoidance systems, and adaptive signalization.

TRANSPORTATION TECHNOLOGY

Intelligent Transportation Systems Improve Flow

Intelligent Transportation System (ITS) technologies can be expected to have a significant impact on traffic flow efficiency along corridors over time. In a transportation corridor research study completed in western Pennsylvania as a case study, the primary emphasis was to quantify the potential benefit of introducing real-time adaptive signal control technology to improve travel time efficiency in corridor settings. To this end, a microscopic traffic simulation model was developed of a particular highway corridor and a simulation analysis showed significant improvement over the conventional Synchro-optimized timing plans that were currently in operation on the corridor. The analysis was extended to examine the impact of future population growth and the implications of current assumptions about how to apportion resources in advance of execution. The advantages of more advanced ITS technologies, such as connected vehicles and self-driving terms, are also worthy of note.

Microscopic Traffic Simulation Analysis of the Impact of Real-time, Adaptive Traffic Signal Control Technologies

From a mobility perspective, transportation modeling tools can inform corridor planning and design decisions in significant ways. Aggregate traffic flow analysis models such as Synchro (Trafficware) are routinely used to develop traffic signal timing plans for corridors that optimize flow

with respect to specified estimates (or measurement counts) of vehicle volumes. These tools also provide a macroscopic basis for estimating the capacity and utilization of an intersection, in support of both new roadway design and traffic impact studies. In general, use of these tools is an integral component of current corridor planning and design processes.

In recent years, a new class of higher fidelity traffic modeling technologies has emerged on the scene. This class of tools, which is generically referred to as “microscopic” traffic simulation, operates with a detailed model of the target road network and analyzes traffic flows at the level of individual vehicles. Some popular microscopic simulation tools include VISSIM (PTV Group), AIMSUN (Transport Simulation Systems), and SUMO (Simulation of Urban Mobility), an open source platform. The road network model of a microscopic traffic simulation captures such detail as the actual physical geometry of each intersection, the number of lanes, the design speed and the distance of each road segment, the inflow/outflow connections at each intersection, and the signal timing plans that govern various movement phases. Traffic flows are generated based on either vehicle volume and turning proportion data at various intersections in the network or from analogous trip volume data (expressed as origin-destination pairs).

The use of a microscopic simulation model offers the opportunity for more substantive analyses of specific corridor design alternatives. The VISSIM microscopic traffic simulation analysis of the

case study corridor provided strong evidence of the potential to reduce congestion and improve traffic flow through the introduction of real-time adaptive traffic signal control technology. The analysis focused specifically on the use of the Surtrac system, a state-of-the-art adaptive signal control technology with unique real-time, traffic flow optimization capabilities that has since been deployed in a commercial district of Pittsburgh with great success. Overall, the results obtained with the microscopic traffic simulation model indicate a substantial reduction in average delay and a reduction in average travel time over the conventional (fixed) signal timing plans that are currently used along the corridor; and the projected improvement is substantially greater if attention is restricted to just the rush hour periods of the day. While each corridor analysis will yield different results, the potential for this technology to change the capacity of existing corridors is significant.

Broader Opportunities

While the results of this simulation analysis have provided useful confirmation of the motivating hypothesis, there is a much broader range of additional questions that could be addressed with the underlying microscopic simulation technology. This could include further opportunities to improve traffic flow modeling as the demographics of a region evolves over time.

The simulation model that was built provided a foundation for carrying out a number of what-

if analyses (some easier than others). The use of this model to produce amplifying and/or complementary results was further investigated. Several possibilities were identified as potential candidates. These included:

- + Traffic congestion with projected future growth along the corridor: One direction of analysis is to investigate the transportation impact of various growth assumptions in bordering municipalities. Using the broader analysis of the corridor to elaborate and verify the core characteristics and dynamics of corridors, a range of growth scenarios could be specified and incorporated into the simulation model to determine impact on traffic flow efficiency.
- + Analysis of roadway design alternatives: Another use of the simulation model could be to analyse various roadway design decisions. For example, along the focus area of the studied corridor the speed limit changes at several points. Assuming the introduction of adaptive signal control, could changes to the speed limit further improve traffic flow efficiency?
- + Alternative transit configurations: A third use of the simulation model could be to specify and evaluate selected scenarios that make different assumptions about transit vehicle patterns. To investigate the potential of such transit configuration changes, one would construct variants of the basic simulation model that incorporate different transit routes and schedules, and (assuming an



Figure 46 | The placement of detectors in a typical installation of SURTRAC's adaptive signalization.

increase in ridership is anticipated as a result of these changes) also incorporate appropriate reductions in vehicle volumes.

- + Integration with bus prioritization: Finally, one could extend and use the model to quantify the benefit of integrating (Surtrac) adaptive signal control with bus prioritization. To accomplish this analysis, it would be necessary to extend the simulation model to include signaling of bus prioritization requests to intersections (as is typical of commercial Transit Signal Priority systems) and the Surtrac control scheme would need to be augmented to interrupt its processing and service prioritization requests whenever a request is received.³⁶

The candidate possibilities for additional analysis identified above imply differing amounts of change to the current simulation model, and have been listed above in order of ease of implementation. The first two items are listed as illustrative examples of the broader uses of microscopic traffic simulation models. Each of these sets of scenarios can be realized with relatively minor changes to the existing VISSIM microscopic simulation model (e.g., adjustments to assumed traffic volumes and origin-destinations, adjustments to basic model parameters). Investigation of the third item would require the design and specification of new transit routes and schedules; and integration of the last item (bus prioritization) with adaptive signal control requires a capability that is not yet supported by Surtrac. Consequently, these analysis questions, as well as others that require changes to the basic

physical/geometric model (e.g., adding a separate dedicated bus lane), need to be addressed in future research.

Emerging Connected Vehicle Technology

Although the introduction of real-time adaptive signal technology has been the principal Intelligent Transportation System (ITS) focus of the transportation technology research as related to improving the traffic flow efficiency of corridors, one can anticipate the transformative effect of other technologies on corridor design and control. One of the first to make a difference will be emerging “connected vehicle technology,” which involves installation of Dedicated Short-Range Communication (DSRC) radios (or similar communication capability) that is capable of interacting with intersections. This technology will provide a number of benefits, including the following:

- + Basic safety enhancement: The basic Signal Phasing and Timing (SPaT) message that has been standardized will communicate “time until the signal is turning red” to enable vehicles to adjust speed as necessary. With this real-time information, it is anticipated that drivers will be less inclined to accelerate at the last minute to get through a signal that is turning yellow, and overall the availability of this information should have a calming effect on traffic flow.
- + Increased mobility: If vehicles are able to share information with the infrastructure, then there are opportunities to provide non-trivial mobility enhancements, even in low penetration rate

settings. For example, recent research (at this point evaluated only via microscopic traffic signaling), has shown that if a vehicle is able to share its route with the intersection, the vehicle can move through the adaptive signal network substantially faster than otherwise, with no negative impact to other (non-equipped) vehicles' progress.³⁷ This may seem unexpected at first but the reason is straight forward: the adaptive signal control system is receiving more information (e.g., it doesn't have to "guess" whether the equipped vehicle is going to turn or go straight at the next intersection), and hence can do a better job to optimize traffic flows. Since a large percentage of drivers now use navigation devices regularly and vehicles increasingly have built in navigation capabilities (facilitating automated communication of route information), there should be strong incentive for a transportation agency to be an early adopter.

+ Intelligent multi-mobility priority: Vehicle to Infrastructure (V-to-I) communication will also open several opportunities for multi-modal optimization of traffic flows. Simple communication of mode information, for example, will allow forms of transit signal priority that do not rely on strict hierarchical prioritization (which may move buses forward at the expense of all other vehicles in the current mix) but can instead base decisions on the overall traffic flow situation. Likewise, it will open opportunities for pedestrians and bicyclists to communicate presence

information, enhancing the ability to control traffic in a manner more consistent with complete streets philosophies.

+ More accurate sensing: Finally, as the level of penetration of connected vehicles increases, the accuracy of sensing at the intersection will increase to the point that contemporary detection hardware (video cameras, radar) will no longer be necessary, lowering the cost of adopting adaptive signal control technology. The increased detection accuracy will also enable better adaptive control decisions.

Self-Driving Vehicles

Following connected vehicle technology, autonomous vehicles will enter the picture. The subsequent introduction and proliferation of self-driving cars will give rise to additional opportunities for both corridor design and more effective traffic signal control. With respect to roadway design, the increased precision of autonomous navigation will allow narrower lane widths, and hence greater vehicle throughput capacity with less physical space required. The ability to move through narrow passages (e.g., tunnels) without reflex de-acceleration will ease congestion. From a traffic control perspective it will be possible to better manage adherence to speed limits, and the adaptive signal system can take advantage of this predictability to further optimize traffic flows while enforcing suitable traffic calming constraints.



Figure 47 | Self-driving vehicles, including trucks and future mass transit, should increase traffic efficiency and increase safety for all users, including urban areas in older cities with narrow roadways.



CORRIDOR

GUIDELINES

CORRIDOR TYPES AND COMPARATIVE MATRIX

Corridor Guidelines build on the history of context sensitive solutions, the PennDOT *Design Manual*, other PennDOT publications, research on complete streets and other design-intensive transportation and multimodal reports. They include lessons learned from best practices and the topic area influences discussed in the previous section. They are cross-referenced with the guidelines for PennDOT's roadway typologies.

The guidelines, written for corridor planning and design project teams, differ in many respects from the roadway typologies; however, their appearance and many of their recommendations are either similar or the same. PennDOT corridors and roadways follow the same roadway typology classifications, settings, and scale. As corridors are comprised of roadway segments, the guidelines are written as a companion and parallel classification system. On closer examination, though, they are heavily infused with multimodal elements and recommendations to achieve an inclusive yet balanced corridor system that meets PennDOT's policies and intentions for smart transportation.

The seven corridor types match the seven roadway types. The corridors borrow the same roadway names, except for Rural Corridors which dropped the "Places" name.

CORRIDOR TYPES

RURAL
SUBURBAN NEIGHBORHOOD
SUBURBAN
SUBURBAN CENTER
TOWN/VILLAGE NEIGHBORHOOD
TOWN CENTER
URBAN CORE

The seven corridor types are each described in four pages that include a general definition; aerial and roadway photographs and a graphic that illustrates typical examples; a summary of key characteristics and recommendations; two cross-sections that illustrate a less- and a more-intensive design recommendation; descriptions of ecological, economic development, and transportation issues and guidelines; and a list of required right-of-way design components. Urban design recommendations are embedded in the text and illustrations. Note also that the urban design, economic development, environmental, transportation, and transportation technology

strategic influences, located in the previous section, contain many insights, guidelines, and recommendations related to the corridor types.

Corridor Typologies Comparative Matrix

The Corridor Typologies Comparative Matrix on the following two pages provides an overview of the corridor types and their responses to major guideline and design elements. Corridors that are candidates for full multimodal facilities and potential candidates for transit-oriented development and traffic calming facilities are keyed by color. Note that several corridor types are candidates for more than one distinction. All corridor types are eligible for multimodal facilities if designed following these guidelines; however, not all would be located within the roadway itself. Also note that highway arterials have been the basis for the design and guideline recommendations in this section.

Users of this document are advised to carefully consider the respective design and guideline details, checklists, and project performance measures for all corridors located in the Corridor Project Delivery and Appendix sections.

CORRIDOR TYPES AND DESCRIPTIONS

CORRIDOR DESCRIPTIONS	RURAL	SUBURBAN NEIGHBORHOOD	SUBURBAN	SUBURBAN CENTER	TOWN/ VILLAGE NEIGHBORHOOD	TOWN CENTER	URBAN CORE
DIAGRAM							
AERIAL							
PERSPECTIVE							
SCALE	LOCAL	LOCAL	LOCAL	REGIONAL	LOCAL	LOCAL REGIONAL	LOCAL REGIONAL
WIDTH	2-4 LANES	2-6 LANES	2-4 LANES	4-6 LANES	2-4 LANES	2-4 LANES	2-4 LANES
ADJACENT LAND USE	AGRICULTURE LOW-DENSITY RESIDENTIAL LOW-DENSITY COMMERCIAL	AGRICULTURE LOW-DENSITY SINGLE-FAMILY RESIDENTIAL MINOR COMMERCIAL AND RETAIL	AGRICULTURE REGIONAL SHOPPING CENTERS LARGE K-12 INSTITUTIONS RECREATIONAL OPEN SPACE PARKS HOTELS	AUTOMOBILE SERVICES DRIVE-INS BIG BOX RETAIL HOTELS EMPLOYMENT CENTER	COMMERCIAL MIXED USE HIGH DENSITY RESIDENTIAL INSTITUTIONAL PARK AND RECREATIONAL FACILITIES	COMMERCIAL MIXED USE MODERATE TO HIGH DENSITY RESIDENTIAL SOME INSTITUTIONS SOME EMPLOYMENT CENTERS	MIXED USE RESIDENTIAL GOVERNMENTAL CULTURAL INSTITUTIONAL RETAIL
PENNSYLVANIA EXAMPLES	RT 22 FROM EXPORT TO EBENSBURG RT 51 SOUTH FROM ELIZABETH	RT 88 LIBRARY ROAD STREETS RUN ROAD NEGLEY AVENUE GREENTREE ROAD	RT 30 FOREST HILLS TO IRWIN RT 51 STUDY AREA	RT 22 MONROEVILLE RT 19 NORTH HILLS TO CRANBERRY	RT 19 DORMONT TO UPPER ST CLAIR FORBES AVENUE BRADDOCK AVENUE	BROWNSVILLE ROAD PENN AVENUE FROM WILKINSBURG TO DOWNTOWN	PITTSBURGH'S BLVD OF THE ALLIES BENJAMIN FRANKLIN PARKWAY FRONT STREET HARRISBURG

CORRIDOR MULTIMODAL SIGNIFICANCE

STRATEGIC SIGNIFICANCE	RURAL	SUBURBAN NEIGHBORHOOD	SUBURBAN	SUBURBAN CENTER	TOWN/VILLAGE NEIGHBORHOOD	TOWN CENTER	URBAN CORE
PEDESTRIAN	LOW	MODERATE NEEDS PROTECTION	LOW NEEDS PROTECTION	LOW NEEDS PROTECTION	PEDESTRIAN DOMINANT	PEDESTRIAN DOMINANT	PEDESTRIAN DOMINANT
BICYCLE	LOW NEEDS PROTECTION	MODERATE NEEDS PROTECTION	LOW NEEDS PROTECTION	LOW NEEDS PROTECTION	HIGH DEDICATED	HIGH DEDICATED	HIGH DEDICATED
TRANSIT ^a	LIMITED TO NONE	LOW NODAL	LOW NODAL	LOW NODAL	LOW TO HEAVY NETWORKED	HEAVY NETWORKED	HEAVY NETWORKED
AUTO	HIGH AUTO DOMINANCE	AUTO DOMINANT	AUTO DOMINANT	AUTO DOMINANT	MODERATE	LOW AUTO DOMINANCE	LOW AUTO DOMINANCE
LAND USE CONTROLS ^b	LIMITED TO NONE FOCUS ON TOWN CENTERS	MODERATE FOCUS ON COMM'L ZONES	LIMITED TO MODERATE FOCUS ON COMM'L ZONES	LIMITED TO MODERATE FOCUS ON COMM'L ZONES	HIGH SUPPORT MULTIMODAL	HIGH SUPPORT MULTIMODAL	HIGH SUPPORT MULTIMODAL
ECONOMIC DEVELOPMENT OPPORTUNITY	LOW NEW AT MAJOR INTERSECTIONS	LOW NEW AT MAJOR INTERSECTIONS	LOW NEW AT MAJOR INTERSECTIONS	MODERATE INFILL AND NEW	HIGH MODERATE INFILL	HIGH MODERATE INFILL AND NEW	HIGH LOW INFILL
ECOLOGICAL OPPORTUNITY	HIGH PRESERVATION	MODERATE RESTORATIVE	MODERATE RESTORATIVE	MODERATE RESTORATIVE	MODERATE INTEGRATED	MODERATE INTEGRATED	MODERATE INTEGRATED
APPLICABLE TRANSPORTATION STRATEGIES		COMPLETE STREETS	COMPLETE STREETS	COMPLETE STREETS	COMPLETE STREETS	COMPLETE STREETS	COMPLETE STREETS
				TRANSIT ORIENTED DEVELOPMENT	TRANSIT ORIENTED DEVELOPMENT	TRANSIT ORIENTED DEVELOPMENT	TRANSIT ORIENTED DEVELOPMENT
	TRAFFIC CALMING ON MAIN STREETS	TRAFFIC CALMING	TRAFFIC CALMING	TRAFFIC CALMING	TRAFFIC CALMING	TRAFFIC CALMING	TRAFFIC CALMING
	TARGET SPEED 20-25 MPH MAIN STREETS	TARGET SPEED 20-25 MPH COMMERCIAL AREAS	TARGET SPEED 25-30 MPH COMMERCIAL AREAS	TARGET SPEED 25-30 MPH COMMERCIAL AREAS	TARGET SPEED 20-25 MPH	TARGET SPEED 20-25 MPH	TARGET SPEED 20-25 MPH

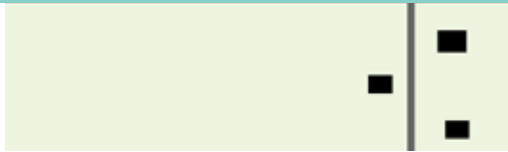
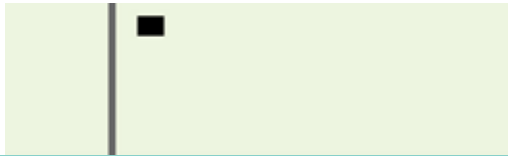
a. Nodal: Stops only at major activity nodes. Networked: Typical urban stops.
 b. Pertains to land use controls that support multimodal facilities.



Multimodal Considerations

Many Rural Corridors are likely to evolve to more dense corridor types. Planning ahead for the density is important. Acquire property to allow for a right-of-ways that accommodate future multimodal facilities. As the density of the corridor changes, refer to other corridor types for best practices.

RURAL CORRIDOR



Functional Classification

Regional Arterial, Community Arterial, Community Collector. Not appropriate as Neighborhood Collectors or Local Roads, however can serve these functions when crossing through towns or residential settlements.

Typical Land Use and Characteristics

Agricultural, low-density residential, low density commercial. Retail uses found in town centers and at major highway intersections.

Pedestrian and Bicycle Significance

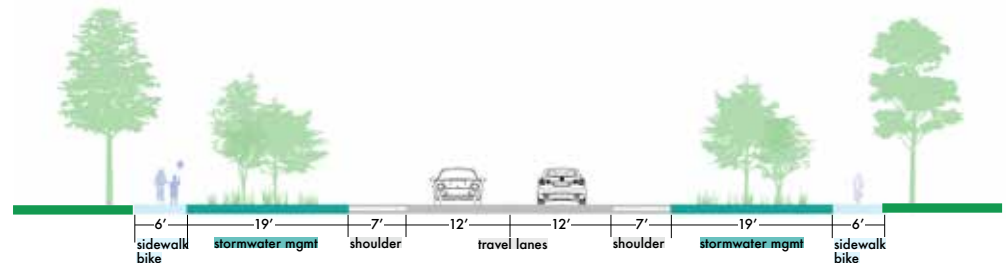
Low. Needs Protection.

Vehicle Significance

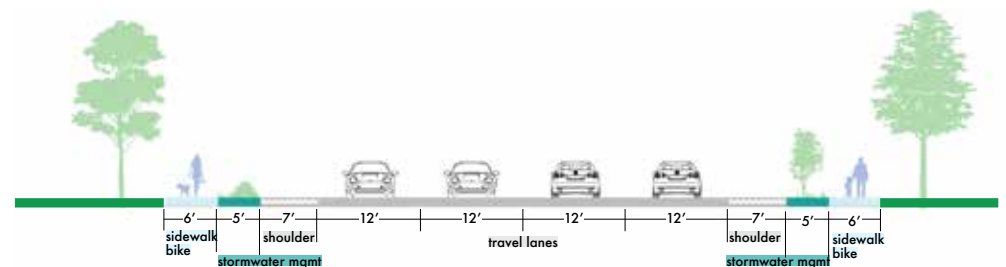
High auto dominance. Limited to No Transit.

Land forms, vegetation, and distant views dominate the visual field of Rural Corridors. The scale of the highway is perceived as smaller in relation to the rural landscape. Depending on location, the landscape can be visually simple with views extending far beyond the right-of-way. Development is sparse and typically concentrated in small towns and at major intersections and can have natural, village, or developed character. Typically, they are two-lane highways through agricultural areas that connect small towns outside of major urban areas, however Rural Corridors can be up to six lanes wide between larger towns and urban areas. Pedestrian and bicycle safety is a major concern.

RECOMMENDED SECTIONAL CONDITIONS



TWO LANE WITH SHOULDER BIKE LANES AND PROTECTED PEDESTRIAN PATHWAYS



FOUR LANE WITH SHOULDER BIKE LANES AND PROTECTED PEDESTRIAN PATHWAYS

ECOLOGICAL

Habitat Restoration

Rural Corridors often traverse agricultural areas, woodlands, and streams. The latter is likely to be part of a larger ecological habitat, a corridor of plants, animals, and people, but not vehicles. Inventory existing biotic corridors and systems and strive to keep them intact. Where it is not possible to eliminate or regenerate (improve to a better than baseline condition) habitats, create opportunities for new ecological community formation through careful attention to soil, topography, aquatic resources, and planting to support a system and not just a species.

Stormwater Quality and Flow Control

Corridor projects are already subject to water quality and quantity controls during and post construction, but managing water resources in Rural Corridors could provide opportunities to establish new biotic communities such as wetlands or bioswales in places where they did not formerly exist. In Rural Corridors, there are great opportunities for biotic water control systems that connect to existing ecological corridors.

Ecological Connectivity

Rural Corridors interface with existing ecological corridors and there are opportunities for new and existing projects to maintain the connectivity of these corridors. Ecological connectivity is closely related to Habitat Restoration, with an emphasis on understanding the movement of species and accommodating their flow. This could mean wildlife bridges or tunnels, which allow for movement and lessen safety issues related to road kill. This can also apply to ongoing maintenance practices or elements that effect connectivity like protective fencing.

Site Vegetation, Maintenance, and Irrigation

Rural highway corridors can promote the movement and spread of invasive species and care must be taken to inhibit or prevent this through construction or maintenance practices (invasives can be introduced during spraying, mowing, mulching, etc.). Preventing the introduction of invasives will help minimize the use of pesticides or energy intensive maintenance practices. Proactively, rural highways can use native or

ecologically suitable materials to minimize maintenance protocol. This also supports ecological restoration and connectivity.

Energy Efficiency and Light Pollution

Rural corridors are rarely lit and so there are few requirements for energy efficient lights with targeted and effective illumination.

Construction Emissions and Noise

Emissions and noise in Rural Corridors have minimal impact on people as the corridors are often outside of developed areas, but construction practices can be very disruptive to animals and habitats.

Noise Abatement

Long term noise can be disruptive to habitats and people and consideration should be given to noise barriers that do not inhibit biotic connectivity. Road design, such as geometry and need for braking and signals, can also contribute to noise and abatement may be useful in Rural Corridors.

RURAL CORRIDOR

ECONOMIC

In most cases, new development is not likely in the short term due to the absence of needed infrastructure (e.g. utilities). Development cycle timing will vary depending upon proximity to growth areas.

Potential Development Patterns

If the rural corridor is located proximate to other arterials/transportation corridors, new development opportunities might include those uses looking for remote locations and affordable land (e.g. large distribution centers, correctional facilities). If the rural corridor is located along the pathway of sprawling growth from an urban/regional center, new residential development would occur first, followed by potential commercial development to support the new residential growth.

If the rural corridor transitions to an employment center (e.g. in many cases in Pennsylvania, the gas industry has generated growth in outlying areas), new master planned communities or business parks/industrial parks may be developed to support the new industry.

URBAN DESIGN AND TRANSPORTATION

For the most part traffic will be free flowing in the Rural Corridor with few traffic signals.

Left turning lanes will suffice at most intersections with secondary roads. Signals are appropriate at intersections with major roads or at commercial nodes.

A four to six lane highway, with turning lanes where warranted and paved shoulders, is the typical road section.

Rural Corridors rarely need or have a median, but it is desirable where the right-of-way is adequately sized.

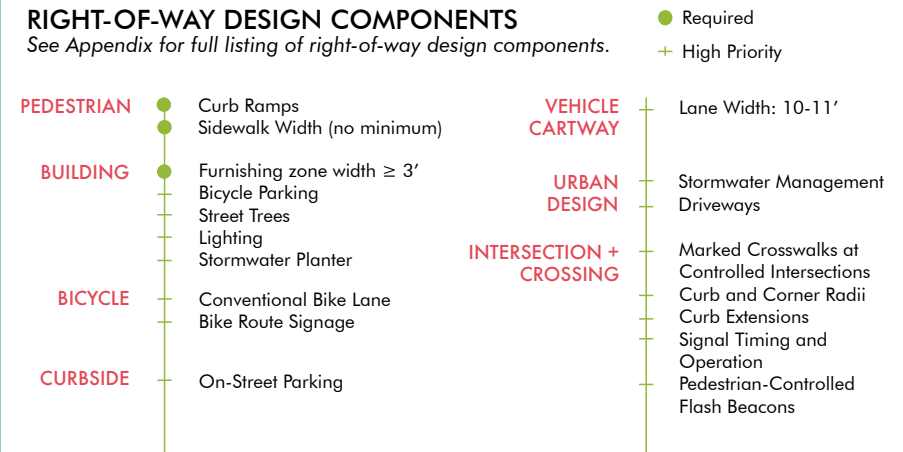
Shoulders should be amply sized and reserved for bicycles, Amish buggies, transit stops, and other infrequent travel modes.

Public transit does not have a major presence in Rural Corridors. If existing at all, public transit connects small cities and towns to the urban core via express buses on the Rural Corridor with no bus stops on the highway itself.

Sidewalks and bike lanes are not recommended except when protected and separate from the corridor travel lanes.

RIGHT-OF-WAY DESIGN COMPONENTS

See Appendix for full listing of right-of-way design components.



KEY DESIGN CRITERIA

TRAVEL LANES

In built areas follow the most appropriate corridor typology.

TARGET SPEED

Design in anticipation of multimodal facilities, including pedestrians and bicycles.

PARKING LANE WIDTH

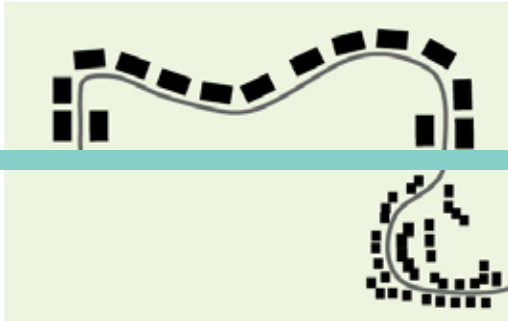
Design narrow to accommodate multimodal integration (bicycles, transit) and to maximize pedestrian area.

Regional Arterial	2-6 lanes, 11-12' width	45-55 mph	NA
Community Arterial	2-4 lanes, 11-12' width	35-55 mph	NA
Community Collector	2 lanes, 11-12' width	35-55 mph	NA
Neighborhood Collector	NA	20-35 mph	NA
Local Road/Street	NA	20-25 mph	NA
Main Streets	2 lanes, 11' width	20-25 mph	7-8' parallel



Multimodal Considerations

Suburban Neighborhood Corridors are important travel corridors for residents and children and pressure is likely for increased vehicle capacity, thus early planning for larger right-of-ways and multimodal is important. They are prime candidates for pedestrian and bicycle activity and their design should adopt many of the characteristics of local streets in urban residential areas. Street trees provide a human scale and protection for pedestrians. Use adaptive signalization to maintain safe driving speeds. Consider a complete streets strategy.



SUBURBAN NEIGHBORHOOD CORRIDOR



Functional Classification

Regional Arterial, Community Arterial, Community Collector. Not appropriate as Neighborhood Collectors or Local Roads, however these roads often contain parking lanes and sidewalks.

Typical Land Use and Characteristics

Low density single-family residential with some agricultural and rural segments. Low density retail and institutional uses at major intersections.

Pedestrian and Bicycle Significance

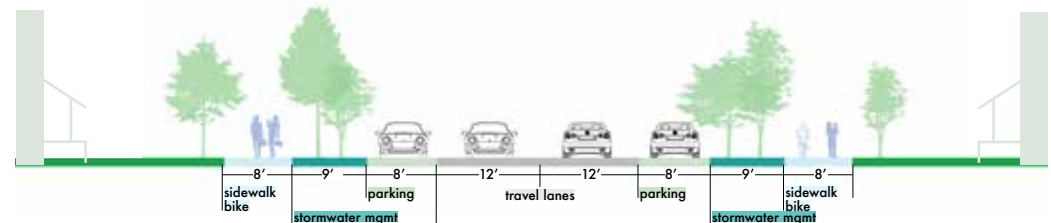
Moderate. Needs Protection.

Vehicle Significance

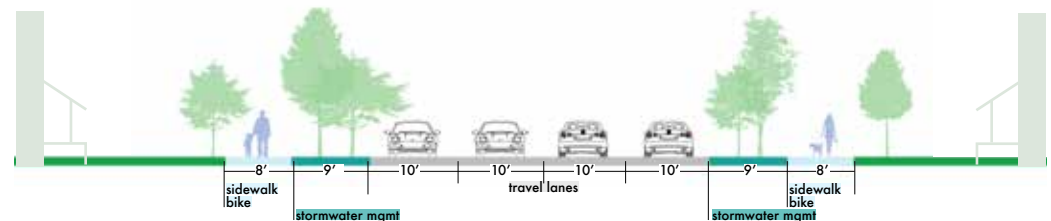
Auto Dominant. Transit only at nodal locations.

Suburban Neighborhood Corridors connect larger suburban neighborhood developments to regional arterials. They are typically found in the outside rings of major urban centers and often contain rural segments. As these corridors traverse residential areas their characteristics are like Town/Village Neighborhood Corridors, where pedestrian and bicycle facilities are expected. However, their densities are lower and design speeds are higher, making multimodal protection a concern. Automobiles dominate. Transit facilities are far apart and typically include park and ride surface lots. Often these corridors connect with recreational facilities, parks, and scenic areas where the natural landscape is predominant.

RECOMMENDED SECTIONAL CONDITIONS



TWO LANE WITH PARKING AND PROTECTED PEDESTRIAN/BIKE LANES



FOUR LANE WITH PROTECTED PEDESTRIAN/BIKE LANES

ECOLOGICAL

Habitat Restoration

Suburban Neighborhood Corridors often traverse open space areas and unmaintained habitats like woodlands and streams. The latter is likely to be part of a larger ecological habitat, a corridor of plants, animals, and people, but not vehicles. It is important to inventory existing biotic corridors and systems and strive to keep them intact. Where it is not possible to eliminate or regenerate (improve to a better than baseline condition) habitats, strive to create opportunities for new ecological community formation through careful attention to soil, topography, aquatic resources, and planting to support a system and not just a species.

Stormwater Quality and Flow Control

Corridor projects are already subject to water quality and quantity controls during and post construction, but managing water resources in rural environments could provide opportunities to establish new biotic communities such as wetlands or bioswales in places where they did not formerly exist. In rural environments, there are great opportunities for biotic water control systems that connect to existing ecological corridors.

Ecological Connectivity

Suburban Neighborhood Corridors traverse existing ecological corridors and there are opportunities for new and existing projects to maintain the connectivity of these corridors. Ecological connectivity is closely related to Habitat Restoration, with an emphasis on understanding the movement of species and accommodating their flow. This could mean wildlife bridges or tunnels, which allow for movement and lessen safety issues related to road kill. This can also apply to ongoing maintenance practices or elements that effect connectivity like protective fencing.

Site Vegetation, Maintenance, and Irrigation

Suburban Neighborhood Corridors, like all roadways, can promote the movement and spread of invasive species and care must be taken to inhibit or prevent this through construction or maintenance practices (invasives can be introduced during spraying, mowing, mulching, etc.). Preventing the introduction of invasives will help minimize use of pesticides or energy intensive maintenance practices. Proactively, scenic corridors can use native or ecologically-suitable materials

to minimize maintenance protocol. This also supports ecological restoration and connectivity.

Energy Efficiency & Light Pollution

Suburban Neighborhood Corridors are rarely lit and so there are few requirements for energy efficient lights with targeted and effective illumination.

Construction Emissions and Noise

Emissions and noise in Suburban Neighborhood Corridors have minimal impact on people as the corridors are often outside of developed areas, but construction practices can be very disruptive to animals and habitats.

Noise Abatement

Long term noise can be disruptive to habitats and people, but noise barriers are not likely to be used. Road design, such as geometry and need for braking and signals can also contribute to noise, and abatement may be especially useful in Suburban Neighborhood Corridors.

SUBURBAN NEIGHBORHOOD CORRIDOR

ECONOMIC

Development patterns are typically established by low-density residential development and open space/agricultural uses.

Potential Development Patterns

Major new development/redevelopment is unlikely given existing land use patterns. Potential new development may include infill residential development and commercial development at key intersections. As with Suburban Corridors, in higher growth areas new development may occur within the corridor as growth radiates out from the urban center/suburban centers. However, new development is more likely along the other two suburban corridor typologies.

URBAN DESIGN AND TRANSPORTATION

Suburban Neighborhood Corridors usually have two to four travel lanes, but can be as wide as six lanes in denser areas.

They have paved shoulders in some sections and with 5 foot sidewalks in other sections where commercial or residential development uses are adjacent.

Medians may be required at left turns at some intersections. Traffic signals are appropriate at intersections with major arterial streets.

Bike lanes are desirable if they can be accommodated in the right-of-way, especially if they can be part of a regional bikeway network.

Public transit is more likely to be present than in the Rural Corridor, particularly in areas of commercial or residential density where local bus stops or light rail stops along the corridor are warranted.

Multimodal aspects should be considered, however usage is typically low. Protection is a concern for pedestrians and cyclists on arterial corridors.

RIGHT-OF-WAY DESIGN COMPONENTS

See Appendix for full listing of right-of-way design components.

- Required
- + High Priority

<p>PEDESTRIAN</p> <ul style="list-style-type: none"> ● Curb Ramps ● Sidewalk Width (no minimum) 	<p>BUILDING</p> <ul style="list-style-type: none"> ● Furnishing Zone Width $\geq 3'$ Bicycle Parking Street Trees Lighting Benches Stormwater Planter Street Furniture 	<p>BICYCLE</p> <ul style="list-style-type: none"> Conventional Bike Lane Bike Route Signage Buffered Bike Lane Shared Use Path 	<p>CURBSIDE</p> <ul style="list-style-type: none"> Transit Stops and Shelters 	<p>VEHICLE CARTWAY</p> <ul style="list-style-type: none"> + Lane Width: 10-12' + Medians + Raised Speed Reducers 	<p>URBAN DESIGN</p> <ul style="list-style-type: none"> ● Stormwater Management 	<p>INTERSECTION + CROSSING</p> <ul style="list-style-type: none"> + Marked Crosswalks at Controlled Intersections + Curb and Corner Radii + Curb Extensions + Pedestrian Refuge Islands + Signal Timing and Operation + Pedestrian-Controlled Flash Beacons
--	---	---	---	--	--	--

KEY DESIGN CRITERIA

TRAVEL LANES

In built areas follow the most appropriate corridor typology.

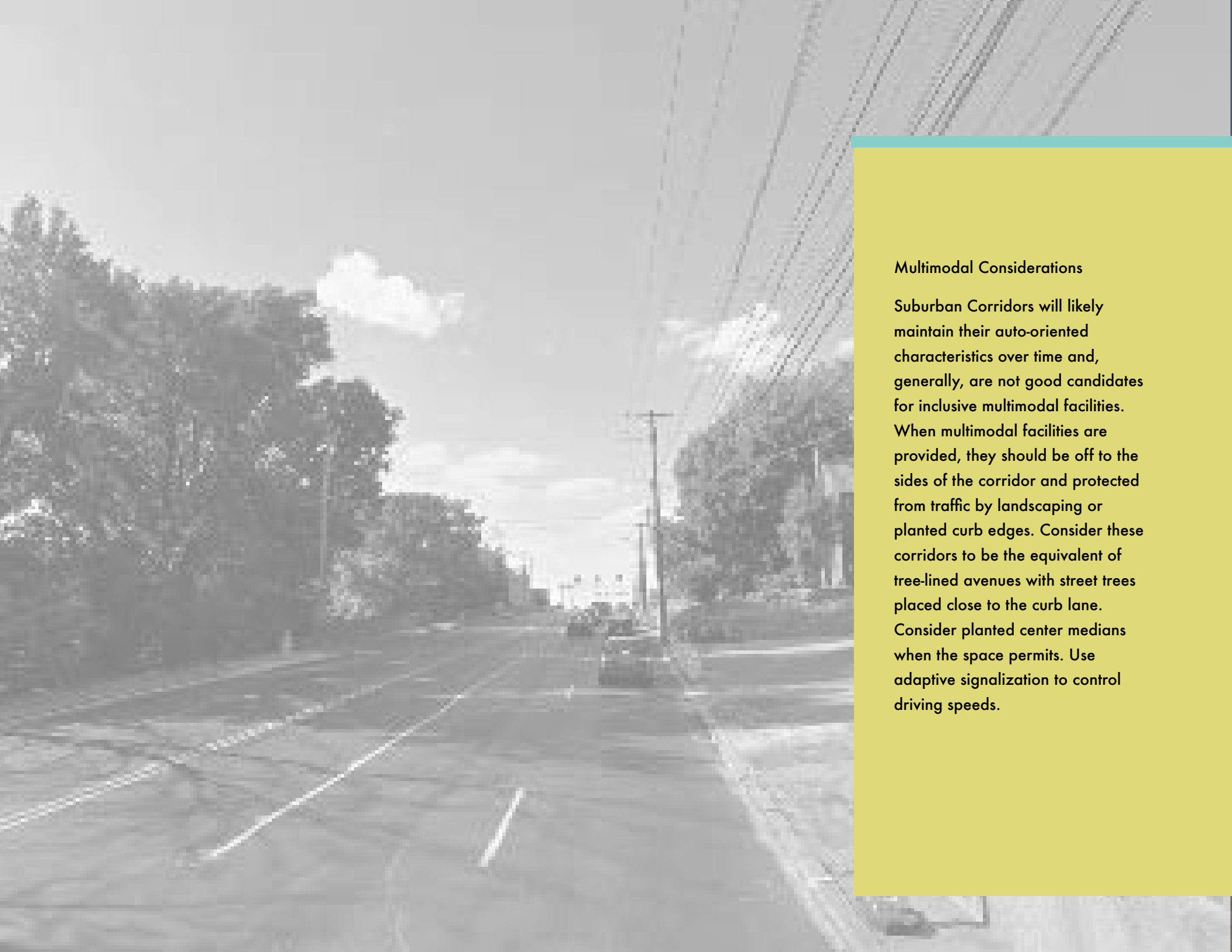
TARGET SPEED

Design in anticipation of multimodal facilities, including pedestrians and bicycles.

PARKING LANE WIDTH

Design narrow to accommodate multimodal integration (bicycles, transit) and to maximize pedestrian area.

	TRAVEL LANES	TARGET SPEED	PARKING LANE WIDTH
Regional Arterial	2-6 lanes, 11-12' width	45-55 mph	NA
Community Arterial	2-4 lanes, 11-12' width	35-55 mph	NA
Community Collector	2 lanes, 11-12' width	35-55 mph	NA
Neighborhood Collector	NA	20-35 mph	NA
Local Road/Street	NA	20-25 mph	NA
Commercial Areas	2 lanes, 11' width	20-25 mph	7-8' parallel

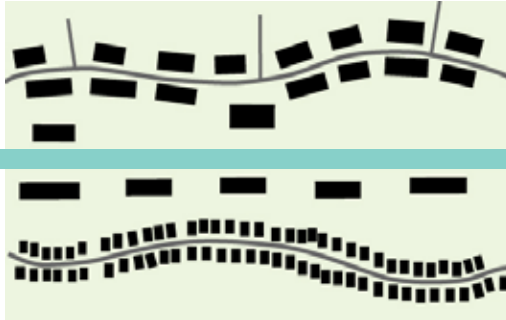


Multimodal Considerations

Suburban Corridors will likely maintain their auto-oriented characteristics over time and, generally, are not good candidates for inclusive multimodal facilities. When multimodal facilities are provided, they should be off to the sides of the corridor and protected from traffic by landscaping or planted curb edges. Consider these corridors to be the equivalent of tree-lined avenues with street trees placed close to the curb lane. Consider planted center medians when the space permits. Use adaptive signalization to control driving speeds.

SUBURBAN

CORRIDOR



Functional Classification

Regional Arterial, Community Arterial, Community Collector. Not appropriate as Neighborhood Collectors or Local Roads.

Typical Land Use and Characteristics

Low density residential including apartments, office parks and industrial employment centers, major regional shopping centers, larger K-12 educational institutions. May include rural and parkland segments, as well as large recreational facilities. Mixed-uses and hotels as these corridors approach urban centers.

Pedestrian and Bicycle Significance

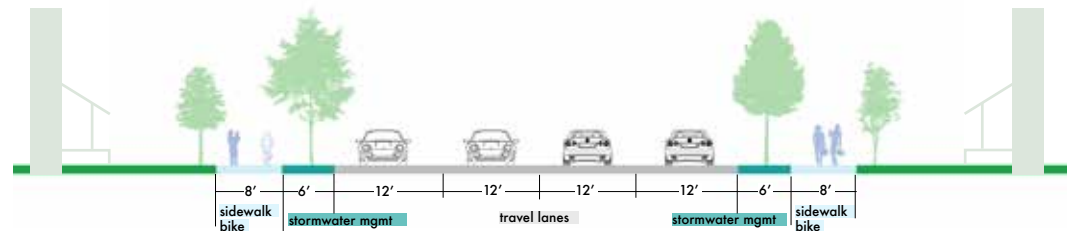
Moderate. Needs Protection.

Vehicle Significance

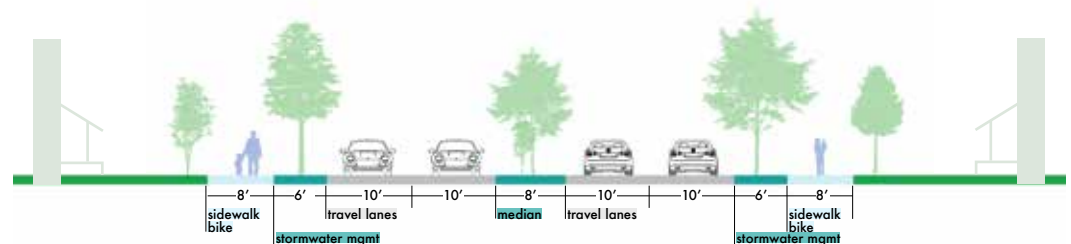
Auto dominant. Transit only at nodal locations.

Suburban Corridors provide connections between suburbs, including low and high density settlements. Like Suburban Neighborhood Corridors, they primarily serve as larger collectors and arterials for the neighborhood corridors. They are higher speed roadways, often with limited access when not located in urbanized areas. Regional uses, such as office and industrial employment centers, are often accessed by Suburban Corridors. They are auto-dominant and not pedestrian- or bicycle-friendly due to their higher design speeds, and incorporating these facilities will require separation and protection. Express and local buses operate on these corridors to deliver passengers to and from city centers and major destinations in the outer rings of larger urban centers.

RECOMMENDED SECTIONAL CONDITIONS



FOUR LANE WITH PROTECTED PEDESTRIAN/BIKE LANES



FOUR LANE WITH MEDIAN AND PROTECTED PEDESTRIAN/BIKE LANES

ECOLOGICAL

Habitat Restoration

Suburban Corridors often traverse agricultural areas and unmaintained habitats like woodlands and streams. The latter is likely to be part of a larger ecological habitat, a corridor of plants, animals, and people, but not vehicles. Inventory existing biotic corridors and systems and strive to keep them intact. Where it is not possible to eliminate or regenerate (improve to a better than baseline condition) habitats, strive to create opportunities for new ecological community formation through careful attention to soil, topography, aquatic resources, and planting to support a system and not just a species.

Stormwater Quality and Flow Control

Corridor projects are already subject to water quality and quantity controls during and post construction, but managing water resources in rural environments could provide opportunities to establish new biotic communities such as wetlands or bioswales in places where they did not formerly exist. In Suburban Corridors, there are great opportunities for biotic water control systems that connect to existing ecological corridors and the roadway itself may follow stream or river corridors. Special attention

should be paid to design elements that support the health of these waterways, minimize pollution, erosion, and introduction of invasive species.

Ecological Connectivity

Suburban Corridors interface with existing ecological corridors and there are opportunities for new and existing projects to maintain the connectivity of these corridors. Ecological connectivity is closely related to Habitat Restoration, with an emphasis on understanding the movement of species and accommodating their flow. This could mean wildlife bridges or tunnels, which allow for movement and lessen safety issues related to road kill. This can also apply to ongoing maintenance practices or elements that effect connectivity like protective fencing.

Site Vegetation, Maintenance, and Irrigation

Suburban Corridors can promote the movement and spread of invasive species and care must be taken to inhibit or prevent this through construction or maintenance practices (invasives can be introduced during spraying, mowing, mulching, etc.). Preventing the introduction of invasives will help minimize the use

of pesticides or energy-intensive maintenance practices. Proactively, interurban highways can use native or ecologically suitable materials to minimize maintenance protocol. This also supports ecological restoration and connectivity.

Energy Efficiency and Light Pollution

Suburban Corridors have areas of lighting that should follow best practices for energy efficient lights with targeted and effective illumination.

Construction Emissions and Noise

Emissions and noise in Suburban Corridors do have impact on human and ecological communities. Construction management practices should ameliorate their impact on human and biotic communities.

Noise Abatement

Long term noise can be disruptive to habitats and people and consideration should be given to noise barriers that do not inhibit biotic connectivity. Road design, such as geometry and need for braking and signals, can also contribute to noise, and abatement may be useful.

SUBURBAN CORRIDOR

ECONOMIC

The typical Suburban Corridor development pattern has already been established and in many cases, the transportation function limits economic development to entrances/exits to arterials.

Potential Development Patterns

Development is most likely to occur near the access points to arterials or at major intersections with other arterials. These are highly desirable locations for commercial uses (both retail and employment) given their access to the larger region, as well as their visibility along a high-traffic corridor.

Depending upon the location, suburban corridors may also transition to more densely developed corridors as growth radiates out from the nodes/settlements that the corridor is serving. This is especially true if the corridor is served by other forms of transit besides automobiles and buses.

URBAN DESIGN AND TRANSPORTATION

The Suburban Corridor is very similar to the Suburban Neighborhood Corridor, except traffic speed is 35 to 55 mph and sidewalk widths are 5 to 6 feet.

Often with four travel lanes, these corridors are designed to move vehicular traffic efficiently and in high volumes. Multimodal conversions will require careful design attention.

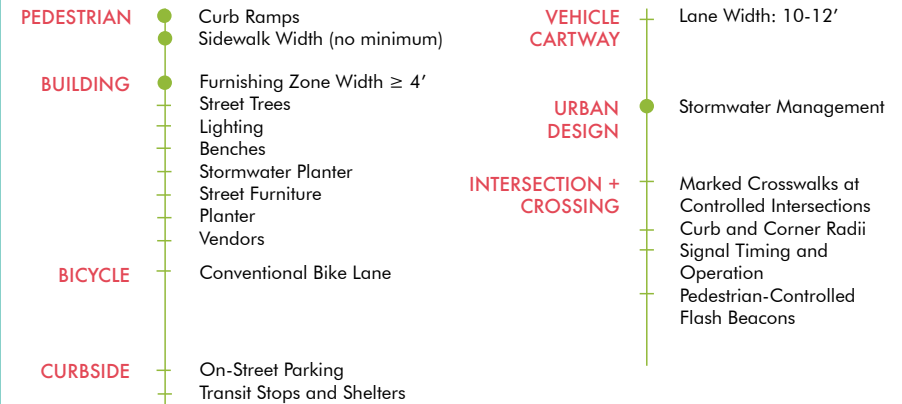
Stormwater can be managed with green infrastructure. Using street trees to create a greener landscape and to slow traffic in higher-density locations can result in an improved pedestrian environment.

The adjacent street network should be used for multimodal travel where possible.

RIGHT-OF-WAY DESIGN COMPONENTS

See Appendix for full listing of right-of-way design components.

- Required
- + High Priority



KEY DESIGN CRITERIA

TRAVEL LANES

In built areas follow the most appropriate corridor typology.

TARGET SPEED

Design in anticipation of multimodal facilities, including pedestrians and bicycles.

PARKING LANE WIDTH

Design narrow to accommodate multimodal integration (bicycles, transit) and to maximize pedestrian area.

Regional Arterial	2-6 lanes, 11-12' width	45-55 mph	NA
Community Arterial	2-4 lanes, 11-12' width	35-55 mph	NA
Community Collector	2 lanes, 11-12' width	35-55 mph	NA
Neighborhood Collector	NA	20-35 mph	NA
Local Road/Street	NA	20-25 mph	NA
Commercial Areas	2 lanes, 11' width	20-25 mph	7-8' parallel

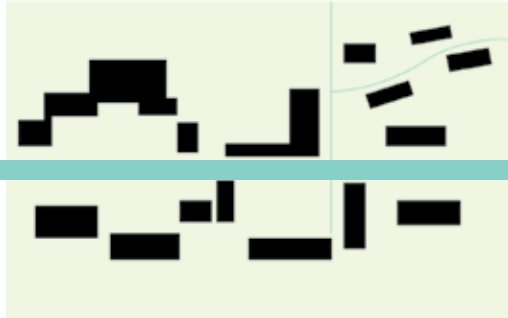


Multimodal Considerations

These auto-oriented corridors are often four to six lanes wide and are the most difficult to convert to multimodal use as their original designs addressed only efficient vehicle flow and motorist safety. While not good candidates for high multimodal activity, Suburban Center Corridors should provide for pedestrian cross traffic and some transit service.

Design with an image of avenues and boulevards as the vision to promote higher design quality and the desire to place commercial land uses closer to the corridor's right-of-way. Use landscaping to create enclosure at major intersections and to calm traffic. Provide on-street parking in commercial locations. Adaptive signalization is important to calm traffic and allow for pedestrian crossings.

SUBURBAN CENTER CORRIDOR



Functional Classification

Regional Arterial, Community Arterial, Community Collector. Not appropriate as Neighborhood Collectors or Local Roads.

Typical Land Use and Characteristics

Automobile services, drive-ins such as fast food or banks, "big box" retail, shopping centers, hotels, medical facilities. Employment centers, either as office or industrial parks.

Pedestrian and Bicycle Significance

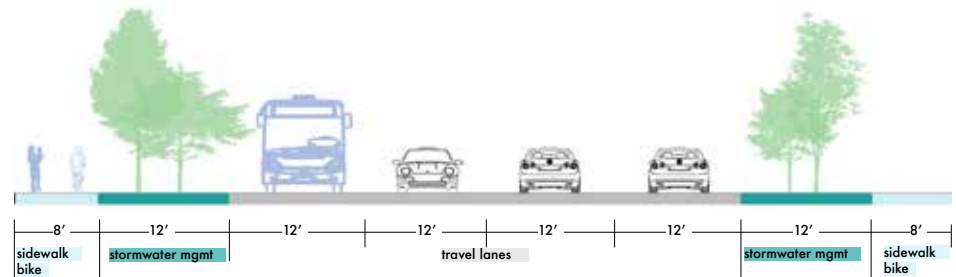
Low. Needs protection.

Vehicle Significance

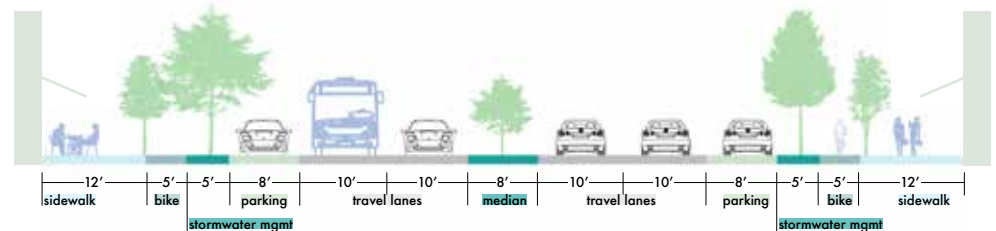
Auto dominant. Transit only at nodal locations.

Suburban Center Corridors are characterized by their auto-oriented development patterns, including buildings set back significantly from the corridor, generally with parking lots in front of commercial uses, and the presence of drive-through pick-up stations. Shopping centers, big box retail, automobile dealerships, auto-oriented hotels, chain restaurants, and some employment centers are found on Suburban Center Corridors. These auto-oriented corridors are not pedestrian- or bicycle-friendly nor are they likely to attract pedestrian traffic other than at transit stops or commercial clusters with outdoor accommodations. Their multimodal significance is primarily due to the presence of transit stops, as denser residential development is located behind and between commercial clusters.

RECOMMENDED SECTIONAL CONDITIONS



FOUR LANE NON-COMMERCIAL AREA WITH PROTECTED PEDESTRIAN/BIKE LANES



FOUR LANE COMMERCIAL AREA WITH MEDIAN, PARKING, AND DEDICATED BIKE LANES

ECOLOGICAL

Habitat Restoration

The adjacent land use in Suburban Center Corridors can be more impactful on habitat than the road design itself. Considering the design of adjacent land use with the road design and maintenance could provide opportunities to have larger areas of habitat and to increase connectivity. For example, coordination of roadway and adjacent parcel stormwater control could allow for bioswales and other plant communities to maintain a critical size instead of the fragmentation that occurs with parcel-by-parcel development.

Stormwater Quality and Flow Control

Corridor projects are already subject to water quality and quantity controls during and post construction, but by managing water resources with larger land use patterns in mind, environments could provide opportunities to prevent fragmentation. In Suburban Center Corridors, there is a need for coordination with other systems that may include shared control systems.

Ecological Connectivity

Suburban Center Corridors often erase ecological connectivity

patterns present on the site prior to development. Ecological connectivity is closely related to Habitat Restoration, with an emphasis on creating areas of critical biological size.

Site Vegetation, Maintenance, and Irrigation

Suburban Center Corridors often incorporate ornamental vegetation. Being attentive to the use of invasive species is key to preventing their introduction into adjacent environments. Construction or maintenance practices can also introduce invasive plants during spraying, mowing, mulching, etc. Preventing introduction of invasive plants will help minimize the use of pesticides or energy intensive maintenance practices. Encourage the use of native or ecologically suitable materials to minimize maintenance protocol and support ecological restoration and connectivity.

Energy Efficiency and Light Pollution

Suburban Center Corridors have intensive lighting use, often on the roadway and from adjacent parcels. Although PennDOT does not control adjacent parcel lighting, roadway lighting should use the most efficient

technology for targeted and effective illumination.

Construction Emissions and Noise

Emissions and noise in Suburban Center Corridors do have an impact on people and construction management practices should ameliorate their impact on human and biotic communities.

Noise Abatement

Long term noise can be disruptive to people, but noise abatement is unlikely to be implemented as visibility is valued more than noise isolation. Road design, such as geometry, design speed, and need for braking and signals can also contribute to noise, and abatement may be useful in Suburban Center Corridors.

SUBURBAN CENTER CORRIDOR

ECONOMIC

The development pattern is well-established. Redevelopment of desired anchor sites along corridor may reduce the number of curb cuts and increase the need for pedestrian scale improvements. In many cases, street-facing large-scale parking lots make complete street improvements difficult to implement.

In some cases, suburban center corridors include major destinations such as regional shopping malls, employment centers, and institutional anchors (e.g. medical uses). These destinations dictate transportation controls (e.g. access roads, turn lanes, signalization).

Potential Development Patterns

In many cases, the development patterns along auto-oriented commercial corridors will continue in a similar pattern, with commercial uses desiring the high traffic counts and visibility provided by Suburban Center corridors. Land ownership patterns dictated by this type of development also imply the continuation of similar development patterns (highest and best use of the land). New development is most likely to occur at key intersections located along the corridor.

URBAN DESIGN AND TRANSPORTATION

Suburban Center Corridors pass through commercial centers with street-facing retail, service, and office buildings.

They typically have two to four travel lanes with signaled left turn lanes at intersections in the commercial center.

On street parallel parking lanes of 8 feet are often present with sidewalks of 9 to 14 feet.

Bike lanes are also appropriate as the right-of-way permits.

Public transit stops will be present and should include bus shelters and light rail stations.

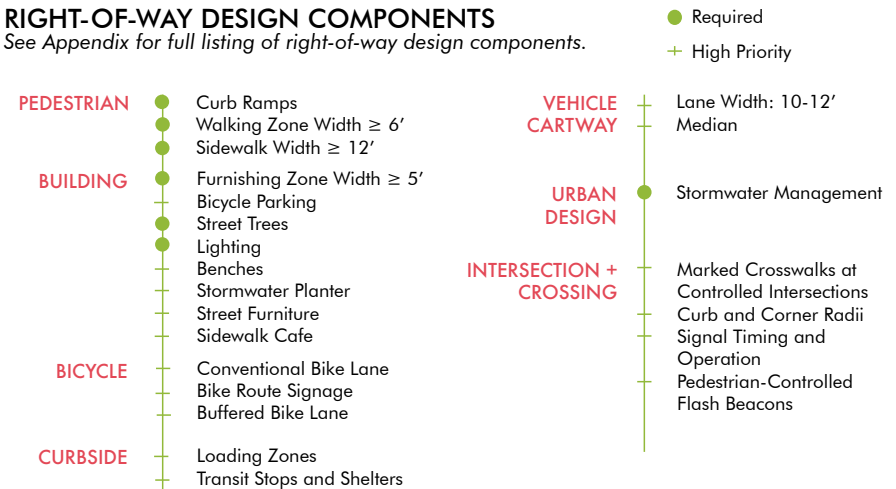
Green infrastructure including street trees should be used to calm traffic, manage stormwater, and improve the pedestrian environment.

Driveways may create frequent conflict points, particularly along older suburban center corridors which catered to stand-alone establishments. New curb cuts should be restricted if not prohibited.

Use signal timing, crosswalks, etc. to create safe pedestrian crossings.

RIGHT-OF-WAY DESIGN COMPONENTS

See Appendix for full listing of right-of-way design components.



KEY DESIGN CRITERIA

TRAVEL LANES

In built areas follow the most appropriate corridor typology.

TARGET SPEED

Design in anticipation of multimodal facilities, including pedestrians and bicycles.

PARKING LANE WIDTH

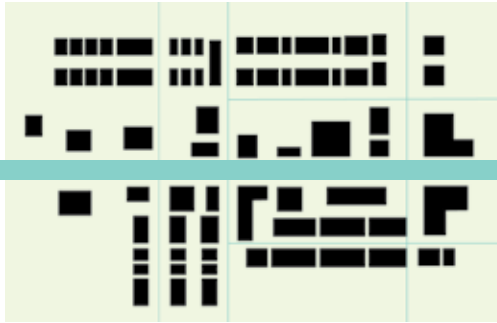
Design narrow to accommodate multimodal integration (bicycles, transit) and to maximize pedestrian area.

Regional Arterial	2-6 lanes, 11-12' width	45-55 mph	NA
Community Arterial	2-4 lanes, 11-12' width	35-55 mph	NA
Community Collector	2 lanes, 11-12' width	35-55 mph	NA
Neighborhood Collector	NA	20-35 mph	NA
Local Road/Street	NA	20-25 mph	NA
Commercial Areas	2 lanes, 11' width	20-25 mph	7-8' parallel



Multimodal Considerations

The Town/ Village Neighborhood Corridor type serves pedestrian and some commercial activity. These thoroughfares require sidewalks and bicycle lanes to accommodate children and others who bike or walk to transit stops. Auto impact and vehicular access is moderate, as is multimodal activity. Where the corridor is narrow, consider widening the right-of-way to provide sidewalks and bicycle lanes. Adaptive signalization will maintain steady movement of vehicles and transit. Complete streets should be implemented.



TOWN/VILLAGE NEIGHBORHOOD CORRIDOR



Functional Classification

Regional Arterial, Community Arterial, Community Collector, Neighborhood Collector, Local Road.

Typical Land Use and Characteristics

Commercial, mixed use, higher density residential, and some industrial activity Parks, educational and other institutions, and recreational facilities are located on these corridors.

Pedestrian and Bicycle Significance

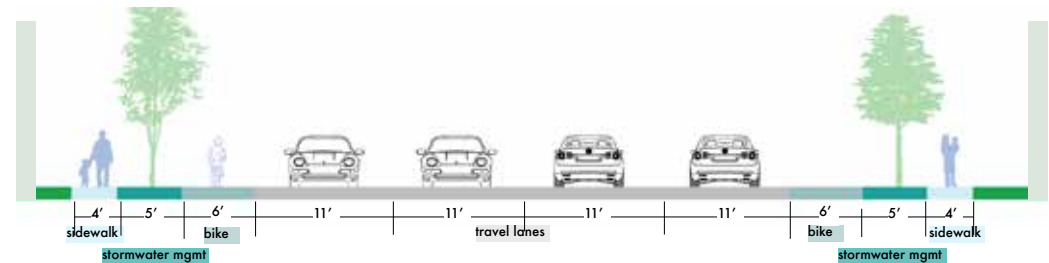
Pedestrian Dominant. High bicycle usage – dedicated lanes.

Vehicle Significance

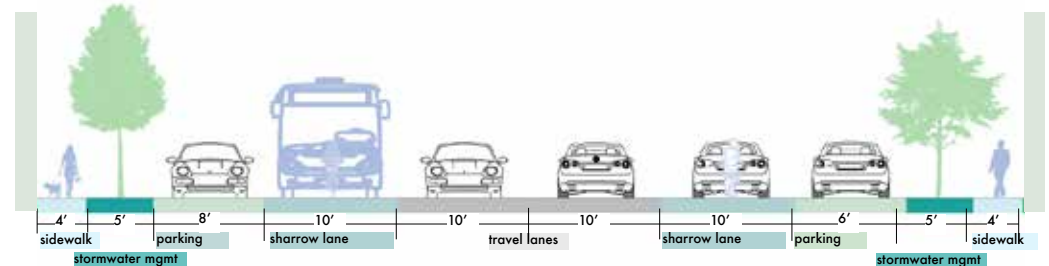
Moderate auto. Networked, low to heavy transit usage.

Town/Village Neighborhood Corridors begin at the outskirts of urbanized areas and often continue into the downtown core. Most are wider roadways within the urban grid, and depending on topography may be part of a network of streets or a single lineal roadway located in valleys or atop ridges. Those within an urban street grid with connected residential streets serve an important role for local vehicle and pedestrian traffic by either offering multimodal facilities within the corridor or just behind on adjacent streets where traffic is calmer. The fronts of buildings in commercial areas typically meet the edge of the sidewalk and encourage pedestrian traffic, unlike the local residential streets where dwellings are set back to allow for front yards. These corridors are good candidates for multimodal travel, speed calming at major intersections, and complete streets design.

RECOMMENDED SECTIONAL CONDITIONS



FOUR LANES WITH DEDICATED BIKE LANES



FOUR LANES WITH PARKING AND SHARROW BUS/AUTO/BIKE LANES

ECOLOGICAL

Habitat Restoration

Habitat restoration in Town/Village Neighborhood Corridors is not likely, but areas of aggregated open space in the form of urban parks may become part of a palette of ecological improvements. Plants are most likely to be hardscaped in green infrastructure, street trees, and planters. Projects should strive for a diversity of these installations and attention should be paid to networking opportunities for water flow and species travel. For example, networked stormwater tree pits can play a role in creating a healthy urban forest that reduces heat island effect, improves air quality, and supports animal populations.

Stormwater Quality and Flow Control

Corridor projects are already subject to water quality and quantity controls during and post construction, and urban environments usually require structured systems for permanent installation. Capturing and conveying stormwater is one of the primary functions of the

roadway, with storage and infiltration occurring with below grade systems or with biotic green infrastructure.

Ecological Connectivity

Town/Village Neighborhood Corridors can create connectivity with an emphasis on urban forestry and biotic stormwater control. The location, frequency and design of these elements will determine if they will support a larger biotic community or if each element will remain isolated and lack connectivity.

Site Vegetation, Maintenance, and Irrigation

Town/Village Neighborhood Corridors often incorporate ornamental vegetation. Encourage the use of native or ecologically suitable materials to minimize maintenance protocol and support ecological restoration and connectivity. Natives or ecologically suitable material also needs to address the especially difficult urban conditions related to salt, solar exposure and heat island effects. Choose materials for longevity.

Energy Efficiency and Light Pollution

Town/Village Neighborhood Corridors have intensive lighting use, often on the roadway and from adjacent parcels. Although PennDOT does not control adjacent parcel lighting, roadway lighting should use the most efficient technology for targeted and effective illumination.

Construction Emissions and Noise

Emissions and noise in Town/Village Neighborhood Corridors do have an impact on people and construction management practices should ameliorate their impact on human and biotic communities.

Noise Abatement

Long term noise can be disruptive to people. Road design, such as geometry, design speed, and need for braking and signals can also contribute to noise, and abatement may be useful in Town/Village Neighborhood Corridors.

TOWN/VILLAGE NEIGHBORHOOD CORRIDOR

ECONOMIC

New economic (re)development patterns are likely given existing densities and function of the roadway.

Potential Development Patterns

(Re)development patterns will vary widely depending upon the economic vitality of the community. For those areas which are transitioning due to population growth, increasing property values, and political desire, new commercial (re)development is likely, leading to increased desire and need for pedestrian scale improvements. Since economic development is likely, traffic impacts are also likely in the near to medium term. New downtown development should occur as mixed-use development.

For those communities suffering from disinvestment and population loss, new (re)development patterns are not likely in the short to medium-term. If conditions change (e.g. public/political focus), new redevelopment patterns will dictate the same interventions mentioned above.

TOD – Successful TOD is most likely along those downtown network corridors where the stations are located within the fabric of the district. If the stations are located behind or outside of the downtown district itself, TOD becomes increasingly challenging.

URBAN DESIGN AND TRANSPORTATION

A Town/Village Neighborhood Corridor passes through a developed area of a town or neighborhood and includes residential and commercial areas.

Like Suburban Center Corridors these corridors are typically two to four lanes with traffic lane widths of 10 to 12 feet and sidewalk widths of 10 to 16 feet.

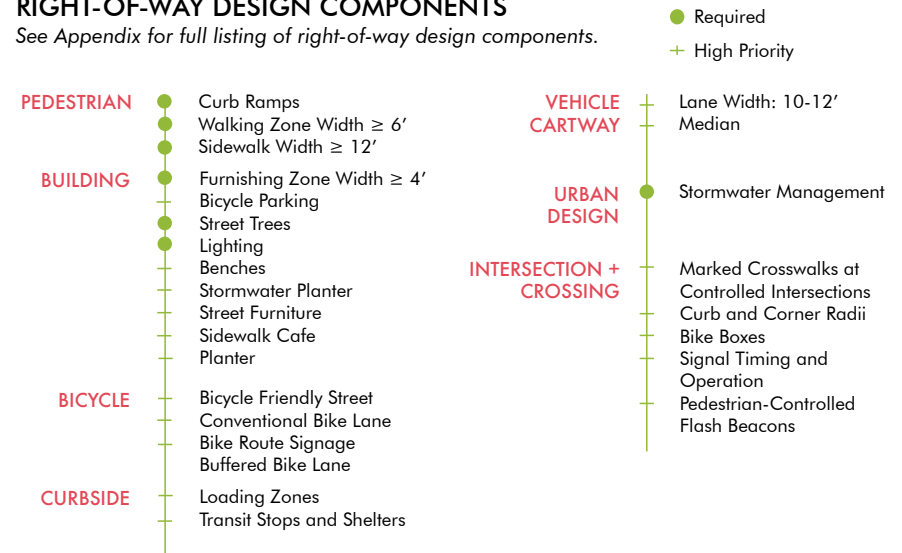
All other design aspects are similar to the Suburban Center Corridor. Buildings set at edge of property lines create the potential for active sidewalks.

The multimodal potential as well as lower design speeds are high due to residential and commercial activity.

Green infrastructure will improve the pedestrian environment, manage stormwater, and slow traffic.

RIGHT-OF-WAY DESIGN COMPONENTS

See Appendix for full listing of right-of-way design components.



KEY DESIGN CRITERIA

TRAVEL LANES

In built areas follow the most appropriate corridor typology.

TARGET SPEED

Design in anticipation of multimodal facilities, including pedestrians and bicycles.

PARKING LANE WIDTH

Design narrow to accommodate multimodal integration (bicycles, transit) and to maximize pedestrian area.

Regional Arterial	2-6 lanes, 11-12' width	45-55 mph	NA
Community Arterial	2-4 lanes, 11-12' width	35-55 mph	NA
Community Collector	2 lanes, 11-12' width	35-55 mph	NA
Neighborhood Collector	NA	20-35 mph	NA
Local Road/Street	NA	20-25 mph	NA
Commercial Areas	2 lanes, 11' width	20-25 mph	7-8' parallel

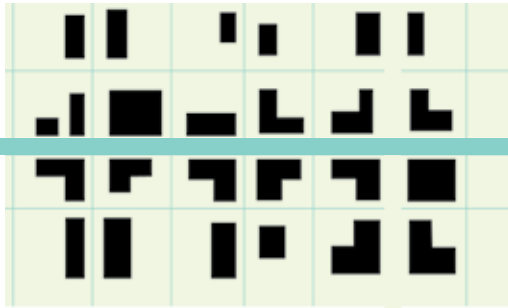


Multimodal Considerations

Multimodal activity is high along Town Center Corridors and design speed should be kept to minimum acceptable levels. As the urban density increases so will the usage of these corridors. Safety is a major concern as large numbers of pedestrians will be present. Multimodal activities should be provided in equal amounts to vehicular traffic. Street trees add character and scale to these corridors as do sidewalk activities, such as café seating. Adaptive signalization will move traffic and transit at slower, but steady speeds. Complete streets should be implemented.

TOWN CENTER

CORRIDOR



Functional Classification

Regional Arterial, Community Arterial, Community Collector, Neighborhood Collector, Local Road. Low design speed encourages multimodal activity on all roadway types.

Typical Land Use and Characteristics

Retail, commercial mixed-use, moderate to high-density residential, some institutional uses and employment centers.

Pedestrian and Bicycle Significance

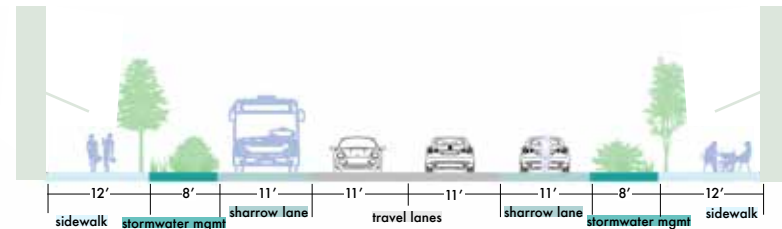
Pedestrian Dominant. High bicycle usage – dedicated lanes.

Vehicle Significance

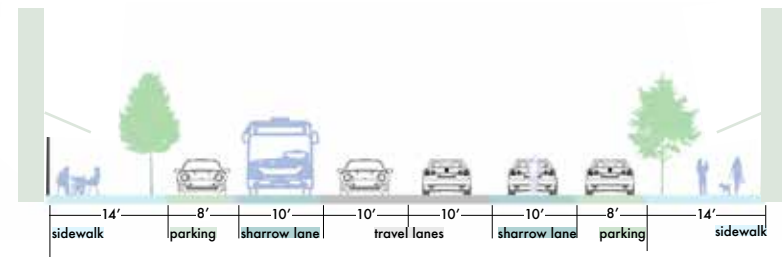
Low auto dominance. Networked, heavy transit usage.

Town Center Corridors are active commercial corridors with pedestrian-friendly physical development patterns. On these streets, parking and access needs of local businesses often compete for limited right-of-way with pedestrian and bicycle facility needs. Town Center Corridors are generally well-served by bus or fixed guideway transit because of their walkable access to high-density residential, mixed-use, and active commercial centers. Their network of streets offers multimodal alternatives and complete street potential either on the corridor or on adjacent streets to compensate for often narrow corridors in older cities; however, topographic conditions may cause the corridor to take a linear form which may restrict multimodal improvements.

RECOMMENDED SECTIONAL CONDITIONS



FOUR LANES WITH SHARROW BUS/AUTO/BIKE LANES



FOUR LANES WITH PARKING AND SHARROW BUS/AUTO/BIKE LANES

ECOLOGICAL

Habitat Restoration

Habitat restoration in Town Center Corridors is not likely, but areas of aggregated open space in the form of urban parks may become part of a palette of ecological improvements. Plants are most likely to be hardscaped in green infrastructure, street trees, and planters. Projects should strive for a diversity of these installations and attention should be paid to networking opportunities for water flow and species travel. For example, networked stormwater tree pits can play a role in creating a healthy urban forest that reduces heat island effect, improves air quality, and supports animal populations.

Stormwater Quality and Flow Control

Corridor projects are already subject to water quality and quantity controls during and post construction, and urban environments usually require structured systems for permanent installation. Capturing and conveying stormwater is one of the primary functions of the

roadway, with storage and infiltration occurring with below grade systems or with biotic green infrastructure.

Ecological Connectivity

Town Center Corridors can create connectivity with an emphasis on urban forestry and biotic stormwater control. The location, frequency and design of these elements will determine if they will support a larger biotic community or if each element will remain isolated and lack connectivity.

Site Vegetation, Maintenance, and Irrigation

Town Center Corridors often incorporate ornamental vegetation. Encourage the use of native or ecologically suitable materials to minimize maintenance protocol and support ecological restoration and connectivity. Natives or ecologically suitable material also needs to address the especially difficult urban conditions related to salt, solar exposure, and heat island effects. Choose materials for longevity.

Energy Efficiency and Light Pollution

Town Center Corridors have intensive lighting use, often on the roadway and from adjacent parcels. Although PennDOT does not control adjacent parcel lighting, roadway lighting should use the most efficient technology for targeted and effective illumination.

Construction Emissions and Noise

Emissions and noise in Town Center Corridors do have an impact on people and construction management practices should ameliorate their impact on human and biotic communities.

Noise Abatement

Long term noise can be disruptive to people. Road design, such as geometry, design speed, and need for braking and signals can also contribute to noise, and abatement may be useful in Town Center Corridors.

TOWN CENTER CORRIDOR

ECONOMIC

The development pattern is typically already established. New development likely as infill and at key intersections.

Potential Development Patterns

Increasingly, linear commercial development is occurring as mixed-use development. In some cases, overlay zoning districts are established to encourage mixed-use and/or higher density development patterns, especially in areas located near transit stops.

Similar to Town/Village Neighborhood Corridors, if the Town Center Corridor is located within a transitioning or designated redevelopment area, more substantial new development patterns are possible as new investment occurs in the area.

TOD – Successful TOD is likely along those linear commercial corridors where the stations are located within the fabric of the commercial corridor. If the stations are located behind or outside of the commercial corridor itself, TOD becomes increasingly challenging.

URBAN DESIGN AND TRANSPORTATION

Town/Village Center Corridors are denser and similar to the Urban Core Corridors than Town/Village Neighborhood Corridors with increased mixed use. They have similar characteristics, with the exception of sidewalks which range from 12 to 18 feet.

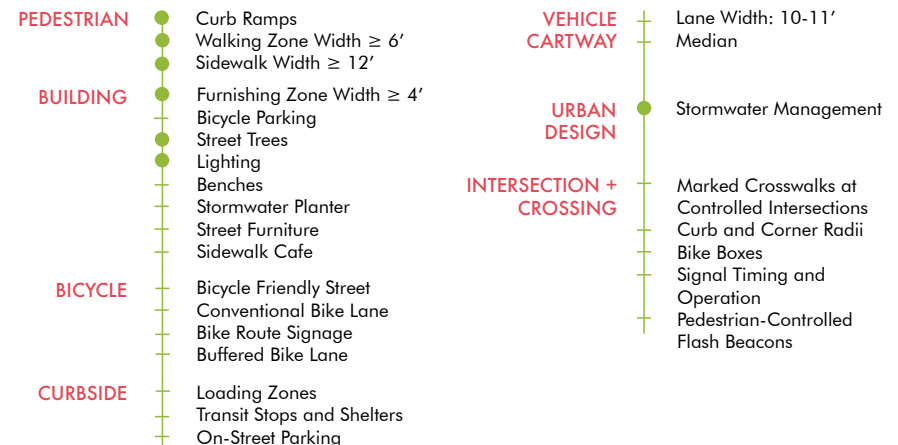
Public transit is more frequent than on a Town/Village Neighborhood Corridor and will require multiple stops or stations. There are high levels of pedestrian activity. Design focus should be on the pedestrian environment, the public realm, transit, and street place-making.

Commercial buildings are prevalent and are typically set at the edge of the street line. Commercial uses and wider sidewalks encourage sidewalk encroachment for cafes and vendors.

RIGHT-OF-WAY DESIGN COMPONENTS

See Appendix for full listing of right-of-way design components.

- Required
- + High Priority



KEY DESIGN CRITERIA

TRAVEL LANES

In built areas follow the most appropriate corridor typology.

TARGET SPEED

Design in anticipation of multimodal facilities, including pedestrians and bicycles.

PARKING LANE WIDTH

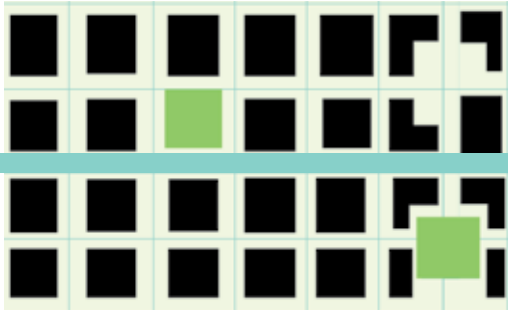
Design narrow to accommodate multimodal integration (bicycles, transit) and to maximize pedestrian area.

Corridor Type	Travel Lanes	Target Speed	Parking Lane Width
Regional Arterial	2-6 lanes, 11-12' width	45-55 mph	NA
Community Arterial	2-4 lanes, 11-12' width	35-55 mph	NA
Community Collector	2 lanes, 11-12' width	35-55 mph	NA
Neighborhood Collector	NA	20-35 mph	NA
Local Road/Street	NA	20-25 mph	NA
Commercial Areas	2 lanes, 11' width	20-25 mph	7-8' parallel



Multimodal Considerations

Plan Urban Core Corridors for multimodal functionality. Expect that congestion will occur and use it to allow for higher pedestrian traffic. Transit impact will be heavy and pull-out lanes or dedicated travel lanes should be considered. Add street trees wherever possible to provide human-scale shade, along with sidewalk activities and furniture. Complete streets should be implemented.



URBAN CORE

CORRIDOR



Functional Classification

Regional Arterial, Community Arterial, Community Collector, Neighborhood Collector, Local Road. At the center of the urban core, almost all corridors function as local streets.

Typical Land Use and Characteristics

High density, governmental, cultural, institutional, retail, and mixed-residential. Some of the first mapped streets, grand buildings, parade routes.

Pedestrian and Bicycle Significance

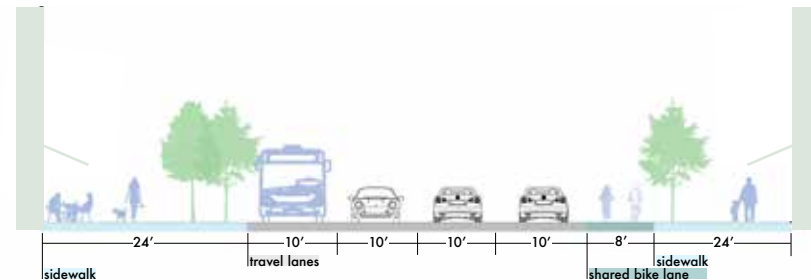
Pedestrian dominant. High bicycle usage – dedicated lanes.

Vehicle Significance

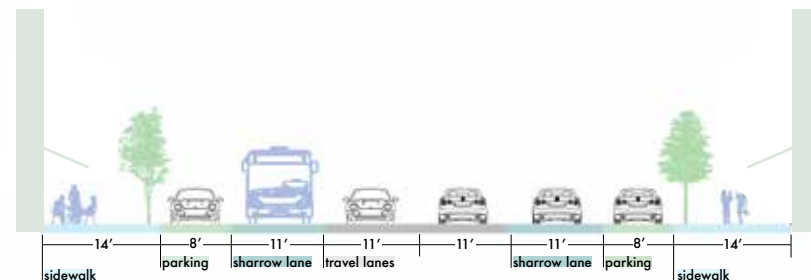
Low auto dominance. Networked, heavy transit usage.

Urban Core Corridors are active commercial corridors with pedestrian-friendly physical development patterns. Vehicle speeds are slower and the roadways become more enclosed and dense. Pedestrian activity is high and sidewalks often include café seating and vendors. Urban Core Corridors can be from two to six lanes wide, with some designed as tree-lined boulevards and others for efficient vehicle movement to accommodate commuters. Some serve high density mixed-use residential neighborhoods, while others may be congested due to their proximity to destinations. Many are special places that play a unique role in the life of the city. Sidewalks function as promenades for persons and vehicles alike and multimodal travel is commonplace. These corridors are well-suited to complete street design improvements.

RECOMMENDED SECTIONAL CONDITIONS



FOUR LANES WITH PARKING AND SHARROW BUS/AUTO/BIKE LANES



FOUR LANES WITH DEDICATED BIKE LANES

ECOLOGICAL

Habitat Restoration

Habitat restoration in Urban Core Corridors is not likely, but areas of aggregated open space in the form of urban parks can provide ecological improvement. Plants are likely to be hardscaped in green infrastructure, street trees, and planters as well as in open areas related to the boulevard design (island and green strips). Projects should strive for a diversity of these installations and attention should be paid to networking opportunities for water flow and species travel. Boulevard green areas can provide space for the establishment of biotic communities and play a role in creating a robust urban forest that reduces the heat island effect, improves air quality, and supports animal populations.

Stormwater Quality and Flow Control

Corridor projects are already subject to water quality and quantity controls during and post construction, and urban environments usually require structured systems for permanent installation. Capturing and conveying stormwater is one

of the primary functions of the roadway, with storage and infiltration occurring with below grade systems or with biotic green infrastructure. Large open areas can also incorporate significantly sized stormwater control that supports biological diversity.

Ecological Connectivity

Urban Core Corridors can create connectivity with an emphasis on urban forestry and biotic stormwater control. The location, frequency and design of these elements will determine if they will support a larger biotic community or if each element will remain isolated and lack connectivity.

Site Vegetation, Maintenance, and Irrigation

Urban Core Corridors often incorporate ornamental vegetation. Encourage the use of native or ecologically suitable materials to minimize maintenance protocol and support ecological restoration and connectivity. Natives or ecologically suitable material also needs to address the especially difficult urban conditions related

to salt, solar exposure, and heat island effects. Choose materials for longevity.

Energy Efficiency and Light Pollution

Urban Core Corridors may have intensive lighting use from the roadway and perhaps from adjacent parcels. Although PennDOT does not control adjacent parcel lighting, roadway lighting should use the most efficient technology for targeted and effective illumination.

Construction Emissions and Noise

Emissions and noise in Urban Core Corridors do have an impact on people and construction management practices should ameliorate impact on human and biotic communities.

Noise Abatement

Long term noise can be disruptive to people. Road design, such as geometry, design speed, and need for braking and signals can also contribute to noise and abatement may be useful.

URBAN CORE CORRIDOR

ECONOMIC

The development patterns along urban and ceremonial boulevards are well established. In some cases, these corridors terminate at large institutional uses (e.g. Spring Garden Street in Philadelphia which terminates at the Philadelphia Art Museum). Established institutional uses, such as museums and state capitals are not likely to change, thus transportation patterns are also not likely to change significantly.

Potential Development Patterns

New infill development may occur depending upon the location.

URBAN DESIGN AND TRANSPORTATION

The Urban Core is defined as a dense downtown mixed-use district with medium to high-rise buildings.

The roadway and speed characteristics are similar to the Town/Village Center Corridor, but with sidewalks from 12 to 20 feet.

Public transit connects the urban core to surrounding neighborhoods and adjacent communities, including surface light rail, subways, bus rapid transit, and bus transit.

On street parking, though permitted, may be prohibited at evening and morning rush hours.

Traffic signals may have a pedestrian-only cycle.

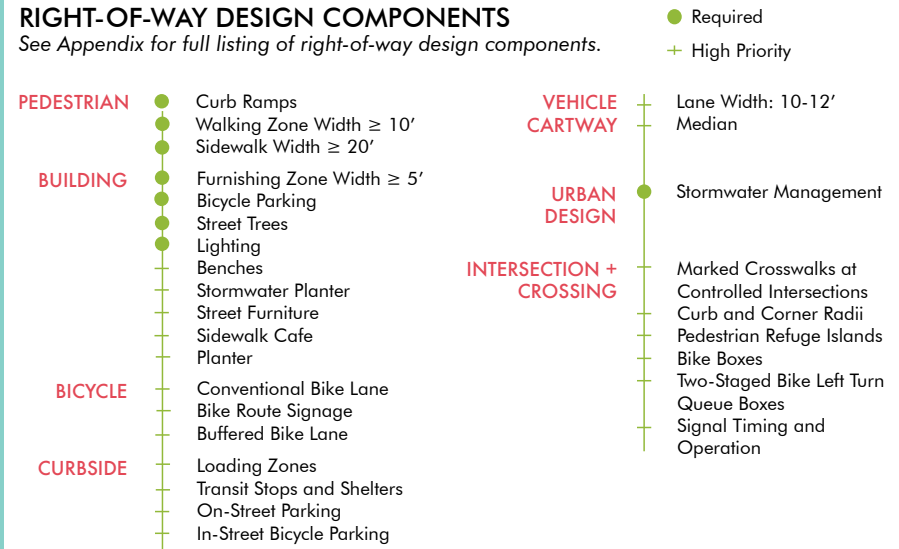
Bicycles may be accommodated by sharrows or protected bike lanes.

There are high levels of pedestrian activity. Focus on pedestrian environment and the public realm to create desirable street places.

Use green infrastructure to improve the pedestrian environment, calm traffic, and manage stormwater.

RIGHT-OF-WAY DESIGN COMPONENTS

See Appendix for full listing of right-of-way design components.



KEY DESIGN CRITERIA

TRAVEL LANES

In built areas follow the most appropriate corridor typology.

TARGET SPEED

Design in anticipation of multimodal facilities, including pedestrians and bicycles.

PARKING LANE WIDTH

Design narrow to accommodate multimodal integration (bicycles, transit) and to maximize pedestrian area.

Regional Arterial	2-6 lanes, 11-12' width	45-55 mph	NA
Community Arterial	2-4 lanes, 11-12' width	35-55 mph	NA
Community Collector	2 lanes, 11-12' width	35-55 mph	NA
Neighborhood Collector	NA	20-35 mph	NA
Local Road/Street	NA	20-25 mph	NA
Commercial Areas	2 lanes, 11' width	20-25 mph	7-8' parallel



CORRIDOR PROJECT DELIVERY

Design Checklist
Right-of-Way Components
Civic Engagement Checklist

DESIGN CHECKLIST

Applicability

The guidelines are appropriate for all types of corridor improvements at different scales.

Reuse and Redevelopment: Large projects in mature urban areas that permit reconfiguration and/or are experiencing changes in the function of a corridor are good candidates for repositioning to multimodal facilities. Changes could include the following:

- + Surrounding land uses
- + Roadway realignment
- + Addition of new connections
- + Change in mode or usage, such as exclusive busways, wider sidewalks to serve new or anticipated economic development, or the addition of bike lanes, or accommodating freight movement
- + Functional classification changes
- + Modal split allowing for reallocation of right-of-way among modes

Corridor Reconstruction: These are projects specific to a corridor that offer additional opportunities for improvement, such as: reconstructing major sections to be more compatible with existing context and land uses (e.g. converting from a two-way corridor to a one-way couplet or visa-versa); realigning a corridor to improve accessibility to surrounding properties; and reallocating the right-of-way to better balance design elements with modes of travel.

Greenfield Development: Although building new corridors will be limited in the future, these checklists are applicable for establishing, augmenting or reconfiguring a corridor system to serve an underdeveloped or newly developed area, or long-range plans for future development.

Appropriate Corridor Capacity for Multimodal Functionality

Vehicle volume-per-day (vpd) figures identify the capacity conditions for full and balanced multimodal functionality:³⁸

- + Rural Corridors at Main Street
Segments: All capacities
- + Suburban Neighborhood, Suburban, and Suburban Center Corridors:
1,500 to 25,000 vpd
- + Town/Village Neighborhood
Corridor: 1,500 to 20,000 vpd
- + Town Center and Urban Core
Corridor: 1,500 to 20,000 vpd

Multimodal designs are possible for all corridor types and all major intersections with consideration taken for the safety and protection of pedestrians, bicyclists, and transit riders.

Climate Adaptation

Floodplain: Determine if the project area is within a designated floodplain or has experienced flooding. If yes, proceed to design for the Copenhagen Cloudburst Plan, latest edition, for all alternatives.

GENERAL CORRIDOR DESIGN ISSUES

Main Street and Commercial Portions of All Corridors

All corridors will include a commercial or institutional segment. Traffic calming measures are indicated to protect multimodal activity, including.

- + Design or Target Speed: Use a maximum of 20 to 25 mph for all corridor types, including Regional Arterials.
- + Roadway: Consider downsizing to two travel lanes if possible.
- + Travel Lanes: Reduce to 10 or 11 feet.
- + On-Street Parking: On-street parking is desirable even if it is restricted to non-rush hour times.
- + Pedestrian Zone: Increase the space between the curb and the right-of-way line to as wide as possible for planting strips and sidewalks.
- + Intersections: Emphasize slow speeds and high visibility. Design the full intersection as compact as possible to provide short pedestrian crossing distances, using curb extensions when feasible. Curb radii should be only large enough to accommodate large vehicles that frequently use the corridor, such as buses. Provide crosswalks on all approaches and consider midblock crossings for block segments longer than 600 feet.

Pedestrians and Bicyclists

Adequately and safely accommodating pedestrians and bicyclists influences overall decision making

for the utilization and prioritization of the right-of-way, not just the specific pedestrian and bicycle requirements.

Capacity and Vehicular Level of Service

Conventional design uses traffic projections and strives to provide the highest practical level of service. CSS design considers traffic projections and level of service as part of the process of designing for a balance among all users. In urban areas, traffic capacity may have lower priority than economic development or historic preservation, for example. It is best to emphasize overall network capacity as the determinant of design rather than the capacity of the specific corridor under consideration.

Corridor Segments

It is important to expand the perspective beyond the specific corridor's immediate context and to work closely with stakeholders to consider planned uses that may represent a departure from existing development patterns. Multiple municipalities within the project's location may have different goals, not share the same community values, and have different priorities and available funding for shared improvements.

Once the basic segments are identified, fine-tune the identification by locating activity areas and major intersections. Segment differentiation occurs either just after a major intersection or in areas where there is little activity.

Typology Identification

- + Map and identify the visual characteristics of existing conditions and documented plans for the future, with the understanding that corridors last longer than most buildings along its pathway.
- + Assess regional and community plans and review general, comprehensive, and specific plans developed by local municipalities and community development organizations.
- + Review zoning codes. Document community goals and objectives for all municipalities within the project area, including vision statements, goals, and objectives.
- + Compare the project area's predominant land use patterns, building types, and specific land uses to the characteristics of the Corridor Typologies.
- + Analyse residential densities and building types, commercial massing, and building heights.
- + If an area or corridor has a diversity of characteristics that could fall under multiple segments, consider dividing the project area into two or more context segments. Most corridors will have some segments that have Main Street characteristics.
- + Identify current levels of pedestrian and transit activity based on the type, mix, and proximity of land uses. Transit use is a key element of urban segments.
- + Project the area's existing and future characteristics beyond the corridor's intended design. Expand the study area to include the entire adjacent neighborhood(s) or district(s).

Nodes and Important Intersections

- + Identify activity nodes, which are either areas of high density land uses or high traffic volume generators, such as shopping centers, Main Streets, or major employers. They are prime candidates for multimodal facilities and transit-oriented development.
- + Identify all major intersections. These are also locations of accidents and high pedestrian and bicycle activity. Consider traffic calming and pedestrian-oriented safety measures for all major intersections.

Transition Zones

Transitions from one corridor segment to another may often involve a change in posted speed limits. Precautions should be taken to give motorists adequate time to prepare for and react to changes in corridor roadway design and speed.³⁸

- + Avoid reducing the posted speed limit by more than 10 mph between adjacent segments and design the roadway geometry to match.
- + Speed limit reductions should occur in locations between intersections.
- + Step down speed limit postings in 10 mph segments. Only in special circumstances should step-downs exceed 10 mph.
- + Alert the driver that there is an upcoming change in context. Changes in adjacent building heights and setbacks, the width and number of travel lanes, and the shoulder treatment are methods that provide visual cues. Not all motorists are attuned to

visual cues and signage will be necessary, particularly when entering a Main Street area or multimodal intersection where speed limits drop and lanes narrow.

Examples of transition measures include:³⁹

- + Changing a shoulder to a parking lane or introducing a bike lane alerts motorists that they are entering a populated area with pedestrian and bike activity.
- + Narrowing the lane width from 12 feet to 10 feet when approaching a village, town, or urbanized area, is advised for locations where multimodal activity will likely occur.
- + Changes in landscape design include clustering trees into larger groupings nearing populated areas and transitioning to structured tree placement prior to entering a village or town or using structured tree patterns to signal a change from one segment to another.
- + Installing a gateway treatment in the roadway, with landscaping and signage, a median, curb extensions, and decorative treatment.
- + Roundabouts at the entrances to populated areas may be employed.



Figure 48 | Pedestrian and bicycle requirements function as a control that influences decisions for the utilization and prioritization of all elements within the right-of-way.

ROADWAY GEOMETRY

Appropriate for all Corridor Segments

Adaptive Signalization

Strongly recommended for all intersection improvements in commercial or high density areas. Consider a pedestrian-only traffic signal cycle in high volume corridors.

Bike Lanes

Bike lanes may be accommodated in all corridor types except limited access highways. They may not be needed on low volume local roads. Bike lanes should not be installed piecemeal, but according to a comprehensive bike plan. Provide the safest version for the respective corridor type. Sharing bicycle lane(s) with vehicles or pedestrians is not recommended.

Intersections

For pedestrian and bicycle safety design as follows:

- + Design intersections as compact as practical
- + Minimize crossing widths using curb extensions where practical or necessary.
- + Provide crosswalks on all approaches
- + Avoid high-speed channelized right turns
- + Ensure driver and non-driver visibility
- + Provide for flexibility in accommodating bicyclists, pedestrians, and those with mobility challenges.

Median

Medians are optional facilities to improve access control, provide refuge for pedestrians at crossings, increase the appearance and experiential qualities of the corridor, and calm traffic.

Mid-Block Crosswalks

Consider only when block lengths exceed 600 feet. Provide with warning signage and flashing lights embedded in the roadway that activate upon request.

On-Street Parking

Encourage on-street parking where lowering target speed is desired, but minimize width (8 feet typical) to allow space for other multimodal facilities. Parking lanes are appropriate where desired operating speeds are 35 mph or lower. On-street parking should be provided on both sides of corridors in traditional business districts, Main Street settings, and at least on one side in residential areas.

Shoulders

Shoulders should be considered for rural and suburban contexts only. In urban areas paved shoulders should be employed only as part of retrofits to narrow existing wide travel lanes and to accommodate bicycles if bike lanes are not optional. Typical shoulder widths are 8 feet to 10 feet in rural and suburban locations and 4 feet to 6 feet in urban areas if there is no on-street parking or bicycle lane.

Superelevations

Eliminate when multimodal activities are present.

Textured Paving Materials

Change of paving materials can provide traffic calming at pedestrian crossings.

Travel Lanes

The number of travel lanes should be based on the balance of providing vehicle capacity and accommodating multimodal uses. In some instances, the number of travel lanes should be reduced to provide multimodal travel when the right-of-way is narrow.

Travel Lane Width

Ten foot wide travel lanes reduce traffic speed, whereas 11 and 12 foot travel lanes are appropriate for speeds over 35 mph, with 12 feet preferred for regular transit routes and heavy truck traffic.



Figure 49 | Converting existing four-lane corridors into complete streets provides a safer condition for all users of the corridor. Street trees provide perceptual enclosure to the right-of-way, naturally slowing vehicle speeds.

ROADSIDE GEOMETRY

Appropriate for all Corridor Segments

Curb and Driveway Cuts

Minimize the number of curb and driveway cuts.

Curb Return Radii

Minimize the radii in locations where controlling target speed is needed, including suburban locations. Emergency vehicles and large trucks do not need large radii for making right-angle turns; in fact, slowing their speed at intersections promotes safety for all users of the corridor.

Curbside Management or Buffer

The sidewalk zone between the curb and the clear walking space is the buffer. In suburban locations this refers to the planted strip between the curb and the sidewalk and in urban contexts it is where street furniture, bus stops, street trees, and other objects are located. This zone is typically not accounted for in actual practice.

Stormwater Management

Include stormwater management best practices on all corridor improvement projects through the use of rain gardens and stormwater capture basins for infiltration, transpiration by native plant materials, and temporary storage to balance heavy rain event surges. Use permeable pavers for sidewalks

in suburban and urban settings and permeable pavement in rural settings. Use permeable pavement for parking lanes in all settings.

Sidewalk Width

Sidewalk width pertains to the clear width available for walking. Sidewalk width increases as density increases, with rural and suburban neighborhood sidewalks being the narrowest to the widest in urban core locations. The minimal width is 3 foot 8 inches (44 inches) for ADA compliance, but sidewalks in residential areas should be 4 to 5 feet. Sidewalks in commercial areas should be 10 feet or wider.

Street Trees

Install native, water- and salt-tolerant street trees in all corridor design projects to increase stormwater mitigation and for their natural amenity and aesthetics. Trees are beneficial for the following reasons:

- + Help mitigate air and water pollution
- + Mitigate urban heat island effects
- + Reduce emissions
- + Retain stormwater
- + Reduce energy consumption by shading adjacent buildings, which can result in less energy costs, lower outdoor temperatures, and increased property values
- + Slow traffic

RIGHT-OF-WAY COMPONENTS

Defining the Right-of-Way

The term “right-of-way” is generally not well understood by the public, often believing that it is the same as the public realm. That is not its purpose. A right-of-way distinguishes public property that is used for transportation and utilities from private property. A right-of-way does not include publicly-owned property, such as parks or

open space for example, as these are not used for transportation or utility purposes. Right-of-way is defined as:

The public space, dedicated by deed, conveyance, agreement, easement, dedication, usage or by process of law, reserved for and dedicated to the general public for street, highway, alley, pedestrian walkway, storm

drainage or other purpose for transportation and utility use. A right-of-way includes the roadway or cartway and the legal sidewalk between the curb and private property lines.

While it clarifies ownership, there are different overlapping rights and responsibilities.

- + Property Owners: Required to maintain their frontage sidewalk and curb in good repair.
- + Governmental Entities: Provide general maintenance of the cartway and also have the power to approve the placement of objects within the right-of-way, such as overhangs, sidewalk cafes, or signage.
- + Utilities: Responsible for the repair and replacement of utility systems, including those on or below sidewalks.

Transportation corridors, which take the form of other street types within the functional street classification system, are rights-of-way.

Right-of-Way Components

The *Philadelphia Complete Streets Design Handbook* provides an excellent working description of the various zones within the right-of-way. The Handbook uses the term “component” to describe the six zones of a complete street right-of-way and this study has adopted them to maintain consistency of terminology amongst Pennsylvania roadways. Figure 50 illustrates their general location(s) within a typical complete street or corridor right-of-way and the descriptions are adopted from the Handbook.

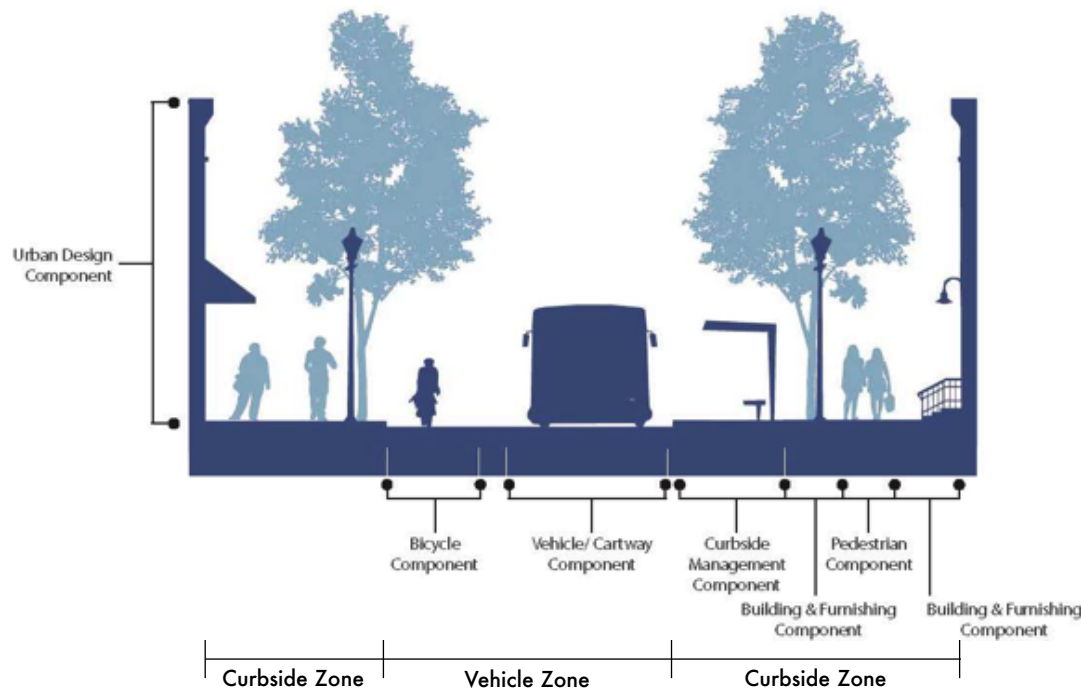


Figure 50 | Right-of-way components and their locations. The Curbside Zone, located between the curb and the property line, is reserved for pedestrian traffic and the Vehicle Zone is reserved for all moving vehicles, including bicycles. In some situations, bicycle paths may be located within the Curbside Zone if they are clearly marked and/or separated from pedestrian paths or sidewalks. Design caution must be exercised where pedestrians cross the Vehicle Zone and where vehicles cross the Curbside Zone.

Vehicle Zone

The vehicle zone is the area between the curbs on either side of a roadway reserved for moving and parked vehicles. This zone is often referred to as the travel lanes, cartway, or roadbed. Bus lanes, bus turnouts or pullouts, shared lanes such as sparrows or shared shoulders, bicycle lanes, and bicycle parking areas within the curb lines are located in the vehicle zone. Light rail and trolleys operate within the vehicle zone when their tracks are embedded in the roadway used by other vehicles.

Curbside Zone

The curbside area is the zone between the curb and the property line. The term applies whether or not there is a sidewalk. The curbside area can contain as many as three constituent parts:

- + Pedestrian Component
- + Building and Furnishing Component
- + Curbside Management Component

Pedestrian Component

The clear space located between the curb and the property line reserved for pedestrian travel, often referred to as the “clear zone” or the “walking zone.” If there is a sidewalk its minimum clear width needs to be 44 inches to meet ADA requirements.

Design Fundamentals:

- + Provide sidewalks that are designed and maintained to create an attractive pedestrian environment and provide

safe access for all citizens.

- + Consider the amount of pedestrian volume and the significance of the corridor within the pedestrian network as defined by the corridor type to inform design decisions.
- + Minimize vehicle intrusions into the pedestrian zone by driveways and lay-by lanes (curb indentations used as drop-offs).
- + Provide direct pedestrian routes between destinations and provide frequent crossing opportunities (recommended no farther than 500 feet apart in higher pedestrian-volume locations) wherever possible. Note that providing crossings is more critical when intersections are spaced greater than 600 feet apart.

Building and Furnishing Component

Street furniture, light poles and traffic lights, elements of buildings that intrude into the sidewalk, and commercial activities that occur on the sidewalk, e.g. sidewalk cafes, are examples of physical and use activities that can occur in this zone. Furnishings and building elements buffer pedestrians from traffic and provide sidewalk amenities and/or enhanced aesthetics for an enjoyable walking experience. This component consists of two parts:

Building Zone: The area of the sidewalk that is immediately adjacent to the building face, wall, or fence marking the property line. This is where awnings, stairs, storefront displays, and other building elements protrude onto or into the

sidewalk area. The edge of a lawn provides a similar demarcation in lower density residential areas. Also termed the “shy distance.”

Furnishing Zone: This is the portion of a typical sidewalk between the walking zone and the curb. Also termed the “curbside management zone” or the “buffer zone.” This is where street furniture, trees and landscaping, transit stops, streetlights, traffic signals, fire hydrants, and other furnishings are located. Note that this zone may occur in more than one location.

Design Fundamentals:

- + Furnishings, commercial activities, and architectural elements can enhance the pedestrian experience.
- + Maintain adequate clear space to ensure accessible and comfortable passage for all pedestrians and guard against creating tripping hazards or pinch points.
- + Make sure that building, furnishing, and landscaping elements do not reduce visibility at intersections or otherwise decrease pedestrian safety. A motorist’s eyesight level is lower than a pedestrian’s and sight lines can easily be blocked by trash containers, newspaper boxes, and other solid elements that would not block a pedestrian’s line of sight.
- + Consider opportunities to incorporate green infrastructure wherever possible in the Furnishing zone.
- + Consider utility locations, above and underground, and potential complications when locating furnishings.

Curbside Management Component

While occurring intermittently, this component facilitates transitional uses between between the roadway or cartway and the sidewalk, including transit stops, on-street parking, loading zones, lay-bys, and alternate uses of the curb lane.

Design Fundamentals:

- + Curbside management is intended to limit conflicts between travel modes and also provide a buffer between traffic and pedestrians. Buffers may include plantings, street furniture, and other similar design features.
- + Transit stops should be designed to increase the comfort and attractiveness of transit. Transit stops, including those located on medians, need to be well-connected to the pedestrian network and surrounding destinations.
- + If appropriate, explore alternate uses of underutilized parking lanes for transit stops, bicycle parking, and green stormwater infrastructure features.
- + Loading zones should be limited in location so they do not interfere with pedestrian and bicycle traffic.
- + Limit lay-by lanes and other vehicle incursions onto the sidewalk.

Bicycle Component

Bikeways and other facilities within the public right-of-way that accommodate bicycle travel, such as pavement markings and signage.

Design Fundamentals:

- + Connect bicycle facilities with local bicycle and transit networks.
- + Provide convenient bicycle connections to residences, work places, and activity destinations.
- + The design of bicycle facilities should always seek to maximize the comfort and safety of bicycling as a transportation option.
- + Do not share bicycle activity with the pedestrian walkway zone.

Vehicle / Cartway Component

The portion of the public right-of-way intended primarily or exclusively for motor vehicle use, including travel lanes. Vehicle travel lanes may be shared with bicycles in pedestrian-dominant locations where vehicle speed is restricted.

Design Fundamentals:

- + Balance vehicle mobility with the mobility and access needs of other roadway users.
- + Promote speeds that are appropriate for the street or corridor type, pedestrian activity, and the surrounding context by applying cartway and streetscape design principles.
- + Minimize roadway width while maintaining multimodal transportation access and amenities. Allow for emergency vehicle access on all corridors. Consider freight and transit access on designated routes.
- + Provide multiple alternate routes wherever possible to and from destinations.

- + Connect and extend the street grid wherever possible when designing new roads.

Urban Design Component

Urban design policies relate to those aspects of urban form that effect corridors and complete streets, particularly the role of buildings that define the edges of the right-of-way and the public realm. These aspects may include, but are not limited to: building setbacks, encouraging active street-facing uses, locating surface parking with respect to lot layout, and limiting driveways and curb cuts that conflict with pedestrian flow.

Design Fundamentals:

- + Activate streets and their sidewalks by encouraging windows, storefronts, and other active uses facing the street, rather than blank walls or parking lots.
- + Use pedestrian scale design elements (e.g. lighting, benches, street trees) to encourage walking and bicycling while increasing pedestrian safety and comfort.
- + Manage curb cuts and curb ramps on streets to reduce pedestrian/bicycle conflicts with vehicles at driveways and intersections.
- + Building entrances/exits and pedestrian paths should be oriented to direct pedestrians to controlled intersection crossings.

Intersection and Crosswalk Component

Design treatments that facilitate the safe movement of all modes at intersections and crosswalks. This component includes treatments that influence the

safety, function, and quality of intersections and street crossings for all users, including intersection geometry, pavement markings, and traffic signals.

Design Fundamentals:

- + Design intersections to reduce conflicts between modes as well as promote pedestrian and bicycle safety and comfort.
- + Make intersections and crossings accessible, as required by ADA, by installing curb ramps, signage and lighting, and providing adequate time to cross.
- + Keep pedestrian crossing distances as short as possible to reduce exposure and increase safety.
- + Narrow streets or travel lanes to slow traffic in high volume pedestrian areas.
- + Extended curves or reduce radii.
- + Break up wide crossings with medians or refuge islands.
- + Consider providing frequent crossing opportunities:
 - + Pedestrians take the most direct route to destinations and should have a safe crossing opportunity every 300 to 500 feet.
 - + Crossings at intersections are generally adequate where blocks are 600 feet long or less.
- + Reduce vehicle speeds and increase visibility at intersections to decrease the number and severity of crashes.
- + Simplify complex intersections. Where possible, convert skewed intersections to right angles and convert slip lanes to public space.

CIVIC ENGAGEMENT CHECKLIST

Deliberative Discourse Best Practices

- + It is important to allow all persons to be heard, not just those who may command the floor. The goal of civic engagement is to deliberate with one another as they consider what ought to be done to address problems in their community.
- + It is best to engage in small group discussions to determine what is important and not to rely on the expert panelists to provide answers. The goal of deliberation is to help people shape an opinion informed by relevant facts, expert information, and the diverse views of others. When deliberating, people do not seek to persuade (debate or activism), nor do they seek conflict resolution. The more information shared with the citizen participants, the better equipped they are to gauge preferences or priorities.
- + Exit surveys are the key method of communicating back about the issue(s) being deliberated. What the planners should be looking for is an understanding of the issues as the public sees them so that the planning becomes informed, yet not necessarily prescriptive. Spend the time to work with expert questionnaire developers so that true preferences and priorities can be elicited from the responses.
- + The table moderator is the key person to spur discussion that brings out different perspectives to the issue(s). The monitor needs to be a facilitator, not an expert voice. Encourage the participants to speak

from their own experience. The idea is to personalize the deliberation to learn of underlying citizen and community values.

- + The expert panelists are also best when they can relate their personal experiences to the issue(s) being deliberated. The viewpoint of a city manager is different from program officer who handles implementation, and just as different from a non-profit leader who may bring a social perspective. Having the panelists speak from life experiences enriches the process and guarantees that the forum provides diverse perspectives and that the experience is an educational one. The process works best when panelists can express what determines their personal decision-making, which humanizes what may otherwise be viewed as a bureaucratic response.

Facilitation Team Best Practices

- + When identifying community partners, effort should be made to choose individuals or community organizations that can help recruit citizens.
- + It is important for the planning team to understand the corridor project's community context and talk with area citizens about how they would like to engage. Research what engagements have taken place, how were they received, their outcomes, and who participated to gain insight into the community's attitude toward another engagement. Learn about the social history of the community in order

Each corridor project will have its own set of stakeholders and public interest. Public outreach, whether it be by stakeholder interviews, focus group sessions, or community-wide forums, the topics for discussion should be issue-based for the most part.

It is best to shy away from preferential opinions in any public forum as those with the loudest voice will often take over session or sway the audience in a direction that is not held by all public participants.

-
- to understand the community network. Seek out persons who are interested and want to participate in the process.
- + The primary motivation for the engagement should be to learn from citizens. Secondly, it should be how to help citizens share that information with the team.
 - + At a minimum, three forums of deliberative engagement that track the planning process are recommended. Given the size and scope of the project, each may need to be repeated in several locations to reach the entire constituency.
 - + It is important for the planning team to acknowledge they have heard what the citizens are saying by responding, first to thank them and play back what was heard and learned, then later to respond with planning alternatives or recommendations that acknowledge their input—not necessarily directly as the citizens are not doing the planning work, but such that their concerns or preferences have been addressed. Keep the public updated and keep lines of communication open.
 - + At the heart of the engagement is listening. “I come with something that I want to learn from you.” Then ask, “How do I guide the discussion so that answers and opinions are freely given?” Take the position of “here is what I know already, but I value what you have to say.”

Planning and Design Team Best Practices

- + The goal of the deliberative forum process is to learn what citizens’ value. This provides information to understand the community’s “sense of community” and the values they closely hold. Not everyone shares the same values; however, there will be a consistency running through most of the comments. Keep in mind that most people have difficulty expressing thoughts that are deeply held and emotionally felt, so be patient and take the time to listen.
- + Do not treat the citizens as consumers, but as persons who have values. Values change very slowly and as a planner one needs to respect this—recommendations that respond to immediate desires are not lasting. The public is not there to be engaged on a prescriptive basis. Take the time to learn why something is important, not that it is.
- + Build relationships as these earn the trust that is needed to see a project through its final outcome. Spend the time and engage with the attitude that “we are here to build relationships.”

Engagement Involving Multiple Municipalities

- + Communication in all of its aspects is of primary importance as it is difficult to interest citizens who live some distance from the

meeting location. Citizens require a structured process with set dates that are communicated early in the project. The language used in any distributed material needs to be clearly stated and void of professional jargon.

Citizens prefer to receive notices and material via several different methods, including a project website; social media; flyers left in mailboxes, mailed, and also distributed at community functions; newspapers; announcements at municipal meetings and events; etc. The most effective are personal messages delivered directly to individuals, but individuals prefer to get these directly from friends, neighbors, and community-based groups (civic, social, religious, etc.).

- + In the initial phase of a corridor project, it may be appropriate for the planning/facilitation team to conduct identical citizen forums in a number of locations to get the word out about the project, solicit local interest, and gain a larger number of responses; and conduct identical forums for specific interest groups, such as public officials, business interests, the faith-based community, and economic development officials.
- + It is important that all later forums not repeat the issues discussed during the previous forum so that citizen participants will focus on the holistic corridor issues pertinent to

the current stage of project development. Keep in mind that citizens' time needs to be respected and that repeating discussions or focusing only on one community's issues is seen as a waste of their time.

- + Once the project is underway, provide a single and consistent meeting location for the engagement forums that is centrally located for all participants. A neutral location, such as a public library, should be sought over a space claimed by a specific municipality.
- + Not all citizens will feel engaged if the process focuses on a single community or on a problem that does not involve all communities. Select the issue topics so that all participants can engage in dialogue, even if their specific community is not directly involved in the solution but would experience its impact.

Keep in mind:

What do I want to learn from citizens?

How can I help them to share that information with me?

Having heard from you, here is how I have responded.



APPENDIX

Right-of-Way Components - Details
Performance Measurements - Details
Research Methodology and Approach
Case Study: Route 51 in Pittsburgh

RIGHT-OF-WAY COMPONENTS - DETAILS

Design Components in the Right-of-Way by Corridor Type

Adopted from the *Philadelphia Complete Streets Design Handbook*⁴⁰ and modified for the proposed Corridor Guidelines, the following charts detail the physical design components pertinent to multimodal facilities in each of the corridor right-of-ways. The components correlate to the section diagram that identifies their location. (Figure 50) An Intersection and Crossings component has been added, which is not indicated on the diagram.

Following the Handbook's component classification system, the components are rated for their appropriateness. "Required" is mandatory for the corridor type. "High Priority" is highly desired and should be included as the width permits. "Priority" is also desired, but should be considered only if the width permits. "Appropriate," the fourth priority, is appropriate in limited conditions, such as a curbless sidewalk for a festival street or a newsstand for the convenience of pedestrians.

Note that changes have been made to the classification of some of the Handbook's component ratings for each corridor type.

Rural Corridor Right-of-Way Design Components

Right-of-Way Corridor Components	Design Treatment	REQUIRED Mandatory	HIGH PRIORITY Include if Worth Pursue	PRIORITY Consider if Worth Pursue	APPROPRIATE in Limited Circumstances
Pedestrian	Sidewalk Width	No Minimum Requirement			
	Curb Ramps	✓			
Building and Furnishing	Furnishing Zone Width	≥ 5'			
	Bicycle Parking				✓
	Street Trees			✓	
	Lighting			✓	
	Benches				✓
	Stormwater Planter			✓	
	Street Furniture				✓
	Sidewalk Cafe				✓
Bicycle	Planter				✓
	Conventional Bike Lane			✓	
	Bike Route Signs			✓	
	Buffered Bike Lane				✓
	Shared-Use Path				✓
	Marked Shared Lane				✓
Curbside Management	Green Colored Pavement				✓
	On-Street Parking			✓	
Vehicle/Carway	Alternative Uses of Parking Lane				✓
	Number of Lanes		4		
Urban Design	Lane Width		10'-11'		
	Stormwater Management		✓		
Intersection and Crossings	Driveways			✓	
	Marked Crosswalks at Controlled Intersections		✓		
	Uncontrolled Crossings				✓
	Curb, Corner Radii			✓	
	Curb Extensions			✓	
	Pedestrian Refuge Islands				✓
	Bike Boxes				✓
	Two-Stage Bike Left Turn Queue Boxes				✓
	Signal Timing and Operation		✓		
	Pedestrian-Controlled Flash Beacon			✓	
Specific Design Element Descriptions					

Suburban Neighborhood Corridor Right-of-Way Design Components

Right-of-Way Corridor Components	Design Treatment	REQUIRED Mandatory	HIGH PRIORITY Include if Worth Pursue	PRIORITY Consider if Worth Pursue	APPROPRIATE in Limited Circumstances	
Pedestrian	Sidewalk Width	No Minimum Requirement				
	Walking Zone Width	≥ 6'				
Building and Furnishing	Curb Ramps	✓				
	Festive (Curbside) Street				✓	
	Building Zone Width	Park	≥ 5'			
		Some	≥ 3'			
	Furnishing Zone Width	Park	≥ 3'			
		Some				
	Bicycle Parking			✓		
	Street Trees		✓			
Lighting				✓		
Bicycle	Benches				✓	
	Stormwater Planter				✓	
	Street Furniture				✓	
	Sidewalk Cafe				✓	
	Planter				✓	
	Vendors				✓	
	Conventional Bike Lane		✓			
	Bike Route Signs		✓			
	Buffered Bike Lane				✓	
	Shared-Use Path				✓	
Curbside Management	Bicycle-Friendly Carway				✓	
	Marked Shared Lane				✓	
	Green Colored Pavement				✓	
	On-Street Parking				✓	
	In-Street Bicycle Parking				✓	
	Loading Zones				✓	
Vehicle/Carway	Transit Stops and Shelters			✓		
	Lay-By Lanes				✓	
Urban Design	Alternative Uses of Parking Lane				✓	
	Lane Width	Park	10'-11'			
		Some	10'-12'			
	Medians				✓	
Chicanes				✓		
Intersection and Crossings	Raised Speed Reducers				✓	
	Stormwater Management	✓				
	Driveways				✓	
	Marked Crosswalks at Controlled Intersections		✓			
	Uncontrolled Crossings				✓	
	Curb, Corner Radii		✓			
	Curb Extensions				✓	
	Pedestrian Refuge Islands				✓	
	Bike Boxes				✓	
	Two-Stage Bike Left Turn Queue Boxes				✓	
Signal Timing and Operation		✓				
Specific Design Element Descriptions	Pedestrian-Controlled Flash Beacon			✓		
	Neighborhood Traffic Circles				✓	
	Roundabouts				✓	

Suburban Corridor Right-of-Way Design Components

Right-of-Way Corridor Components	Design Treatment	REQUIRED Minimum	HIGH PRIORITY Include if Width Permits	PRIORITY Consider if Width Permits	APPROPRIATE in Limited Circumstances
Pedestrian	Sidewalk Width	No Minimum Requirement			
	Curb Ramps	✓			
	Festive (Curbless) Street				✓
Building and Furnishing	Furnishing Zone Width	≥ 4'			
	Bicycle Parking				✓
	Street Trees			✓	
	Lighting			✓	
	Benches				✓
	Stormwater Planter			✓	
	Street Furniture				✓
	Planters				✓
	Vendors				✓
	Bicycle	Conventional Bike Lane		✓	
Bike Route Signs					✓
Buffered Bike Lane					✓
Shared-Use Path					✓
Marked Shared Lane					✓
Curbside Management	Green Colored Pavement				✓
	On-Street Parking			✓	
	In-Street Bicycle Parking				✓
	Loading Zones				✓
Vehicle/Carway	Transit Stops and Shelters		✓		
	Alternative Uses of Parking Lane				✓
	Lane Width		10'-12'		
Urban Design	Median				✓
	Chicanes				✓
Intersection and Crossings	Stormwater Management	✓			
	Driveways				✓
	Marked Crosswalks at Controlled Intersections		✓		
	Uncontrolled Crossings				✓
	Curb, Corner Radii			✓	
	Curb Extensions				✓
	Pedestrian Refuge Islands				✓
	Bike Boxes				✓
	Two-Stage Bike Left Turn Queue Boxes				✓
	Signal Timing and Operation		✓		
Pedestrian-Controlled Flash Beacon			✓		
Specific Design Element Descriptions					

Suburban Center Right-of-Way Design Components

Right-of-Way Corridor Components	Design Treatment	REQUIRED Minimum	HIGH PRIORITY Include if Width Permits	PRIORITY Consider if Width Permits	APPROPRIATE in Limited Circumstances
Pedestrian	Sidewalk Width	≥ 12'			
	Walking Zone Width	≥ 6'			
	Curb Ramps	✓			
Building and Furnishing	Building Zone Width	No Minimum Requirement			
	Furnishing Zone Width	≥ 5'			
	Bicycle Parking				✓
	Street Trees	✓			
	Lighting	✓			
	Benches				✓
	Stormwater Planter				✓
	Street Furniture				✓
	Sidewalk Cafe				✓
	Planters				✓
Bicycle	Vendors				✓
	Architecture Features				✓
	Conventional Bike Lane			✓	
	Bike Route Signs		✓		
	Buffered Bike Lane		✓		
Curbside Management	Shared-Use Path				✓
	Marked Shared Lane				✓
	Green Colored Pavement				✓
	On-Street Parking				✓
Vehicle/Carway	Loading Zones			✓	
	Transit Stops and Shelters		✓		
	Alternative Uses of Parking Lane				✓
Urban Design	Lane Width		10'-12'		
	Median				✓
Intersection and Crossings	Bus Lane				✓
	Stormwater Management	✓			
	Driveways				✓
	Marked Crosswalks at Controlled Intersections		✓		
	Uncontrolled Crossings				✓
	Curb, Corner Radii			✓	
	Curb Extensions				✓
	Pedestrian Refuge Islands				✓
	Bike Boxes				✓
	Two-Stage Bike Left Turn Queue Boxes				✓
Signal Timing and Operation		✓			
Pedestrian-Controlled Flash Beacon			✓		
Specific Design Element Descriptions					

Town/Village Neighborhood Corridor Right-of-Way Design Components

Right-of-Way Corridor Components	Design Treatment	REQUIRED Mandatory	HIGH PRIORITY Include if Feasible	PRIORITY Consider if Feasible	APPROPRIATE In Limited Circumstances
Pedestrian	Sidewalk Width	≥ 12'			
	Walking Zone Width	≥ 6'			
	Curb Ramps	✓			
Building and Furnishing	Festive (Curbs) Street				✓
	Building Zone Width	No Minimum Requirement			
	Furnishing Zone Width	≥ 4'			
	Bicycle Parking		✓		
	Street Trees		✓		
	Lighting		✓		
	Benches			✓	
	Stormwater Planter			✓	
	Street Furniture		✓		
	Sidewalk Cafe		✓		
	Newsstands				✓
	Planter			✓	
	Vendors				✓
Bicycle	Architecture Features			✓	✓
	Bicycle Friendly Street			✓	
	Conventional Bike Lane		✓		
	Bike Route Signs		✓		
	Buffered Bike Lane		✓		
	Shared-Use Path				✓
	Marked Shared Lane				✓
Curbside Management	Green Colored Pavement				✓
	On-Street Parking		✓		
	In-Street Bicycle Parking			✓	
	Loading Zones		✓		
	Transit Slope and Shelters		✓		
Vehicle/Carway	Lay-By Lanes				✓
	Alternative Uses of Parking Lane				✓
	Lane Width		10'-11'		
	Median			✓	
Urban Design	Raised Speed Reducers				✓
	Chicanes				✓
	Bus Lane				✓
Intersection and Crossings	Stormwater Management		✓		
	Driveways				✓
	Marked Crosswalks at Controlled Intersections		✓		
	Uncontrolled Crossings				✓
	Curb, Corner Radii			✓	
	Curb Extensions				✓
	Pedestrian Refuge Islands				✓
	Bike Booms			✓	
	Two-Stage Bike Left Turn Queue Booms				✓
	Signal Timing and Operation		✓		
Pedestrian-Controlled Flash Beacon				✓	
Specific Design Element Descriptions					

Town Center Corridor Right-of-Way Design Components

Right-of-Way Corridor Components	Design Treatment	REQUIRED Mandatory	HIGH PRIORITY Include if Feasible	PRIORITY Consider if Feasible	APPROPRIATE In Limited Circumstances
Pedestrian	Sidewalk Width	≥ 12'			
	Walking Zone Width	≥ 6'			
	Curb Ramps	✓			
Building and Furnishing	Festive (Curbs) Street				✓
	Building Zone Width	No Minimum Requirement			
	Furnishing Zone Width	≥ 4'			
	Bicycle Parking		✓		
	Street Trees		✓		
	Lighting		✓		
	Benches			✓	
	Stormwater Planter			✓	
	Street Furniture			✓	
	Sidewalk Cafe			✓	
	Newsstands				✓
	Planter				✓
	Vendors				✓
Bicycle	Architecture Features			✓	✓
	Bicycle Friendly Street			✓	
	Conventional Bike Lane		✓		
	Bike Route Signs		✓		
	Buffered Bike Lane		✓		
	Shared-Use Path				✓
	Marked Shared Lane				✓
Curbside Management	Green Colored Pavement				✓
	On-Street Parking			✓	
	In-Street Bicycle Parking			✓	
	Loading Zones			✓	
	Transit Slope and Shelters		✓		
Vehicle/Carway	Lay-By Lanes				✓
	Alternative Uses of Parking Lane				✓
	Lane Width		10'-11'		
	Median			✓	
Urban Design	Raised Speed Reducers				✓
	Chicanes				✓
	Bus Lane				✓
Intersection and Crossings	Stormwater Management	✓			
	Oneways				✓
	Marked Crosswalks at Controlled Intersections		✓		
	Uncontrolled Crossings				✓
	Curb, Corner Radii			✓	
	Curb Extensions				✓
	Pedestrian Refuge Islands				✓
	Bike Booms			✓	
	Two-Stage Bike Left Turn Queue Booms				✓
	Signal Timing and Operation		✓		
Pedestrian-Controlled Flash Beacon			✓		
Specific Design Element Descriptions					

Urban Core Corridor Right-of-Way Design Components

Right-of-Way Corridor Components	Design Treatment	REQUIRED Mandatory	HIGH PRIORITY Include if Feasible	PRIORITY Consider if Feasible	APPROPRIATE in Some Circumstances
Pedestrian	Sidewalk Width	≥ 20'			
	Walking Zone Width	≥ 10'			
	Curb Ramps	✓			
Building and Furnishing	Federal (Curbless) Street				✓
	Building Zone Width	No Minimum Requirement			
	Furnishing Zone Width	≥ 5'			
	Bicycle Parking	✓			
	Street Trees	✓			
	Lighting	✓			
	Benches		✓		
	Stormwater Planter			✓	
	Street Furniture			✓	
	Sidewalk Cafe		✓		
	Newstands				
	Planter			✓	
	Vendors				✓
	Architecture Features				✓
	Bicycle	Conventional Bike Lane		✓	
Bike Route Signs			✓		
Buffered Bike Lane				✓	
Green Colored Pavement					✓
Curbside Management	On-Street Parking		✓		
	In-Street Bicycle Parking			✓	
	Loading Zones		✓		
	Transit Stops and Shelters		✓		
	Lay-By Lanes				✓
Vehicle/Carway	Alternative Uses of Parking Lane				✓
	Lane Width		10'-12'		
	Median		✓		
Urban Design	Bus Lane				✓
	Stormwater Management	✓			
Intersection and Crossings	Driveways				✓
	Marked Crosswalks at Controlled Intersections		✓		
	Uncontrolled Crossings				✓
	Curb, Corner Radii		✓		
	Curb Extensions				✓
	Pedestrian Refuge Islands		✓		
	Bike Score		✓		
	Two-Stage Bike Left Turn Queue Score			✓	
	Signal Timing and Operation		✓		
Specific Design Element Descriptions					✓
					✓

PERFORMANCE MEASUREMENTS – DETAILS

Project Evaluation

The National Complete Streets Coalition, a program of Smart Growth America, in their publication *Evaluating Complete Streets Projects: A Guide for Practitioners* includes the following measures and metrics for the purposes of evaluating complete streets to assist the AARP organization in advocating for the enactment and implementation of complete streets policies. While not all complete streets are highway corridors, these measurements and metrics for evaluating a project (scale: project) and its impact on the broader community (scale: network) are apropos for evaluating multimodal transportation facilities.

The measures have been supplemented by listings from other sources to augment the original list. The Coalition grouped the subjects by complete streets policy goals, stated verbatim from the Guide at the beginning of each listing, however they have been rearranged here to align with triple bottom line accountability of sustainability and the needs of the physical environment:⁴¹

Sustainability	Goal
Social	Access, Engagement, Equity, Public Health, Safety
Environmental	Environment
Economic	Economy
Physical	Place

This listing is by no means complete and transportation planning teams, in conjunction with the project’s Advisory Committee and PennDOT, should select those measures for project evaluation that are appropriate for each project’s goals and objectives, scope, and context.

Social: Access

Goal: Effective transportation systems (facilities) allow people to access destinations safely and reliably, by foot or assistive device, bicycle, transit, car, or truck by creating comprehensive, integrated, multimodal transportation networks. The measures below help quantify how well people are connected to places via various modes of travel.

Measure	Scale	Metrics
Auto trips	Project	<ul style="list-style-type: none"> + Driving trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status + Increase in roadway throughput capacity + Improvement in travel times
	Network	<ul style="list-style-type: none"> + Vehicle miles traveled per capita + Driving commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Driving trips to primary and secondary school (ages 5 to 18 years)
Bicycle trips	Project	<ul style="list-style-type: none"> + Bicycling trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status + Improvement in travel times
	Network	<ul style="list-style-type: none"> + Bicycling trips as portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status + Bicycling commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Participation in community bicycling events + Bicycling trips to primary and secondary school (ages 5 to 18 years)
Community connections	Project	<ul style="list-style-type: none"> + Percent of persons living or working within 1/2-mile (walking) and 3 miles (bicycling) of facility: by gender, age, income, race, ethnicity, and disability status + Percent of persons living or working within a set distance of transit stop: by gender, age, income, race, ethnicity, and disability status + Connects important destinations, e.g. schools, employment centers, homes, parks
Freight movement	Project	<ul style="list-style-type: none"> + Freight trips as portion of total trips along project + Improvement in travel times
On-street parking	Project	<ul style="list-style-type: none"> + Presence of parking per goals established in process
Presence of bicycling facilities	Project	<ul style="list-style-type: none"> + Count of new or refurbished facilities by type, e.g. bike lane (and type), advanced stop lines or bike boxes, bike signal heads, bike racks + Percent of intersection with advanced stop lines or bike boxes, painted bike lanes through the intersection, bicycle signal heads, bicycle loop detectors + Provision of appropriately-scaled bicycle facilities relative to demand + Inclusion of appropriately-scaled bicycle facilities relative to the volume, speed and direction of auto traffic
Presence of transit facilities	Project	<ul style="list-style-type: none"> + Number of transit stops with new or upgraded shelters + Percent of accessible transit stops and stations + Miles of new or refurbished transit-only lanes + Intersections with transit signal priority + Crosswalks and sidewalks provide direct connections to major destinations or activities, such as shops, libraries, schools, and other civic sites
Presence of walking facilities	Project	<ul style="list-style-type: none"> + Count of new or refurbished facilities by type, e.g. sidewalks, marked crosswalks, islands, curb extensions, countdown signals, Leading Pedestrian Intervals, accessible curb ramps, Accessible Pedestrian Signals + Percent of intersections with marked crosswalks, islands, curb extensions, countdown signals, Leading Pedestrian Intervals, accessible curb ramps, Accessible Pedestrian Signals + Average distance between signalized or protected crosswalks
Transit reliability	Network	<ul style="list-style-type: none"> + Frequency of transit service + Connectivity of routes (transit-to-transit) + Transit trips as portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status + Transit commutes as proportion of total commutes: measured by gender, age, income, race, ethnicity, and disability status

Social: Access (continued)

Measure	Scale	Metrics
Transit trips	Project	<ul style="list-style-type: none"> + Transit trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status + Scheduled headways between transit vehicles + Average speed of transit vehicles + Average wait time for passengers + Number of paratransit trips shifted to fixed-route transit trips + Improvement in travel times
Transportation connections	Project	<ul style="list-style-type: none"> + Closes gap between existing bike/walk facilities + Makes "last mile" connection to transit: 1/2 mile for walking and 3 miles for bicycling.
Trip consistency	Project	<ul style="list-style-type: none"> + Travel time along project length, by mode and purpose + Travel time reliability (reduced non-reoccurring delay), measured by mode and purpose
	Network	<ul style="list-style-type: none"> + Travel time for trips, by mode and purpose + Travel time reliability (reduced non-reoccurring delay), by mode and purpose + Percent pf person-hour change in delay, by mode and purpose + Emergency response and travel time to health facilities
Walk trips	Project	<ul style="list-style-type: none"> + Walking trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status + Improvement in travel times and delays
	Network	<ul style="list-style-type: none"> + Walking trips as portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status + Walking commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Participation in community walking events + Walking trips to primary and secondary school (ages 5 to 18 years)

Social: Equity

Goal: Transportation services and infrastructure often impact certain populations and neighborhoods disproportionately, with important implications for social equity. In project evaluation, agencies should look at the distribution of impacts and benefits for traditionally disadvantaged communities, including people of color, older adults, low-income households, and people with disabilities. Many equity measures can be integrated in project evaluation.

Goal	Measure	Scale	Metrics
Access	Auto Trips	Project	+ Driving trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status
		Network	+ Vehicle Miles Traveled (VMT) per capita + Driving commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Driving trips to primary and secondary school (ages 5 to 18 years)
Access	Bicycle trips	Project	+ Bicycling trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status
		Network	+ Bicycling trips as portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status + Bicycling commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Participation in community bicycling events + Bicycling trips to primary and secondary school (ages 5 to 18 years)
Access	Community connections	Project	+ Percent of persons living or working within ½ mile (for walking) and 3 miles (for bicycling) of facility: measured by gender, age, income, race, ethnicity, and disability status + Percent of persons living or working within a set distance of a transit stop: by gender, age, income, race, ethnicity, and disability status + Connects important destinations, e.g. schools, employment centers, homes, parks
Access	Transit reliability	Network	+ Frequency of transit service + Connectivity of routes (transit-to-transit) + Transit trips as portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status + Transit commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Transit commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status
Access	Transit trips	Project	+ Transit trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status + Scheduled headways between transit vehicles + Average speed of transit vehicles + Average wait time for passengers + Number of paratransit trips shifted to fixed-route transit trips
Access	Transportation connections	Project	+ Closes gap between existing bike/walk facilities + Makes "last mile" connection to transit: ½ mile for walking, 3 miles for bicycling
Access	Walk trips	Project	+ Walking trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status
		Network	+ Walking trips as a portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status + Walking commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Participation in community walking events + Walking trips to primary/secondary school (ages 5 to 18 years)
Economy	Access to opportunities	Project	+ Driving trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status
Economy	Employment	Project	+ Temporary and permanent jobs created by project + Use of local workforce
Economy	Land value	Project	+ Tax yield per acre + Monetary value of residential, commercial properties

Social: Equity (continued)

Goal	Measure	Scale	Metrics
Environment	Air quality	Project	<ul style="list-style-type: none"> + Air toxics along project: diesel particulate matter, benzene + Clean Air Act contaminants: particulate matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, lead
Place	Embrace of cultural, historical, and architectural resources	Project	<ul style="list-style-type: none"> + Presence, preservation, or augmentation of local assets in project process and completion
Place	Quality of automobile trips	Project	<ul style="list-style-type: none"> + Driving Level of Service (LOS)/Multimodal Level of Service MMLOS—at segment and/or intersection + Travel lane pavement condition + Appropriate and easy-to-read signage
Place	Quality of bicycling environment	Project	<ul style="list-style-type: none"> + Bicycle Level of Service (LOS)/Multimodal Level of Service (MMLO) – at segment and/or intersection + Bicycle Environmental Quality Index (BEQI)) – at segment and/or intersection + Bicycle Level of Traffic Stress (LTS), Level of Comfort + Separation from traffic is in accord with volume, speed of cars and with land use + Width of bicycle facilities + Right Turn on Red restrictions + Pavement condition of bicycling facility + Presence of bicycle network wayfinding
Place	Quality of pedestrian environment	Project	<ul style="list-style-type: none"> + Pedestrian Level of Service (LOS)/Multimodal Level of Service (MMLOS)) – at segment and/or intersection + Pedestrian Environmental Quality Index (PEQI) – at segment and/or intersection + Crossing distance and times + Wait time at intersection + Width of walking facility + Width of pedestrian medians + Sidewalk surface condition + Presence of enhanced crosswalks + Right Turn on Red restrictions + Wayfinding signs, maps
Place	Quality of transit environment	Project	<ul style="list-style-type: none"> + Transit Level of Service (LOS)/Multimodal Level of Service (MMLOS) – at segment and/or intersection + Quality of accommodations for passengers at stops + Presence of wayfinding and system information + Real-time arrival information + Off-board payment option
Place	Resident engagement in place	Project	<ul style="list-style-type: none"> + Number of people using the project space, measured in activity, age, gender, race, ethnicity, and disability status + Number of new and/or returning participants + Number of resident-led (non-governmental) placemaking initiatives + Instances of temporary activities or installations + Frequency of community events/programmed activities
Safety	Adequate lighting	Project	<ul style="list-style-type: none"> + Presence of ADA/AASHTO compliant lighting for all modes + Addition of lighting to dark corners

Social: Equity (continued)

Goal	Measure	Scale	Metrics
Safety	Fatalities	Project	+ Number of fatalities: by mode, age, gender, income, race, ethnicity, and disability status
		Network	+ Total number of fatalities suffered by all users + Progress toward achieving zero serious injuries + Rate of serious injuries as measured per 100,000 miles/use: by mode, age, gender, income, race, ethnicity, and disability status
Safety	Personal security	Project	+ Perception of safety survey of visitors, residents, commercial staff, and ownership + Number of crimes, violent and non-violent + Number of calls for service + Removal of obstacles to pedestrian line of sight at intersections and crossings
Safety	Serious injuries	Project	+ Number of injurious crashes: by mode, age, gender, income, race, ethnicity, and disability status
		Network	+ Total number of serious injuries suffered by all users + Progress toward achieving zero serious injuries + Rate of serious injuries as measured per 100,000 miles/use; by mode, age, gender, income, race, ethnicity, and disability status

Social: Engagement

Goal: While not a goal of the Coalition’s definition of complete streets policy, civic engagement is one of the few available methods of the public to influence transportation projects. Only through meaningful engagement and discourse can community values and interests be represented in transportation projects and their effect on a community’s quality of life.

Measure	Scale	Metrics
Resident participation in process	Project	<ul style="list-style-type: none"> + Number of responses gathered + Number of people at meetings/outreach events + Public input is representative of community demographics and population size

Social: Public Health

Goal: Common project-level public health measures indicate whether transportation investments allow people to have healthier lifestyles through increased access to physical activity and active transportation, decreased incidence of serious or fatal injury, and reduced exposure to pollutants. The overlap with several common transportation goals means it can be easy to integrate health indicators into transportation project evaluation.

Goal	Measure	Scale	Metrics
Access	Bicycle trips	Project	+ Bicycling trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status
		Network	+ Bicycling trips as portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status
Access	Transit trips	Project	+ Transit trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status + Number of paratransit trips shifted to fixed-route transit trips
Access	Transportation connections	Project	+ Closes gap between existing bike/walk facilities + Makes "last mile" connection to transit: 1/2-mile for walking, 3 miles for bicycling
Access	Trip consistency	Network	+ Travel time for trips: by mode and purpose + Emergency response and travel time to health facilities
Access	Walk trips	Project	+ Walking trips as portion of total trips along project: measured by gender, age, income, race, ethnicity, and disability status
		Network	+ Walking trips as a portion of total trips in community: measured by gender, age, income, race, ethnicity, and disability status + Walking commutes as portion of total commutes: measured by gender, age, income, race, ethnicity, and disability status + Participation in community walking events + Walking trips to primary/secondary school (ages 5 to 18 years)
Environment	Air quality	Project	+ Air toxics along project: diesel particulate matter, benzene + Clean Air Act contaminants: particulate matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, lead
Environment	Stormwater runoff	Project	+ Treats runoff to a higher level of quality than set threshold + Corrects poor drainage and flow + Reduces rate and volume of runoff + Percent of stormwater runoff absorbed through biofiltration + Use of pervious surfaces + Presence of rain gardens
Environment	Vegetation	Project	+ Number of trees retained and/or newly planted + Use of native plants/trees + Xeriscaping/water-conserving landscaping
Safety	Fatalities	Project	+ Number of fatalities: by mode, age, gender, income, race, ethnicity, and disability status
		Network	+ Total number of fatalities suffered by all users + Progress toward achieving zero serious injuries + Rate of serious injuries as measured per 100,000 miles/use: by mode, age, gender, income, race, ethnicity, and disability status
Safety	Serious injuries	Project	+ Number of injurious crashes: by mode, age, gender, income, race, ethnicity, and disability status
		Network	+ Total number of serious injuries suffered by all users + Progress toward achieving zero serious injuries + Rate of serious injuries as measured per 100,000 miles/use: by mode, age, gender, income, race, ethnicity, and disability status

Social: Safety

Goal: Ensuring people are able to safely travel to their destinations is a fundamental transportation goal. With complete streets [corridor] projects, this means prioritizing safety for all who use the street—walking, bicycling, riding public transportation, and driving cars or trucks. Safety measures should track both the characteristics related to injurious crashes and those related to perceptions of safety.

Measure	Scale	Metrics
Adequate lighting	Project	<ul style="list-style-type: none"> + Presence of ADA/AASHTO compliant lighting for all modes + Addition of lighting to dark corners + Visibility of crosswalks at nighttime
Compliance with speed limit	Project	<ul style="list-style-type: none"> + Percent of drivers exceeding the speed limit + Match between target speed, design speed, and 85th percentile
Crashes: minor	Project	<ul style="list-style-type: none"> + Number of crashes on project: by mode, age, gender, income, race, ethnicity, and disability status
	Network	<ul style="list-style-type: none"> + Total number + Rate of serious injuries as measured per 100,000 miles/use: by mode, age, gender, income, race, ethnicity, and disability status
Fatalities	Project	<ul style="list-style-type: none"> + Number of fatalities: by mode, age, gender, income, race, ethnicity, and disability status
	Network	<ul style="list-style-type: none"> + Total number of fatalities suffered by all users + Progress toward achieving zero serious injuries + Rate of serious injuries as measured per 100,000 miles/use: by mode, age, gender, income, race, ethnicity, and disability status
Personal security	Project	<ul style="list-style-type: none"> + Survey of visitors, residents, commercial staff and ownership + Number of crimes, violent and non-violent + Number of calls for service + Removal of obstructions to pedestrian line of sight at intersections and crossings
Serious injuries	Project	<ul style="list-style-type: none"> + Number of injurious crashes: by mode, age, gender, income, race, ethnicity, and disability status
	Network	<ul style="list-style-type: none"> + Total number of serious injuries suffered by all users + Progress toward achieving zero serious injuries + Rate of serious injuries as measured per 100,000 miles/use: by mode, age, income, race, ethnicity, and disability status
Speed reduction	Project	<ul style="list-style-type: none"> + Vehicle speed reduction below 85th percentile in areas of high pedestrian activity
Design measures	Project	<ul style="list-style-type: none"> + Number of properly marked crosswalks + Sidewalk widths and designs provide comfortable walkway space for pedestrians and persons with disabilities
Congestion reduction	Project	<ul style="list-style-type: none"> + Increase in Level of Service from baseline

Environment

Goal: Minimizing the impact on the natural environment can lead to fiscal savings in the cost of project materials and maintenance. It can also influence public health outcomes by minimizing pollutants.

Measure	Scale	Metrics
Air quality	Project	<ul style="list-style-type: none"> + Air toxics along project: diesel particulate matter, benzene + Clean Air Act contaminants: particulate matter, ground-level ozone, carbon monoxide, sulfur oxides, nitrogen oxides, lead
Energy efficiency	Project	<ul style="list-style-type: none"> + Use of reflective surfaces + Use of dark-sky, low-energy lighting + Use of materials and designs that facilitate energy conservation in operations
Providing/preserving habitat for native species	Project	<ul style="list-style-type: none"> + Connects or restores habitat + Wildlife crossings
Stormwater runoff	Project	<ul style="list-style-type: none"> + Treats runoff to a higher level of quality than set threshold + Corrects poor drainage/flow + Reduces rate and volume of runoff + Percent of stormwater runoff absorbed through biofiltration + Use of pervious surfaces + Presence of rain gardens
Sustainable sourcing for construction materials	Project	<ul style="list-style-type: none"> + Percentage of recycled materials used in new pavement/construction + Use of locally or regionally sourced materials to reduce transportation costs
Vegetation	Project	<ul style="list-style-type: none"> + Minimal impacts on existing vegetation, including mature trees, grasses and other absorptive plants and vegetation + Number of trees retained and/or newly planted + Use of native plants/trees + Xeriscaping/water-conserving landscaping + Landscaping used to enhance the physical appearance
Noise	Project	<ul style="list-style-type: none"> + Reduction in overall noise levels + Minimize impact of noise on adjacent residential uses
Construction	Project	<ul style="list-style-type: none"> + Use of environmentally sensitive construction techniques + Proper disposal of recyclable materials
Operations and maintenance	Project	<ul style="list-style-type: none"> + Use of enhanced durability materials (extended productive life), minimal salt/de-icing requirements, and reduced maintenance

Economy

Goal: Evaluation of transportation projects can include metrics that show how the project contributes to economic performance, whether by connecting people to jobs, by providing employment in transportation construction and operation, or by boosting the value and attractiveness of abutting land.

Measure	Scale	Metrics
Access to opportunities	Network	<ul style="list-style-type: none"> + Jobs accessible by 30- or 45-minute transit trip + Ratio of jobs accessible by a 30- or 45-minute transit trip + Ratio of jobs accessible by a 30- or 45-minute automobile trip to those accessible by a 30- or 45-minute transit trip
Building vacancy	Project	<ul style="list-style-type: none"> + Rate of vacancies along project, and as compared to larger community or comparable corridor + Number of vacant and underutilized buildings
Employment	Project	<ul style="list-style-type: none"> + Temporary or permanent jobs created by project + Use of local workforce + Stability of employment numbers on segment/corridor
Investments from other sectors	Project	<ul style="list-style-type: none"> + Amount of private and foundation/grant/non-transportation investment in adjacent properties
Land values	Project	<ul style="list-style-type: none"> + Tax yield per acre + Monetary value of residential, commercial properties + Assessed valuation
Parking utilization	Project	<ul style="list-style-type: none"> + Portion of provided spaces for cars, bicycles used over the course of a day
Retail vibrancy	Project	<ul style="list-style-type: none"> + Retail and restaurant sales at businesses directly adjacent to project + Number of customers, by mode of travel + Number of tourists visiting + Customer experience surveys + Vacancy rates
Economic development	Project	<ul style="list-style-type: none"> + Number of building permits issued + Number and value of property sales, residential and commercial + Number of business establishments
Budget	Project	<ul style="list-style-type: none"> + Compliance with budget, measured by percentage

Physical: Place

Goal: For better or worse, transportation investments influence the community's quality of life. Being aware of the community context, including existing and planned land use and buildings, transportation needs, and residents' culture, can result in streets (and corridors) that are vital public spaces. Place-related evaluation measures help ensure a product that fits and enhances the community.

Measure	Scale	Metrics
Embrace of cultural, historical, and architectural resources	Project	<ul style="list-style-type: none"> + Presence, preservation, or augmentation of local assets in project process and completion + Integrity of archeologically significant structures and sites + Coordination of infrastructure to meet historic district requirements and compatibility
Public art	Project	<ul style="list-style-type: none"> + Number of permanent (or temporary) installations, as part of project or inspired by project
Quality of automobile trips	Project	<ul style="list-style-type: none"> + Driving LOS/MMLOS – at segment and/or intersection + Travel lane pavement condition + Appropriate and easy-to-read signage
Quality of bicycling environment	Project	<ul style="list-style-type: none"> + Bicycle LOS/MMLOS – at segment and/or intersection + Bicycle Environmental Quality Index (BEQI) – at segment and/or intersection + Bicycle Level of Traffic Stress (LTS), Level of Comfort + Separation from traffic is in accordance with volume, speed of cars, and with land use + Width of bicycle facilities + Right Turn on Red restrictions + Pavement condition of bicycling facility + Presence of bicycle network wayfinding
Quality of pedestrian network	Project	<ul style="list-style-type: none"> + Pedestrian LOS/MMLOS – at segment and/or intersection + Pedestrian Level of Quality Index (PEQI) – at segment and/or intersection + Crossing distance and times + Wait time at intersection + Width of walking facility + Width of pedestrian medians + Presence of enhanced crosswalks + Right Turn on Red restrictions + Surface condition of sidewalk/pathway + Wayfinding signs, maps + Use of street furniture and lighting to enhance the appearance
Quality of transit environment	Project	<ul style="list-style-type: none"> + Transit LOS/MMLOS – at segment and/or intersection + Quality of accommodations for passengers at stops + Presence of wayfinding and system information + Real-time arrival information + Off-board payment option
Resident engagement in place	Project	<ul style="list-style-type: none"> + Number of people using the project space, measured by activity, age, race, ethnicity, and disability status, gender + Number of new and/or returning participants + Number of resident-led (non-governmental) placemaking initiatives + Instances of temporary activities or installations + Frequency of community events/programmed activities

Physical: Place (continued)

Measure	Scale	Metrics
Satisfaction	Project	+ Survey of visitors, residents, commercial staff and ownership + Quality of the physical appearance of the community
Scenic views	Project	+ Provides or preserves views of scenery or vistas
Seating	Project	+ Presence and quantity of seating available + Square feet of outdoor dining space per foot of restaurant façade
Shade	Project	+ Percent of public space and travel areas shaded by trees, shelters, etc.

Blank Page

RESEARCH STUDY METHODOLOGY AND APPROACH

This study was preceded by a Phase I investigation of the Route 51 corridor in Pittsburgh that was funded by The Heinz Endowments.

The majority of the Phase I investigation was proof of concept research to evaluate the potential benefits of the CMU Robotics Institute's Surtrac signalization computer model compared to the system employed by the Southwestern Pennsylvania Commission. The adaptive signalization referenced in this report relied on the findings of the Phase 1 modeling work. The role of the Remaking Cities Institute in Phase I involved the collection of Route 51 information, including GIS documentation, prior studies and reports, historical and current photographs, interviews with key stakeholders, and civic engagement forums to understand the corridor's context, issues, and citizen concerns. RCI worked with the CMU Program for Deliberative Democracy for the civic engagement portion.

Phase I: Methodology and Approach

The process involved collecting and analysing information, relative to highway corridor planning in general and the Pittsburgh case study in particular. The initial information was developed and analysed and alternative corridor development scenarios followed to understand the impact of growth or decline along the corridor.

GIS land use cluster analysis of the case study data proved useful. The team concluded that time and density were the measures of success and potential

depending on the cluster's development uses and distance from the corridor. Clusters further from the corridor have less impact. This insight modified the study's methodology. Measuring opportunity as a resource is a derivative of resource flow management, where the efficiency of materials flow (e.g. a utility's distribution of energy) is best optimized.

The research team used resource flow to determine opportunity boundaries for degrees of economic and transportation development. Three growth scenarios were developed for comparative purposes: disinvestment, low to moderate growth, and fast or high growth. However, further analysis showed the study area to be growing at a slower rate than the region, and that topography was a primary contributor: little available flat land meant that economic development will only occur as infill where it is already located—flat land. The team concluded that cluster analysis is a useful tool for corridor planning, particularly for networked and network-potential corridors where there is greater opportunity for off-corridor investment.

Phase II: Methodology and Approach

Phase II was organized as a three-part process: research, alternative investigations, and recommendations. While linear in its organization, the study team's approach was iterative. Testing the alternatives required that evaluative criteria, in this case appropriate design criteria gathered from best practices, be comparatively evaluated,

with accountability taken for national transportation policy evolution since the 1990.

Task 1 followed a standard research protocol. Time was divided between general corridor research and the Pittsburgh case study analysis. Research was summarized according to the five disciplines on the research team: urban design, economic development, environmental infrastructure, transportation and transportation technology.

Task 2 involved a systems integration approach where each discipline brought a body of specific knowledge to working sessions for discussion. This approach produced an “outcome” at each session as the research team collectively integrated the findings as an iteration. These sessions not only synthesized the respective research tasks, but also developed performance criteria and indicators. Several integration rounds were achieved.

Task 3 continued the Task 2 research process, and included new research in transportation planning from around the country. PennDOT’s *Smart Transportation Guidebook* and *Design Manual, Part 2 Highway Design* were seminal documents that provided the foundation benchmark for evaluating context design, roadway typology classification and design criteria, and specific regulations and directives. The *Philadelphia Complete Streets Design Handbook* and the *Boston Complete Streets Design Guidelines* provided guidance for multimodal and complete streets design principles and criteria. Most of the synthesis was spent understanding the differences between corridors and standard

roadways, corridor relationships to PennDOT Roadway Typologies, future influences on corridor design, and how the five discipline areas will be of strategic influence on corridor planning over the next fifty or more years. Seven corridor typologies were developed and documented, including specific typology recommendations as well as design recommendations and guides for transportation project team use.

Task 4 concentrated on editing, fact and reference checking, graphics additions, and finalization of the Task 3 report.

Stakeholder Involvement

The research team worked with three “clients” for this study: PennDOT, Economic Development South (who has the task of planning the Route 51 development strategy), and a Technical Advisory Committee (TAC), comprised of community leaders, professionals, and organizations. Each client was apprised of progress and provided valuable feedback as the study progressed.

The civic engagement portion of the study had its own research agenda: to learn how citizens, as participants in a planning project, desire to be engaged in the planning process, will know that their input was valued, and will stay engaged throughout the project’s tenure. The Program for Deliberative Democracy had an additional goal: how to engage citizens from multiple municipalities in an engagement process where the “good of the whole” may be more important than the “good of only one”.

CASE STUDY: ROUTE 51 IN PITTSBURGH, PA

Location

The case study corridor is located in the South Hills area of Pittsburgh beginning at the intersection with Route 19 and continuing south for 13.5 miles to the southeasterly community of Large, Pennsylvania.

Lessons Learned

The case study provided two valuable insights into corridor planning: (1) definition of a corridor and a strategy for understanding a corridor's context, in relationship to existing roadway and corridor typologies; and (2) an overview of the type and amount of investment strategies to improve the corridor. From this information, the study's purpose was to gain a basic understanding of context and multimodal design parameters for developing corridor design options and to undertake a civic engagement process appropriate to corridor planning.

Corridor Definition

Understanding a corridor's general characteristics is necessary before proceeding onto detailed information gathering. First, determine whether the corridor is an individual or networked corridor, or combinations of the two patterns. Individual corridors are closed systems, meaning that there are limited alternatives for dispersing traffic, with limited potential for growth unless the topography is flat and developable on both sides, and most improvements will be limited to the existing right-of-way that cannot be widened.

Route 51 is an individual corridor with almost no opportunity for evolving into a network corridor with parallel roads. The topography is

the dominant factor which limits parcel size and growth potential.

Corridor Scale Type

Generally, a corridor can be described as one of the five roadway scales (regional arterial, community arterial, community collector, neighborhood collector, or local road/street). The land uses that face the corridor are good indicators of typology as are the corridor's destination(s). While the corridor may exhibit several land use typologies, one type usually dominates. The number of lanes, width of lanes, and other roadway facilities can be false indicators as these can apply at several scales. Identification of the scale type provides overall general planning information as to whether it is a major commuter route or a gatherer of local streets that feed a more active corridor.

Route 51 is a regional arterial that connects Uniontown, PA to Pittsburgh then continues north. Overall, Route 51 is about 100 miles in length. The case study portion is a four lane regional arterial serving suburban and river town commuter traffic into and out of downtown Pittsburgh.

Nodes

Nodes are where two paths meet and are generally found where the corridor crosses another corridor or major roadway, such as an arterial. There will be signs of more active and denser commercial or residential land uses. Nodes are places where people congregate and where higher pedestrian and bicycle traffic can be expected. Nodes are also

potential transit-oriented development locations, whether they serve as important bus stops or have the potential for multimodal transfer and significantly higher land use density. Often nodes are transition points between corridor segments.

The case study area has three major nodes: the intersection with Route 88 at Library Road; the intersection at Brownsville Road; and the area around the Century III Mall and adjacent to Lebanon Church Road, an intersecting corridor. The Route 88 intersection, a bottleneck for motorists, has little potential for major development because of limited parcel size; it could be a multimodal transfer location for suburban express bus passengers to transfer to the light-rail trolley/subway system rather than continuing into Downtown.

Corridor Segment Types

Most corridors have more than one roadway segment. The transitions will typically identify where different segments begin and end, allowing for roadway typologies to be defined. The transitions may occur at nodes or where there are recognizable changes in land uses or the scale of buildings. This information gives the planner a basic understanding of the corridor's context and pattern composition, as well as the general design parameters for the improvement or solution. Urban design, environmental, and economic strategies will differ for each segment.

The Route 51 case study location is primarily an auto-oriented Suburban Center Corridor for its length. It is lined with regional-type uses for more than 10 miles of the 13.5-mile study area. Its least developed southern end has the potential to function as an ecological green boulevard due to its daylight stormwater stream and floodplain identification. Likewise, the northern end of the study area from Route 88 to the Liberty Tunnels has experienced major disinvestment of its floodplain-designated properties, which presents another opportunity for an ecological green boulevard with limited development in the portions above the floodplain.

By identifying a corridor's segments, a planner should have enough context and roadway design information to focus further development and corridor facility attention.

Economic Development

Understanding the development potential is key to determining the type, scale, and timeline parameters for corridor right-of-way multimodal design needs. There are many factors that influence economic development, including climate change. The project planning team should broaden its perspective to include additional consultants and the community in the process. The intent is to understand the variables and costs of alternative and adaptive design strategies. This information is invaluable for understanding the scale/timeline variables of likely development that will guide

design and timing decisions. It will also translate abstract ideas into likely and achievable design alternatives.

Understanding potential economic development for the Route 51 case study corridor puts growth potential into perspective and provides strategic insight into why the corridor has been experiencing disinvestment for several decades. With this information, the research team determined that major economic development would not occur until fundamental changes took place to Pittsburgh's economic and demographic profile. Presently, there are many less-costly locations for economic development than this section of Route 51 and that, for the time being, the focus should be on improving traffic flow and efficiency. Considering the two end segments for robust stormwater control and converting them into park-like settings for multimodal use is a logical conclusion.

Design Improvements

With the understanding that corridors evolve over time and require different design strategies as market conditions and development responds, corridor right-of-way design improvements based on timing can be investigated more thoroughly. It is helpful to assess economic development and corridor design needs at different scale/time intervals, such as:

- + Site specific improvements for localized needs
- + Nodal specific improvements, generally based

- on TOD potential within the holistic context
- + Capture area or opportunity-wide improvements, based on potential strategic change (activity center evolution or addition, or city-wide change that suggests alternate routes to other destinations)

When assessing the study area's economic development possibilities, the team identified three levels of scale/time improvements for Route 51, given the fact that growth will be slow. Site specific improvements could solve isolated problem locations, such as the consolidation of numerous curb cuts or addition of functional bus stops. Nodal improvements, specific to the Route 88 and Brownsville Road intersections, need to allow for safe pedestrian crossings tied to modest commercial development. Further investigation of the Century III Mall site may allow for its development as a transit-oriented development and activity center. However, the most important task was assessing Route 51 in context with the Pittsburgh region and its longer-term future. With Pittsburgh's current slow growth and its topographical conditions, the Route 51 area will experience slower growth than other sections of the metropolitan area. Redeveloping the Century III Mall site will be a boost to the local economy, but its likelihood as a major employment center is fairly low due to its location in the larger city and county context. This information provided an overview of the

degree of corridor improvement investment and the types and locations where those investments would be beneficial.

Segment Analysis

The segment analysis was the most important factor of the case study exercise. On the broader scale, the segments define the basic structure of the corridor as an interconnected series of roadway typologies, which led to understanding the corridor's basic functioning, its overall character, how and why the current corridor's context and condition is what it is, and what portends its future. On the detail level, each corridor segment provided design parameters (per PennDOT's roadway typologies) for eventual design improvement recommendations.

Multimodal accommodation on Route 51 will be difficult without major changes in the corridor's basic physical structure. With four narrow travel lanes; posted speeds of 35 and 40 mph; numerous left turns without a designated turn lane; one or more curb cuts for each property; few locations for sidewalks and those that exist are narrow, in poor condition, and at the edge of the highway; bus stops that are only a bus stop sign; and no bicycle facilities, Route 51 is dangerous for all users. It is prohibitive for bicyclists. Detailed analysis identified the design and accommodation problems between design speed, level of service, limited traffic calming ability, and

multimodal objectives. It became apparent that on Route 51 design speed and multimodal facilities conflict with one another, and thus report recommendations followed for lowering corridor speeds and implementing design changes to accommodate multimodal facilities.

Segment 1: Liberty Tunnels to Provost Road

- + Corridor Form: Linear, non-network
- + Corridor Type: Formerly auto-oriented but largely disinvested. This segment has design potential as an urban park-like, scenic boulevard.
- + Context: Lack of adjacent development, disinvestment is mostly due to floodplain issues; low-rent uses are prevalent; floodplain vulnerability; no network potential — closed system. Traffic speed is significantly higher than posted speed limit and cars weave in and out to bypass those making left turns.
- + Connectivity: Poor due to high slopes on both corridor sides. Lateral intersections occur at Bausman, Edgebrook, and Maytide to plateau neighborhoods, with some potential for pedestrian/bike/transit connections at light rail stations. There are good light rail connections, but the stations are located midway up the slopes and off the corridor. Good potential for connections to the Seldom Seen Greenway and McKinley Park.
- + Environmental: High ecological value due to undeveloped slopes and open stream.

Consider coordination with Pittsburgh Water and Sewer Authority, Army Corps of Engineers, Pittsburgh Department of City Planning, and Economic Development South to convert this segment into a scenic parkway.

- + Economic Development: Limited. Little development value without the ability for flood insurance. Some limited development spots exist on the north side of the corridor.
- + Urban Design: Two nodes exist in this segment, at the Route 19 and Route 88 intersections. Route 19 is a major interchange with open space as its primary use. The Route 88 node could see higher density mixed-use development, however some of parcels are in the floodplain. There are some pockets of higher density development on flat parcels outside of the floodplain. Those will remain commercial or maybe high-density residential (nearer to Route 88). High quality of life value could be realized if the corridor were designed as a scenic parkway with protected bicycle and pedestrian trails alongside Saw Mill Run.
- + TOD Potential: There is potential as a transit transfer location at the Route 88 intersection; however there is limited area for economic development and multimodal prospects. Multimodal transfer occurs from express and local buses to fixed rail transit into Downtown. This is an opportunity to divert numerous buses from Downtown. This is not a potential park-and-ride location, as most autos would continue into Downtown if this segment becomes a scenic parkway.

Segment 2: Prospect to Brownsville Road

- + Corridor Form: Linear, non-networked.
- + Corridor Type: Auto-oriented suburban
- + Context: Small stores and buildings are auto-oriented with parking in front and on sides. Some strip retail is present, but most are stand-alone structures. There are many vacancies and curb cuts. Motorist speeds in this area are typically above the posted speed limit and dangerous for all users.
- + Connectivity: There is one major intersection at Greenlee Road, and it only serves the southern side of Route 51. Other intersections are at local streets with little impact on access, except for providing a pedestrian connection to bus stops. Bus stop usage is high in this area, particularly closer to Brownsville Road. Brownsville Road offers an alternate route to Downtown if there is congestion on the corridor, however its value as an access corridor is limited because it functions primarily as a local street.
- + Environmental: Low impact. Both the width of the right-of-way and lot depths are limited due to slope topography. Some green stormwater mitigation is possible, but because of limited space it would be best to capture the majority of the stormwater and pipe it to Saw Mill Run.
- + Economic Development: Undergoing disinvestment. Close to thirty parcels are owned by one family with no master plan for future development; the area will not develop until the owners decide what to do. Future uses are questionable due to shallow

- parcel depth; it will most likely remain auto-oriented with the possibility of high-density residential development. South Hills Golf Club is a potential site for future mixed commercial and high-density residential uses.
- + Urban Design: The node at Brownsville Road is currently built out to market potential. There are possibilities for sidewalk/bicycle integration along Route 51, but not in the roadway; protective barriers are required. Building massing will most likely remain the same over the foreseeable future, with the possibility for some parcel consolidation. There is also potential to slow traffic and improve pedestrian safety by creating perceptual enclosure at the Brownsville Road and Route 88 intersections. Roadway improvement should include a bike/pedestrian shared sidewalk on one side of the corridor. Create a sense of motorist “enclosure” and incorporate complete streets features at the two nodes to perceptually slow traffic.
 - + TOD Potential: There is TOD potential at the Brownsville intersection when the South Hills Country Club is sold for development. At the present time, there is no reason for TOD as there are few parcels available for development and the location is within one mile of the Route 88 intersection.

Segment 3: Brownsville Road to Lebanon Church/ Curry Hollow Road

- + Corridor Form: Linear, non-networked
- + Corridor Type: Auto-oriented suburban
- + Context: This is a transition zone into a

- suburban context due to the location of the golf club and the wooded slopes on the northern side of the corridor. The high school is a landmark. The built environment and landscape quality levels are higher than in other areas of the study corridor. Traffic moves swiftly here and is not as congested as the other northern segments.
- + Connectivity: Generally local residential streets connect to suburban neighborhoods. Streets Run Road is the only large intersection in this segment, however it is not a strong location for major development. The freeway interchange at Lebanon Church Road is both out-of-context with rest of the corridor and not compliant with current interchange design standards.
 - + Environmental: The awkward topography does not lend itself to significant environmental improvements as it is comprised mostly of developed, short-height slopes, with little room beyond the right-of-way for robust stormwater mitigation. It is best to capture stormwater and pipe it to Streets Run Road or other location(s) for mitigation.
 - + Economic Development: There is potential in this segment for redevelopment of two parcels and new development on a third if the Lebanon Church Road intersection is rebuilt as an at-grade signalized intersection.
 - + Urban Design: There is potential for a shared sidewalk/bike pathway outside of the curb line. Prospective development could occur at Lebanon Church Road if the intersection is rebuilt. This would provide sites for high-

density residential or commercial uses. The remainder of this segment will remain auto-oriented with infill and single-property redevelopment the most likely scenario. Adding street trees to compress the enclosure and incorporating complete streets features at the two nodes will perceptually slow traffic.

- + TOD Potential: Not advisable because of the intersection's proximity to Century III Mall.

Segment 4: Lebanon Church Road to Lewis Run Road (Route 885)

- + Corridor Form: Linear, with some possibility for a localized street network at the Century III Mall site.
- + Corridor Type: Auto-oriented suburban.
- + Context: This is a recently developed section of Route 51, with big box retail and auto-centric retail businesses on both sides of the roadway. The landscape is bare, consistent with an auto-dominant setting where roadside retail is the focus.
- + Connectivity: Only one intersection of importance exists here at Century III Mall. Otherwise, the local residential streets serve suburban neighborhoods. Route 885 is an alternate route into the employment centers of Downtown and Oakland, with commuters experiencing almost the same travel time by transit as they do via Route 51. If growth occurs here, Route 885 will need more improvement than Route 51, as it is a two-lane corridor for most of its length.
- + Environmental: There is little value currently, as most of the landscape has

- been developed with auto-dominant uses and impervious surfaces. Add street trees to compress the enclosure and incorporate complete street features at the Century III Mall node to perceptually slow traffic.
- + Economic Development: Corridor parcels in this segment are fully developed with little change anticipated. The Century III Mall site has good development potential as an employment/residential center, however growth demand is questionable at the present time. Once this area begins to redevelop, it should spur other employment-centric development in the immediate area and northeast along Lebanon Church Road; however, impact to the Route 51 corridor is unpredictable.
- + Urban Design: The focus here should be on the Century III Mall site and how Route 51 reacts to it. Presently the form is auto-centric with a preponderance of big box development. The near term strategy should be to add street trees and begin to compress the perceptual enclosure to slow traffic and incorporate complete street features at the Century III Mall entrance.
- + TOD Potential: This segment has the highest TOD potential of the case study area, but only off of the Route 51 right-of-way and onto the Century III Mall parcel. This is a good interceptor site for express buses and park-and-ride facilities; the location provides a Route 885 bus-transit alternative depending on Route 51 congestion. The location could become a classic example of bus-transit oriented development.



Flood in Overbrook 1956



Bailey's Auto Service, Maytide Street
1930



Bausman Avenue 1909

Segment 5: Lewis Run Road to Large, PA

- + Corridor Form: Linear, with no prospective network street development.
- + Corridor Type: Auto-oriented corridor, with the same potential as Segment 1 as a future scenic corridor.
- + Context: Significant disinvestment due to its location within the floodplain. There are dramatic steep slopes on both sides of corridor. Some sites could become available for potential development proximate to the Century III Mall site. Suburban to rural countryside with large-lot residential development on hilltop ridges. There is more investment potential at Lewis Run Road and Large, PA, but these are not viable TOD locations.
- + Connectivity: Poor, such that only local residential streets intersect with Route 51. The Coal Valley Road intersection with access to Jefferson Hospital is the only portion that has future potential for traffic calming measures on Route 51.
- + Environmental: There is high ecological value here due to its undeveloped slopes and open stream. Coordinate with Army Corps of Engineers and Economic Development South in order to convert this segment to a scenic corridor.

- + Economic Development: Limited. There is little development value without the purchase of flood insurance. Some limited development parcels exist on both sides of Route 51 where Peters Run crisscrosses the corridor.
- + Urban Design: The Mon-Fayette Expressway node in Large, PA could include higher density mixed-use development, however some parcels are in the floodplain. There is potential for higher density development on the large, flat parcels outside of the floodplain. Those parcels will remain commercially zoned at the Route 43 and Lewis Run Road intersections with the potential for some higher-density residential uses between them. High quality of life value is possible if the corridor is converted to a scenic parkway with protected bicycle and pedestrian trails alongside Peters Run.
- + TOD: There is some potential at Large, PA for transit-hub TOD, however the current heavy industrial uses will limit its potential as a classic TOD. This segment is a good interceptor site to pick up auto traffic from the Mon-Fayette Expressway, however most motorists would continue on to Century III Mall unless parking was free of charge.

URBAN DESIGN

Corridor Character

Route 51 in the study area presents an overall appearance of disinvestment, physical unattractiveness, and unsafe conditions for pedestrians and motorists alike. It is similar to a place that at one time enjoyed an active retail, business, and residential character that provided both regional and local services. Today it is well past its prime. Consequently, its purpose today is to move high volumes of traffic as efficiently as possible so that motorists can reach destinations of work and home with as little time spent on the corridor as feasible.

Physical Conditions

The corridor naturally divides itself into five segments that are topographically different. At both ends of the study are flat floodplains with large parcels and some large footprint buildings that lead onto rising sloping segments typically lined with small-scale development. In the center section, which is in a third watershed, and generally flatter than the two sloping sections on either side. It could be argued that the center section is comprised of two or even three segments as the topography and fabric acknowledges the sloping ground plane.

Disinvestment is physically apparent in three segments of the corridor: at its northern portion in the floodplain section between the Liberty Tunnels and Library Road (Route 88), between Library Road almost to Brownsville Road, and at

its southern floodplain portion south of Century III Mall to Large, PA. Continual flooding of Saw Mill Run and Peters Creek at its two bookends has resulted in abandoned buildings, temporary uses that would not suffer significant economic hardship if flooded, and a left-behind landscape of former parking areas, weeds, and debris. In the area south of Library Road, many buildings are for sale, lack of building and site maintenance is apparent, and there is visual clutter. Behind the foreground in all three of these segments are quite beautiful and green steep hillside slopes that separate the residential fabric atop the slopes from the commercial uses along the corridor. All three of these zones are in valley locations where the steep slopes infringe on the properties that line the arterial. Interestingly, at both the northern and southern portions the properties are larger than south of Library Road; however, it is in these two locations where natural forces have caused the disinvestment. South of Library Road, economic forces have caused disinvestment.

Investment is apparent along the corridor beginning north of Brownsville Road and continuing through the Boroughs of Whitehall, Baldwin, and Pleasant Hills, all three wealthier communities. Properties are well maintained and the corridor appears to exhibit some sense of life. The corridor widens just north of Brownsville Road allowing for a center turning lane and a more spatial feel. This segment of the corridor is the most promising for future development as it is the flattest section of the corridor, extends outward in both east and west



Saw Mill Run Boulevard at the Overbrook Business District 1936



Mckinley Bridge at Bausman Street, wood replaced with steel structure 1929



Overbrook Market 1934



Route 51 South Mall entrance



Route 51 at Brentwood Town Square

directions, and contains some of the largest parcels within the corridor's opportunity reach. The eastern area is filled with a wide variety of uses that has proven to be sustainable over the last 40+ years, irrespective of the Century III Mall's rise and fall, which is typical of a shopping mall's 20-year life cycle.

Poor physical conditions are often a sign of opportunity. EDS's desire for a green boulevard along Library Road to the Tunnels with pockets of investment outside of the floodplain appears as a rational treatment of this segment and could be a similar strategy for the Peters Creek segment in Jefferson Hills. On the other hand, the better connections in the center section, particularly in the vicinity of Lebanon Church Road and Century III Mall, offer the structural underpinnings of flatter land and better access and the potential for future population growth, making this area a possible candidate for transit-oriented development.

The settlement patterns along the corridor are a good example of a cross-section transect and beneficial in defining use and patterning differences between each transect zone. Beginning at the northern end the fabric is mid-density residential on city-sized blocks in a fairly cohesive orthogonal pattern similar to most grid cities. That pattern begins to turn to a suburban one proceeding south between Library Road and Brownsville Road, where residential lot sizes begin to enlarge and an inner-ring suburban fabric begins to dominate. Towards Lebanon Church Road and southwards

in Pleasant Hills, the fabric evolves into a second-ring suburban transect with larger lots and more cul-de-sac residential streets. Once entering into Jefferson Hills the fabric evolves again into a rural fabric where few streets connect with one another, lots are large, and buildings are spaced far apart. In a sense, it is a classic radial transect procession from the center city outward to the countryside and a good physical model for a corridor case study.

Functional Performance

As a transportation corridor, Route 51 is a classic example of an arterial's evolution from a combination of local service strip segments with a healthy mix of regional uses and draws to an inner-city and high-volume traffic corridor functioning on a street design meant for slower moving traffic. Multiple curb cuts, small commercial establishments, and many intersections with bus stops are out of place with fast moving traffic. Feedback from the previous civic engagement sessions confirms this by the responses from local residents who avoid the corridor except for its commuter function to downtown Pittsburgh. Anyone driving the corridor is aware of its narrow lanes and speeding commuters weaving around automobiles attempting left turns into feeder streets or commercial establishments.

Route 51 is a one-ended destination corridor. Downtown Pittsburgh is its single destination and its use today is predominately for commuter traffic, including express bus service to Downtown from communities beyond Pittsburgh's outer suburbs.

While Century III Mall was once a significant destination, it no longer meets that criterion, which has an impact on the type of transit service that is feasible in the future unless there is a large population growth with concomitant employment centers that draw traffic in the opposite direction.

Newer development is happening off the corridor where parcels are larger, access is better, and safety is improved. As the South Hills evolves, particularly in the Boroughs of Brentwood, Whitehall and Pleasant Hills and along the Lebanon Church Road corridor, Route 51 risks being left behind. The recent overlay zoning to address the deterioration of the corridor in the Baldwin, Brentwood, and Whitehall communities by seeking to increase the attractiveness of the corridor to developers, enhance its pedestrian access, and improve its aesthetic appeal with required sidewalks, streetlights, landscaping, restrictions on curb cuts, and coordinated signage, among others, recognizes that the Route 51 corridor must become calmer and friendlier if it is to economically survive.

Connectivity

The corridor's topography is a strong deterrent to its connectivity. As one of Pittsburgh's major radial arterial that occupy valley floors it lacks a strong pattern of crosscurrent feeder streets that link it to a strong street network. Many of its intersecting streets classify as local streets without a network of collectors. The few that do link to other communities occur in the center segments

of the corridor where the land is flatter; however, this section of the corridor occupies only about 25 percent of the distance within the study area. Most intersecting streets are located in narrow ravines or along ridge tops where there are limited building opportunities.

While the steep-sloped hillsides along most of the corridor provide an aesthetic buffer and appealing green backdrop, they are also a barrier to all but buses and automobiles. They are too steep to walk or bike for the average person, which limits accessibility and connectivity.

The major roads that interconnect with Route 51 do provide connectivity in the eastern direction toward the Monongahela River and its communities. Unfortunately, these former steel towns are not strong job centers or predominant destinations. The one arterial to the west that does connect with communities along the I-79 corridor, Library Road, suffers many of the same problems as the deteriorated sections of Route 51: narrow roadway, floodplain restrictions, and visual unattractiveness. The other western roads lead to more suburban residential areas and the rural countryside beyond.

Way Finding and Orientation

For a corridor that travels for over 10 miles through the South Hills there are very few landmarks or recognizable destinations along its path. Many of the intersections look the same and the corridor's auto-orientation deter way finding by landmark, a characteristic throughout most of Pittsburgh's urban



Route 51 opposite Cloverleaf Towers



Route 51 at Large, PA

fabric. The new jug-handle intersection at Library Road, the green open space golf course Whitehall, in freeway-like intersection at Lebanon Church Road, and the big box retail surrounding Century III Mall comprise its few landmarks to provide both way finding and orientation. The South Busway and T light rail transit lines would normally provide visual orientation; however, both are imbedded into the hillsides and generally not visible.

The simple fact that the corridor is a continuous 4-lane arterial provides its distinction. Only Lebanon Church Road and a short portion of Brownsville Road equals its width and both are not visible to motorists on the Route 51 corridor. All other connecting streets are 2-lane roads

Sense of Place, Associative Qualities, and Character of Experience

The corridor's topography provides its sense of place. The valley-like bookends at the north and south ends of the study area provide dramatic green spatial walls that enclose the valley and strengthen its relationship to its physical environment. Where the corridor climbs out of its valleys the hillsides lose their height; however, they come closer to the roadway and their presence is more closely experienced. The houses atop the plateau in the Overbrook and Brentwood areas are highly visible and almost appear to engage with the activity along the corridor. Although they

functionally do not, their presence as an urban hilltop edge is characteristic of Pittsburgh.

The greenery, open space, and care of the built environment in the Whitehall and Baldwin section of the corridor are most attractive. A sense of pride is apparent in the attention to detail and cleanliness of the corridorscape. This section stands out more for its contrasting differences between its neighboring segments than as a best practices corridor built environment.

At the top of the plateau and beginning the southern downward slope toward Century III Mall in the Pleasant Hills and West Mifflin area, the bowl formed by the surrounding topography and the artificial hill formed by the dumping of Clairton Coke Work's slag nestles the Mall's presence and that of its out buildings with a view hampered only by the unattractiveness of the built environment.

Otherwise, the corridor has little visual attractiveness. Its architecture is utilitarian and the foreground environment has generally been neglected. Most of the corridor appears as if it has been "used" and forgotten.

Relationship to Corridor Communities

Like most of Pittsburgh's transportation corridors, including its rivers, local communities and neighborhoods turn their backs onto their

surroundings. Mostly a resultant of the area's sloping topography that defines the borders of neighborhoods, residential communities developed as self-reliant villages complete with a retail commercial service core, school, library, and local professional services. Their cores are at their centers and their edges form the seams for connector arterials and multi-neighborhood commercial and businesses. Often the neighborhoods are and were settled by persons who shared ethnic or religious backgrounds that made Pittsburgh one of the nation's more familiar melting pots. While the topography separates neighborhoods, their social and cultural roots contribute to their isolation and "defensive" posture.

The Route 51 corridor is no different than other urban transportation corridors in the region. Kept at the edges of communities in the seams between them and not engaged as a strong determinant of physical form or community pride, they not strongly connected physically and culturally to the communities they serve.

One of the best examples of this situation is the condition of Route 51's bus stops. Almost all have a minimal physical presence. Many are just a curb next to a high-speed traffic lane and a sign, and even some lack the sign. They are unsafe and

unattractive. They do not belong to any community, even those whose boundaries lie on both sides of the corridor. While Route 51's bus stops are endemic of a larger problem, they do make it clear that corridor planning strategies are dependent on the context in which they exist. Corridors that are isolated require different planning solutions than those who are ingrained within their surrounding communities.

Street System and Access

Corridor Street System and Street Patterning

The Route 51 corridor is an arterial spine where the linear path is dominant and its branches, the arterials and local streets that connect to it perpendicularly, primarily serve as feeders to the spine. It does not take the form of a tree structure where the branches are larger at the bottom and taper toward the top, because the corridor's steep-slope valley topography at either end of the study area precludes that possibility. Although the urban fabric and street density at its northern end is compact and dense, the Mount Washington neighborhoods at its eastern plateau are not large nor populous and the communities of Brookline and Overbrook to its west, with similarly sized populations, have spread their street fabric over a greater area in favor of larger residential parcels. The net result is few and far between connector and

local streets branching off the spine. At the southern end in Jefferson Hills, the connecting streets are also spaced far apart but longer and thinner; however, they serve a very small population.

Instead it is more like a spine with longer middle extensions and shorter ends. Lebanon Church Road in West Mifflin and its extension west between Baldwin and Pleasant Hills extends as an arterial far in either direction with its own set of feeder streets.

As a spine system it does not operate well as a network with cross street interconnectivity. Some street networking does occur closer to Downtown where the orthogonal grid pattern provides more choices, some interconnectivity amongst the suburban patterns of the corridor's middle section, but practically no network interconnectivity at the corridor's southern end where almost every intersecting street operates independently. As a street system a spine is so directional and geometrically deterministic that it almost precludes networking. Spines make it difficult to engage with adjacent communities simply because they become more inefficient the more they are punctured by intersections.

Issues of Access

While not competing directly with Route 51, the Route 51 corridor's opportunity influence extends farther along the Lebanon Church Road corridor than others due to its flatter topography and

the fact that Lebanon Church Road takes a very circuitous route to its eventual Downtown and Mon Valley destinations.

Other arterials branching off the corridor are Library Road (Route 88), Streets Run, Brownsville Road, and Highway 43, which also includes the Mon-Fayette Expressway, feed into the corridor, but their effect is not substantial. The 2-lane Library Road is also the route of the T transit service into downtown Pittsburgh that originates in Castle Shannon a fairly short distance west of Route 51, which takes a large burden of automobile traffic off the corridor. Brownsville Road is the only arterial that competes directly with the corridor as a commuter route to Downtown. Although only a 2-lane arterial that travels the ridge line and runs through the middle of several neighborhoods, it offers a more pleasant and neighborhood-scaled experience that takes an almost equal amount of time to its Downtown destination. Its ridership is high and competes with that of Route 51.

The street systems on either side of the corridor create a very loose network due to the topography of ridges and valley ravines. The topography does not allow for a robust street network available to a grid pattern on flat land and cross-connections are few and space far apart. It is only when close into the city that the street networks begin to resemble grid patterns, yet even those offer few connections beyond their neighborhood's topographical boundaries.

Influence of Topography that Shapes the Corridor

Route 51 is definitely shaped by its topography. As discussed previously its valley locations do not allow any street geometry other than a spine. Once it reaches its center section the topographical situation flips and the corridor begins to run along topographic contours near watershed ridgelines, and in some instances portions of ridgelines. Due to slopes either upwards in valleys and downwards on or near ridges, buildable land and large development parcels are difficult to achieve because of these slope “boundaries.” While the study area exhibits some flatter land in its center section, topography still dominates this corridor.

Corridors in other locations will respond differently to their topography. Those with gentler slopes, such as a landscape with rolling hills where the slopes are between 8 and 15 percent, grid patterns begin to appear and street network choices are possible. Geometrical hierarchy typically remains as these grids usually run parallel to the slope while collector streets gather local streets into corridors spaced farther apart. Flat lands less than 8 percent with unequal grids present no issues for networked and highly efficient grids. Some grids, though, can become so efficient, such as square grids, that creating hierarchy is problematic because of their geometric ambiguity. In these cases, the lack of topography is a problem because there are no contextual clues and one must rely on street widths to order the system.

Without topographical boundaries, corridors on flat land grids, even those with distinctly rectangular shapes and different street widths, still benefit from contextual clues in order to understand their relationship to the community or communities within its sphere of influence. In some cases, the natural landscape can provide that context by understanding its environmental context of watercourses or even soil types that support different vegetation. In urban areas where the natural landscape has been compromised, other patterns can provide those clues. Settlement patterns, by their built form or density, create areas of strength and weakness that form hard or soft edges, just like topography. Development does not do well within strong settlement fabric except for infill opportunities, whereas soft-fabric edges and seams between fabric types suggest development opportunities. Corridors in greenfield conditions are bounded only by topography, while corridors in flat land urban fabric are bounded by the strength of the fabric that surrounds them.

These situations prevail in the horizontal plane only. For corridor development can also extend in terms of height and, thus, density. Without acquisition capabilities beyond the corridor and its adjacent properties, corridors experiencing growth can respond by increasing density by building upwards instead of horizontally. Transit-oriented development is one such model and its effect can be beneficial to its adjacent or surrounding communities by its catalytic potential for growth and investment. Its only drawback is the need to balance the amount of TOD development with

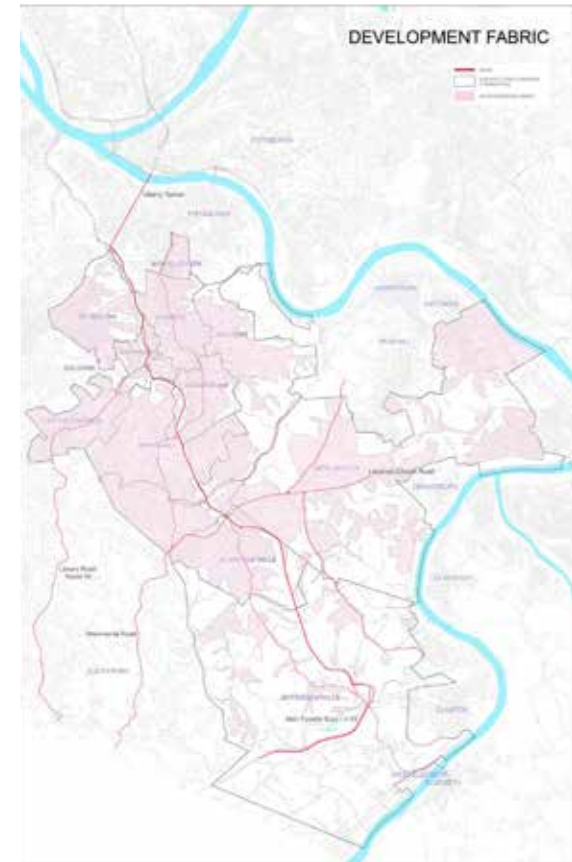
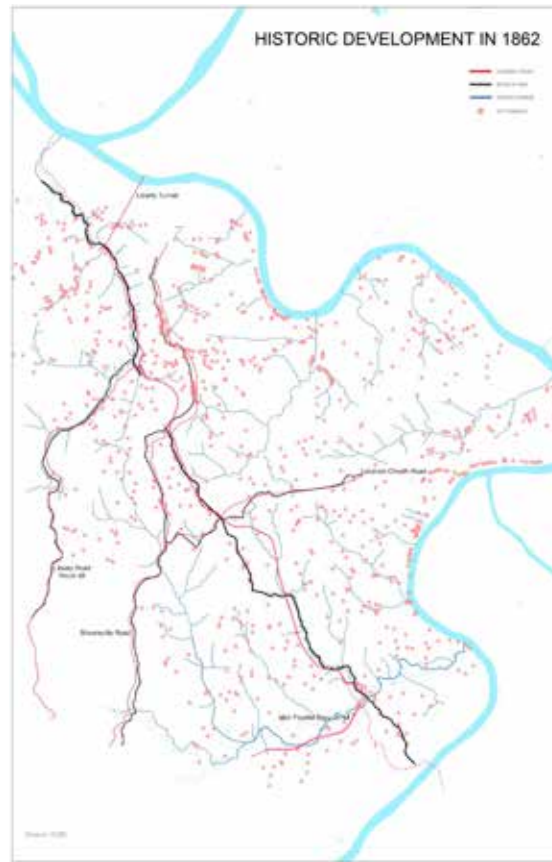
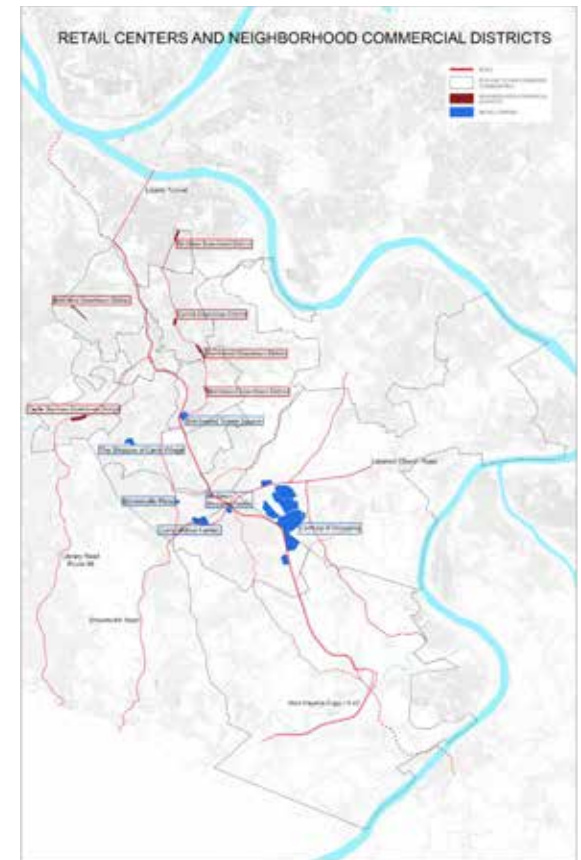
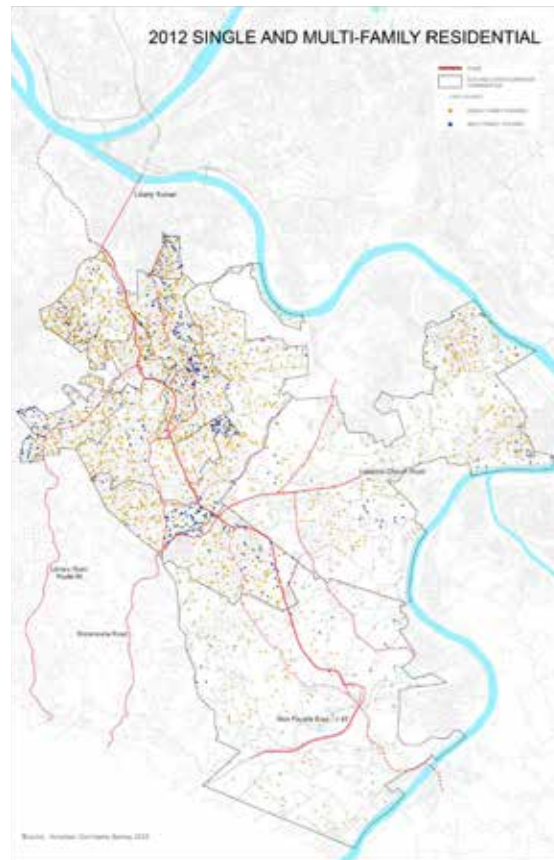
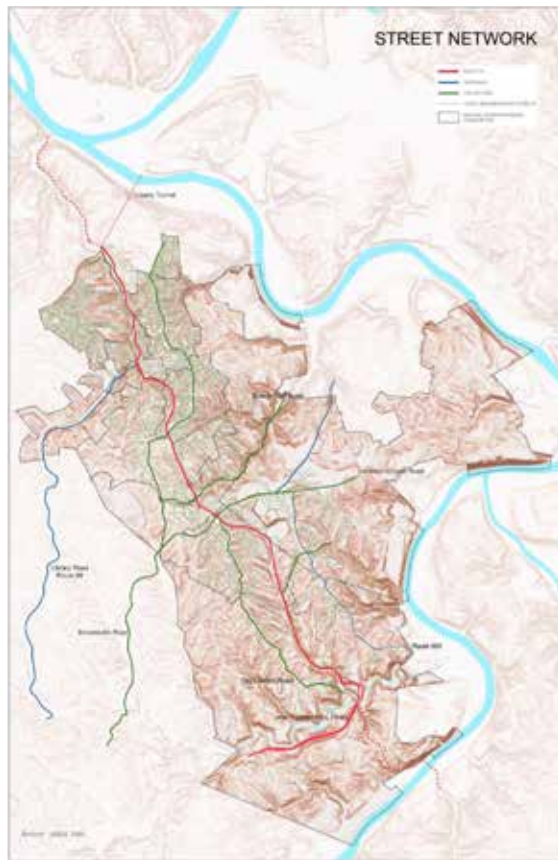


Figure 51 | Urban Design Maps





2013 Flooding in Overbrook



Saw Mill Run Creek Condition



Construction at Route 88 Intersection
2015

that of the community as a whole so that TOD development does not create a competitive market for limited resources.

Corridor Strengths

Physical

- + Sense of place created by valley hillsides at both ends of the corridor
- + Rows of residences lining the lower plateau edges bring the upper plateau into contact with the corridor floor
- + T and South Busway removed from corridor's ground plane making them more accessible to residents
- + Potential to build upon the existing sidewalk infrastructure

Social

- + Multi-municipal cooperation
- + Coordinated corridor planning through a single and local organization
- + Diversity of population and income levels
- + Economic
- + Potential for higher density development around the Century III Mall and the Lebanon Church Road corridor
- + Brentwood Town Center
- + Industrial activity in close proximity to the corridor along Lebanon Church Road

Natural

- + Available land for stormwater mitigation and recreational open space in two locations
- + Green hillside slopes that frame the corridor

- + Saw Mill Run and Peters Creek are both day lit
- + Lush and rural landscape in close proximity to the southern end of the corridor

Corridor Weaknesses

Physical

- + Unattractive built environment for most of the corridor's length
- + Strong corridor spine with limited influence on adjacent communities
- + Narrow lanes and unsafe driving conditions
- + Lack of corridor sidewalks
- + Poor quality bus stops

Social

- + Disinvestment along Saw Mill Run
- + Disinvestment along Peters Creek
- + 30 properties held off the market between Library Road and Brownsville Road without plans for revitalization
- + Population growth basically stagnant
- + Clustering of multi-family residential units in only a few neighborhoods rather than spread throughout the area

Economic

- + Lack of investment along most of the corridor
- + Employment centers are small and mostly retail service

Natural

- + Flooding
- + Poor water and air quality
- + Few corridor trees lining the corridor

ECONOMIC DEVELOPMENT

Potential Redevelopment Sites

In order to identify the potential location sites along Route 51, the research team first mapped the following key factors.

Property with Existing Tax Liens

Property with tax liens (either vacant land or buildings) may present an opportunity to purchase land at a reduced rate for private or public development. In some cases, governments can purchase the tax lien properties and clear title to the property as part of a land banking effort. However, the purchase of properties with tax liens also has certain disadvantages. It may take several months to clear the title of tax lien properties, and the purchaser may also be responsible for other liens on a tax-lien encumbered property. The property may also require extensive repairs in order to bring the property up to code. Tax lien properties have been identified based on county tax records.

Large Contiguous Parcels

Larger parcels of land under the control of one owner and located in a strategic location may present a development opportunity since negotiations with several distinct landowners can be challenging. Redevelopment efforts at Century III Mall are ongoing and reflect, in part, the redevelopment cycle attributable to retail as new construction enters the market.

Publicly Owned Land

Property ownership can be a key factor in determining the location of catalytic sites. In some cases, public entities purchase strategic parcels of land in order to leverage new development in an area. For example, if key parcels are purchased near a potential transit-oriented development site, the public entity can write-down the cost of the land in order to incentivize private development. While there are several publicly owned parcels of land located along the Route 51 corridor, it is not clear if any of these parcels are strategic purchases.

Parcels Located in a Floodplain

In order to locate strategic parcels, it is helpful to eliminate those parcels that are restricted by environmental conditions, with the most obvious restriction including those properties that are located in an existing floodplain. It is important to determine if some of the existing tax lien properties are located within an existing floodplain. Parcels restricted by floodplain locations are located along Saw Mill Run at the northern portion of the Route 51 study area (Library Road to West Liberty Avenue, extending to the Ohio River at the West End) and along Peters Creek at the southern portion of the study area (Route 43 to Large, PA, extending to the Monongahela River at Clairton).

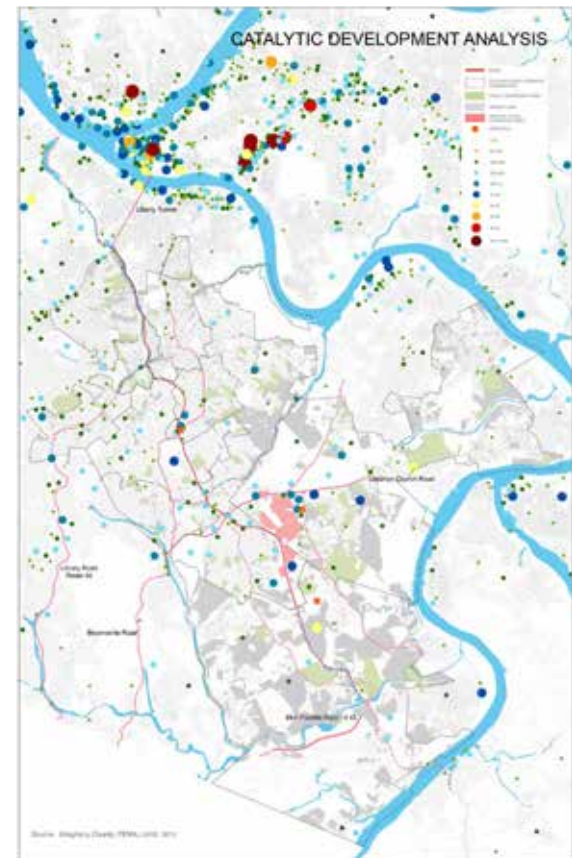
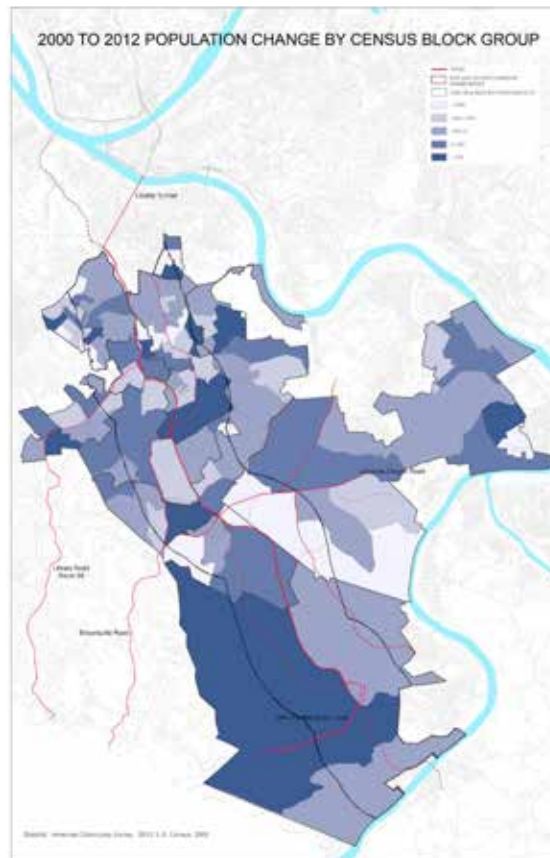
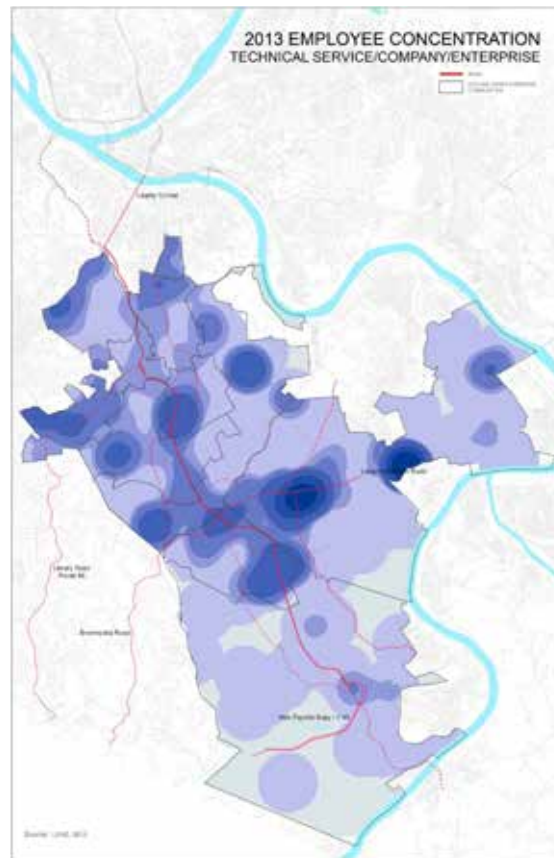
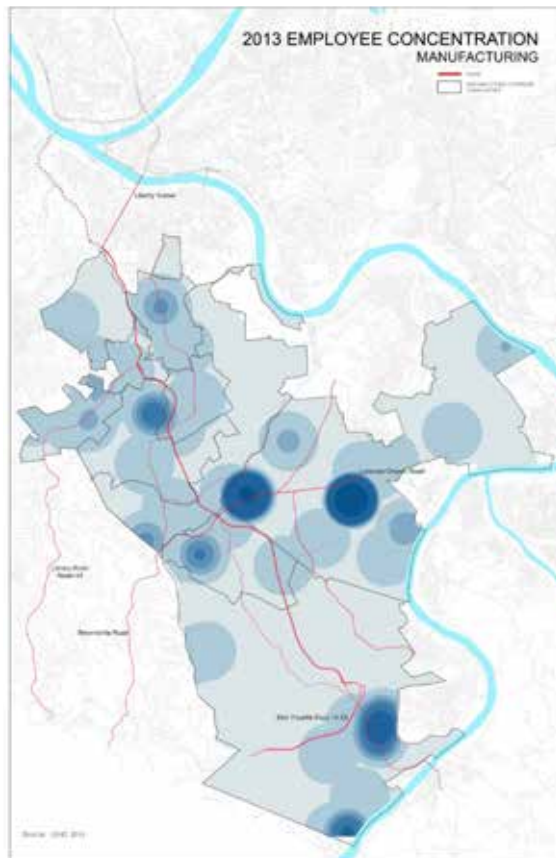


Figure 52 | Economic development data maps



Potential New Development Sites by Key Indicators

In order to better understand potential locations for new development along the corridor, the following key indicators were analyzed.

Locations near Growth Areas

Areas that are growing in terms of population density also point to potential locations for investment. In order to determine growth areas, population change from 2000 to 2012 by block group was mapped, as was forecast new growth areas. As shown, there are four main areas that have experienced growth rates of over 15%. While the area to the south near Jefferson Hills has grown, it is also important to note that the magnitude of the growth is not as significant since the population growth is reflected from a smaller base number.

Locations near Transit and Major Road Intersections

Locations which are near transit and major road intersections provide opportunities for transit-oriented development. These locations are also important for potential commercial users; retailers prefer highly visible sites and office/light industrial users prefer easy access for employees, visitors and shipping. The preferred site for development/redevelopment based on transit and highway

orientation is at the Brownsville Road intersection. Other sites providing access and visibility include the intersection of Lebanon Church Road and at the intersection with Rote 43.

Locations near Escalating Land Values

Increasingly property values also indicate potential desirable locations for new development and investment.

Locations near Other Major Anchors and/or Employment Centers

There may be an opportunity for new development near existing major anchors and/or employment centers, primarily as it relates to new retail or commercial development. Major anchors and employment centers located along or near Route 51 include Century III Mall, Jefferson Hospital, the Community College of Allegheny County South Campus, and the Allegheny County Airport.

PHYSICAL FACTORS

Lands Challenged by Topography

The Route 51 corridor includes significant elevation changes, limiting flat land available for new development.

Lands Located in a Floodplain

As with redevelopment sites, it is helpful to eliminate those parcels that are restricted by floodplains in terms of new development sites. Parcels restricted by floodplain locations are located along Saw Mill Run at the northern portion of the Route 51 study area (Library Road to West Liberty Avenue, extending to the Monongahela River) and along Peters Creek at the southern portion of the study area (Route 43 to Large PA, extending to the Monongahela River at Clairton).

GROWTH AREAS AND DEVELOPMENT INDICATORS

Retail Development

Grocery industry rapidly evolving after decades of emphasis on suburban-site business model:

Price/value/quality/organic market segmentation

Store loyalties diminished by more competition, varied offerings, store hours

Consumer options now include: drug stores, gas/convenience store combinations, Wal*Mart, warehouse club stores like Costco and BJ's & specialty grocers like Trader Joe's

Office Development

Key demand indicator for office buildings: job growth in office-using sectors

Typical occupancy factor: 200-250 SF per employee

Declining due to "hoteling", open floor plans, etc. to reduce tenant occupancy costs

Over-building during 2003—2007 boom characteristic of suburban locations

Recovery from 2007—2009 recession ongoing: tightened capital, pre-leasing requirements

Residential Development

Potential thresholds for new residential development: new construction where existing home values exceed cost of new home construction

Hotel Development

Average suburban hotel site: 2.5-4 acres

Feasibility factors: Average Daily Rates (ADR's); average annual occupancy levels; Revenue Per Available Room (RevPAR)

65% average annual occupancy: threshold for new construction/additional rooms

Major hotel brands ("Flags") increasingly only operate, do not own the properties

Criteria for financing now depend on both who 'owns' and who 'operates'

ENVIRONMENTAL INFRASTRUCTURE

Existing Conditions Landform Morphology

The Western Pennsylvania region is characterized by sedimentary formations deposited millions of years ago when the area was at the eastern edge of a large inland sea that were eroded away into a complex and hierarchical network of ridges and valleys. Rivers that are much larger than today's carved wide floodplain basins bounded by steep slopes. Smaller tributaries created narrower valleys where some secondary waterways flow for miles. In some steep slope areas, tertiary waterways created steep tributary valleys. In other less steep areas, tertiary waterways can run for longer distances at lower velocities.

Landform, Water and Historic Settlement

Landform determined many early settlement patterns that are still visible today. Major urban areas along the rivers appeared first as sparse settlements that took advantage of shallow flood plains, rich soil, and access to raw materials that supported their settlement (for example, sand to make glass). Rivers were the original highways of water and allowed people to transport raw materials and finished goods to larger markets. In the search for materials and land, settlement developed along secondary waterways because their slope was somewhat amenable to early horse

drawn vehicles and later rail lines. Tertiary roads near to major settlements also followed this pattern but with some exception that allowed for dense urban housing for the growing river industries—travel up steep slopes was more difficult and perhaps only accessible by foot and later rail. As travel by horseback or foot was improved to rail and later automobiles, these historic pathways remained largely unchanged in their alignment, and today are inextricable intertwined with the waterways that created them.

Open Space

Open space along the corridor is often “left over space” that was not developed due to slopes, flood plains, lack of accessibility, or other property disposition patterns. Other adjacent open space uses are intentional and include parks or active recreation areas.

Habitat Quality

Regional ecological patterns are driven by landform, which in the Pittsburgh region coincides with the availability of water and soil and thus plant communities. Animal habitat results from these factors. The corridor has a variety of habitats, which for this study will be characterized by disturbance level (highly disturbed habitat has a large number of invasive plants; low disturbance has intact native plant communities), slope (steep slope allows for accessibility for wildlife travel and contributes to

erosion and slope stability problems), and integrity/fragmentation (describes the intact area without development or roadways to allow for interior habitat development in addition to edge habitat conditions). There is a correlation between these factors—highly fragmented habitat with little interior for native plant communities is most likely to host invasive or opportunistic plant communities. This is not to say that fragmented habitat is not valuable, it simply needs a greater level of care to restore conditions for plant communities to thrive.

Air Quality

Heavily used automobile corridors are a large source of air pollution and there is a direct correlation between number of vehicles and the level of air pollution.

Environmental Rules and Regulations Municipal Environmental Land Use Regulation

Land use regulation related to stormwater and/or open space varies greatly between municipalities. Most consistent across municipalities is floodplain regulation that results from FEMA requirements.

Current Ecological Issues Floodplain and Vulnerable Properties

In many areas of the corridor, the waterways are open and settlement is within the floodplain. Recent floodplain legislation has made these properties more difficult to develop and some properties have

already been bought by public agencies to prevent future redevelopment. Some of these properties may gain in ecological value by restoring them to provide natural services for water quality or quantity.

Combined Sewer Outlets (CSO)

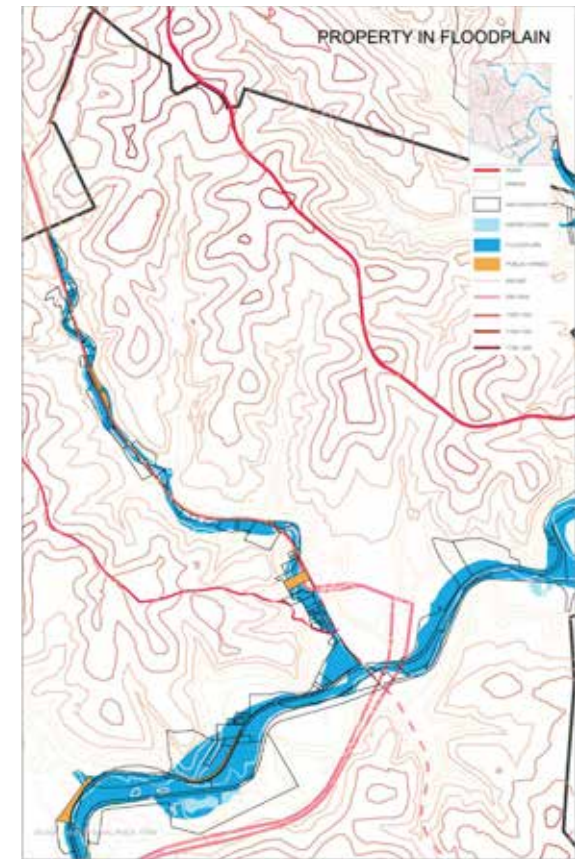
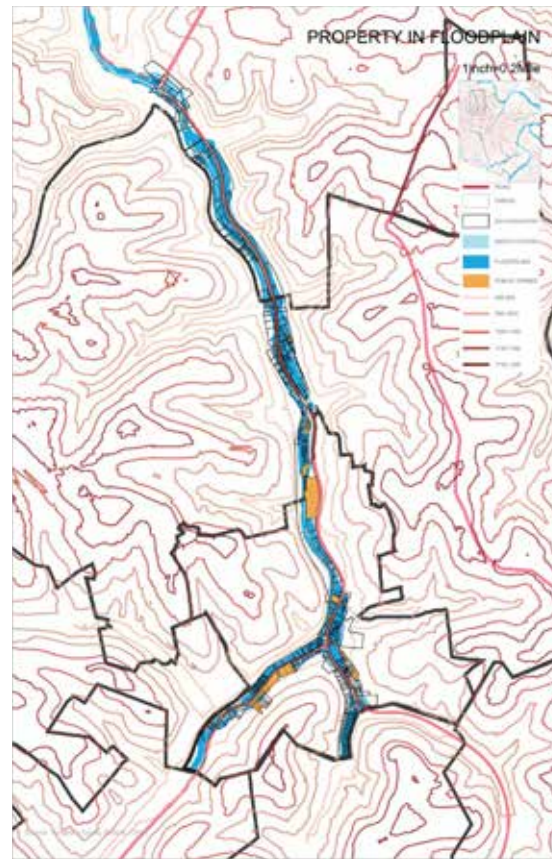
Early regional roads were often developed simultaneously to the construction of combined sewer systems. The two infrastructure systems often share routes and have similar hierarchical reaches into communities. These areas are known combined sewer areas.

Multi-municipal and Authority Collaboration

Land use decisions relative to stormwater, open space, and habitat, are typically managed by municipality and thus transit corridors need to address each separately. This can lead to disconnected strategies. Multi-municipal organizations exist to enable coordinated action. Multi-municipal organizations are shown on this map with environmental projects, policy, or advocacy listed.



Figure 53 | Environmental Infrastructure data maps



TRANSPORTATION

Current Transit and Movement Systems

The current transit system is reflective of the corridor's population, which tapers off as it moves southeast from the Liberty Tunnels past the Pittsburgh city limits. From that point on the suburban population does not begin to compare with the other section of the South Hills along the West Liberty corridor through the communities of Dormont, Mt. Lebanon, and Upper Saint Clair.

Route 51 is primarily a bus transit corridor that is fairly good to minimal as far south as Century III Mall. Service is best during rush hours although it is more efficient during the mid-day, probably due to fewer cars on the corridor. Park and ride locations are minimal along the corridor. They occur far outside the corridor's influence and primarily service the commuter express buses from the south. Economic Development South is looking to establish a few park and ride locations in the Pleasant Hills and Century III Mall environs where there are larger parking lots for underutilized retail uses.

The T light rail system parallels the corridor to Library Road, about one-fifth of the case study's distance, where it makes a 90 degree turn and heads due south to Castle Shannon, another South Hills higher population suburb that shares its border with Mt. Lebanon. While extending the T to Pleasant Hills and the Century III Mall area may be a good idea from an efficiency and connectivity perspective, the present population of the corridor

is not as robust as that of its southern neighbors.

Rail lines are not a factor due to the area's steep topography. Today commuter rail other than the T system are non-existent as buses retired the streetcars and commuter rail lines some years ago. The remaining rail lines, which predominantly carry freight, travel the river's flat topography a good distance from Route 51.

What reigns supreme is the automobile. It is faster, more convenient, pleasant, and personal. Until parking rates are adjusted in Downtown to create equivalency throughout the inner Metropolitan Area, which includes this corridor, it will be difficult to shift motorists to transit passengers.

While most of the Route 51 corridor traverses suburban communities, the corridor's roadway remains at an older urban scale due to the restrictive topography. Although this creates its own problems which are discussed elsewhere, there are very few locations where the corridor exceeds four lanes. Consequently intersections are characteristic of inner-city suburbs where the urban fabric keeps them small and more pedestrian-friendly and not the six- to eight-lane corridors experienced in many western cities. Their dimensions and geometries are more conducive to pedestrian-friendly improvements if traffic could be calmed and more transit-related development were to occur.

Bicycles, Pedestrians, and Steps

The pedestrian and bicycle environment along the corridor is poor at best.

It is clear that any recent investment in pedestrian amenities, such as sidewalks and street trees, has not been a priority. While in good condition around the Brentwood Town Center, the sidewalk infrastructure installed some years ago has not been maintained. Sections have been removed and those that remain are in poor condition. Past Lebanon Church Road sidewalks are few and far between. In general, walking along corridor properties is dangerous due to many unimproved properties and numerous curb cuts that favor the automobile. In several places a pedestrian would need to walk in one of the movement lanes to get around obstacles, including traffic infrastructure, along the curb's edge. Walk Score rankings are very low. Only around Brownsville Road and Route 51 do they rate as "Very Walkable"; most score as "Car Dependent" and only a few locations, mostly at major intersections, rate as "Somewhat Walkable."

Riding a bicycle on Route 51 should be prohibited, as it is so dangerous. The movement lanes are narrow and providing 4 feet of clearance between bicycles and automobiles is not possible unless motorists trail behind bicyclists in the outer travel lanes. There is no room for dedicated bicycle lanes either on the roadway or on adjacent properties. Bike Score rankings barely register: from the Liberty Tunnels to the Overbrook / Whitehall boundary the ratings register "Very Steep Hills, Minimal Bike Lanes," and from there going south are rated as "None."

Due to the steep slopes on either side of the corridor, pedestrian access from plateau residential communities is not very convenient and is not

provided past the Pittsburgh city limits. There are a few community steps in the Overbrook, Brookline and the Carrick neighborhoods down to Route 51, but they are not in good condition. In many places residences are not within a 5-minute walking distance of Route 51. Once on the corridor the bus stops are not accommodating and often are in dangerous locations, such as at the center of the Route 51 / Lebanon Church Road interchange or within an active off-street parking area at a busy intersection.

Only 4 signal locations have pedestrian-priority signalization. It is dangerous to cross the corridor with its fast moving traffic and rush to get to work Downtown and return home.

The natural evolution of property investment has slowly removed the pedestrian from the corridor's environment. It makes little economic sense to provide pedestrian amenities when there are no pedestrians. The recent overlay zoning that seeks to turn around the unattractiveness of the built environment in three wealthy communities with long-sought pedestrian and visual improvements will take a long time to implement as they are dependent on new investment and an economic climate of growth for it to succeed.

Port Authority of Pittsburgh Bus Service

While bus service along Route 51 is generally frequent during rush hours from Century III Mall toward Downtown, traffic congestion is a problem for efficient service. Modeling the Surtrac signalization system produced results of an average

26 percent reduction in travel time and a 49 percent reduction in delay time, both significant improvements. If combined with bus prioritization, bus transit's efficiency would be greatly improved.

Once reaching the South Busway, travel into Downtown is significantly improved because of no stops. However, all buses proceed into Downtown including those who bring in passengers from locations beyond PAT's service area. At the present time there are no provisions for transfer or collector points to limit the transit traffic.

The problem with most bus service is that it is not a pleasurable experience. Vehicles are older and noisy, bus stops are inadequate even in the best of climate conditions, getting across the corridor is hazardous, and the walk to home or business is difficult on streets with steep slopes and no sidewalks. Transit Score reflects this situation. "Good Transit" occurs only between the Liberty Tunnels and Library Road; "Some Transit" registers between Library Road and Lebanon Church Road, although it is intermixed with "Minimal" ratings until near Lebanon Church Road; south of the interchange and for almost one-half the corridor's distance the rating registers as "None."

Port Authority Light Rail Transit (T System)

The South Hills light rail T has been a success. Its ridership is high and service is reliable. Although the transit cars are dated, most of the public prefers the light-rail system to buses. Its location on the valley slopes above the traffic of Route 51 is an admirable feature.



Figure 2: Route 51 Corridor (Northern Part)

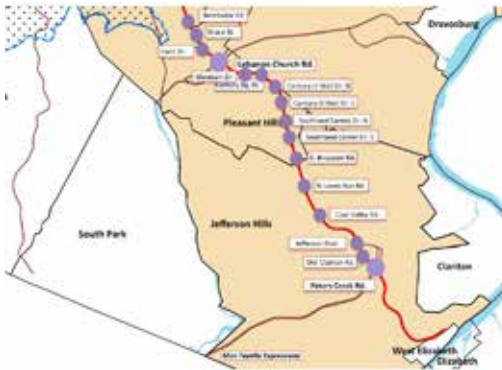


Figure 3: Route 51 Corridor (Southern Part)

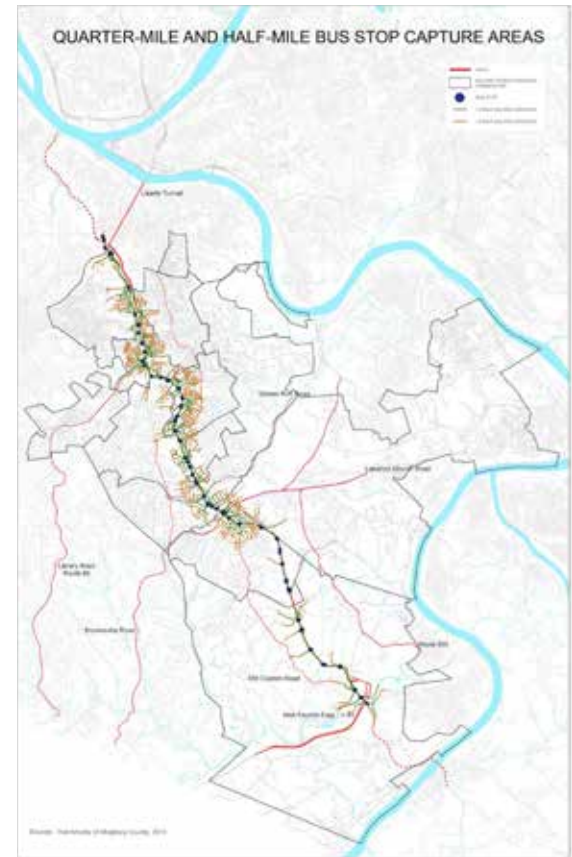
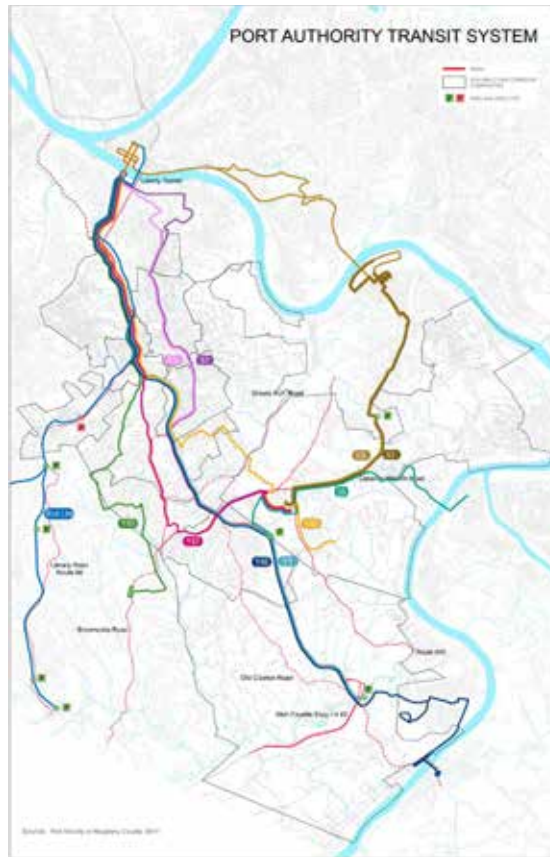
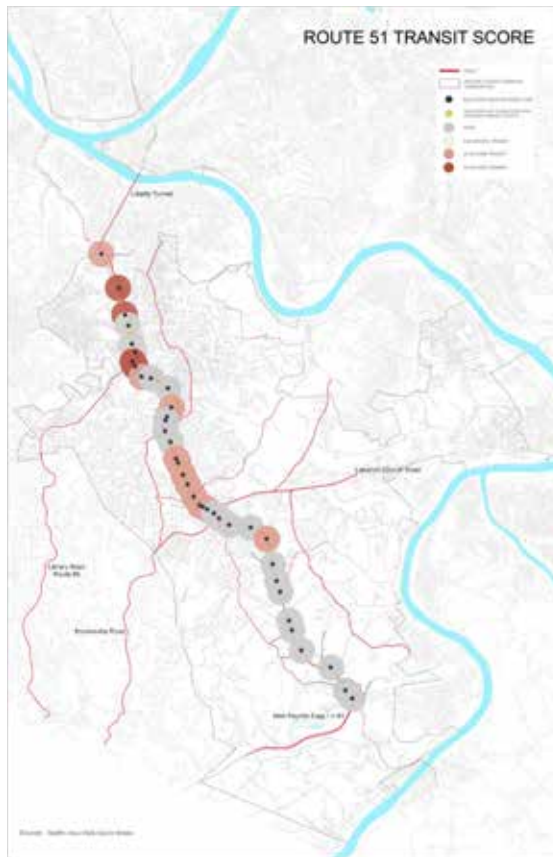


Figure 54 | Transportation Maps



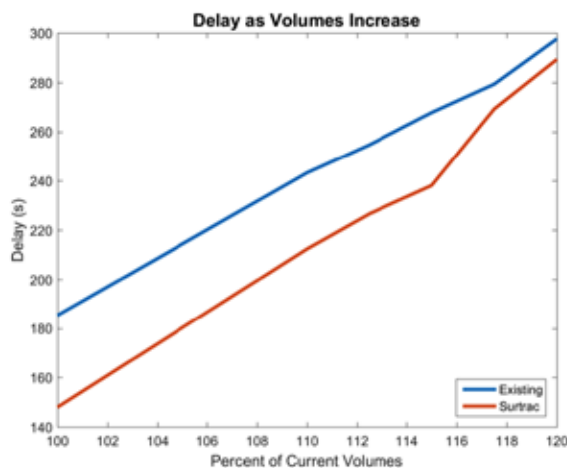


Figure 55 | Increase in average delay (in seconds) over different traffic growth assumptions.

TRANSPORTATION TECHNOLOGY

A microscopic simulation model allowed for a more substantive analyses of specific corridor design alternatives. A VISSIM microscopic traffic simulation model of the Route 51 corridor was constructed to explore two basic traffic signal control alternatives:

- + Bus Prioritization: As a first step, the Southwestern Pennsylvania Commission (SPC) commissioned an analysis that investigated the potential traffic flow efficiency benefit of a commercial bus prioritization scheme, operating under the assumption that buses are strictly more important than other traffic modes (e.g., passenger vehicles, bicyclists, pedestrians), paired with a Synchro-based re-timing of intersection signal timing plans along Route 51. A VISSIM simulation model was constructed to study these two traffic control alternatives. The result indicated a 5-10% improvement in average travel times over current signal timing plan assumptions.
- + Adaptive Traffic Signal Control: Secondly, a VISSIM model using the results of a Synchro-based re-timing of intersections along Route 51 was compared to a variant that utilized Surtrac real-time adaptive control. The results obtained in this study were also compelling:

overall vehicle delay (the difference between free-flow non-stop movement through the network and actual vehicle transit time) was reduced by 26% (and by 35% if attention is restricted to rush hour time periods).

(After the original Route 51 VISSIM modeling and prior to the case study, PennDOT continued work on the roadway and signaling per their project schedule, which has modified the results of the original VISSIM model and the following alternative studies.)

Once a microscopic traffic simulation model was constructed, various model parameters were adjusted to analyze a range of potential corridor design alternatives and operational circumstances. These possibilities included:

- + Corridor Traffic Under Different Population Growth Assumptions: By varying traffic volumes and origin-destination pairs at different locations along the corridor, it is possible to estimate the effect of various levels of growth in traffic along the corridors. For the Route 51 case study, the study team examined the implications of overall growth of traffic volumes along the corridor, both with existing timing plans and with the use of Surtrac traffic signal control. The results are depicted in

Figure 55 with the baseline assumption that growth is uniform throughout the corridor. The results show the benefit of adaptive signal control in (1) delaying the capacity saturation point under increasing volumes, and (2) indicating overall capacity of the network.

As Figure 56 illustrates, adaptive signal control provides significant performance improvement over existing signal timing plans through 115% traffic volumes. Roadway saturation appears to occur at around 120% of current volumes.

+ Corridor Design Speed: Although the simulation model cannot incorporate perceptual aspects of travel safety and speed (e.g., narrow lanes, tight or open building frontage), it is straightforward to examine the delay/travel time tradeoff given vehicle volumes along the corridor. To illustrate, Figure 57 shows this tradeoff for the Route 51 corridor, considering both faster and slower design speed alternatives. As shown elsewhere in the report, the current speed limit varies at different segments along the corridor from 35-40 MPH. This existing state is contrasted with scenarios where (1) the speed limit along 40 MPH segments is reduced to 35 MPH, (2)

the speed limit along 35 MPH segments is reduced to 30 MPH, and (3) the speed limit at 35 MPH segments is increased to 40 MPH. Generally, average delay is reduced at lower speeds at the expense of longer vehicle travel times (since vehicles are moving slower). In this case, the reduction in delay is rather small.

+ Shifts in Transit Ridership: A third type of analysis that could be performed with a bit more effort would be to consider the impact on traffic flow efficiency of changes to transit patterns. One specific scenario of interest with the Route 51 model is one that assumes a transit (transfer) station in the vicinity of the Route 51 and Route 88 intersection. In this case, a model variant would be created where vehicle volumes are adjusted from the nominal model based on estimations of increased transit ridership and reductions in vehicle traffic. Specific changes to the bus schedules currently encoded in the model could be integrated and evaluated.

Traffic Volumes (% of current)	Improvement in Delay with Surtrac over existing timing plans (%)	Absolute improvement in Delay with Surtrac over existing plans (seconds)
100%	20.2%	37.4
110%	12.7%	30.9
112.5%	11.0%	28.1
115%	11.1%	29.7
117.5%	3.6%	10
120%	2.8%	8.3

Figure 56 | Delay versus travel time tradeoff along Route 51 at different design speeds. (*As the posted speed limits are mandated by the Commonwealth, reducing the speed to 30 mph is not an option unless an engineering and traffic study showed that the speed limit could be reduced).

Traffic Volumes (% of current)	Improvement in Delay with Surtrac over existing timing plans (%)	Absolute improvement in Delay with Surtrac over existing plans (seconds)
100%	20.2%	37.4
110%	12.7%	30.9
112.5%	11.0%	28.1
115%	11.1%	29.7
117.5%	3.6%	10
120%	2.8%	8.3

Figure 57 | Performance Advantage of adaptive signal control over different traffic growth assumptions.

CIVIC ENGAGEMENT

Seeking a more productive civic engagement process, the Remaking Cities Institute sought an alternative approach that is more appropriate for holistic corridor planning and one that results in a citizen experience that is satisfying and productive. RCI collaborated with three academic research programs who have developed a more effective issue-based model: the Program for Deliberative Democracy, a program of the Philosophy Department at Carnegie Mellon University; the Art of Democracy, a consultancy whose practice draws on the research of the Program for Deliberative Democracy; and the Congress of Neighboring Communities (CONNECT), located at the University of Pittsburgh in the Graduate School of Public and International Affairs. Deliberative Democracy and the Art of Democracy focus on citizen engagement while CONNECT focuses on the engagement of municipal officials across municipal boundaries. Because there are several terms for a deliberative engagement process used among the three programs, “deliberative discourse” will be used as the generic term to describe this civic engagement model.

Research for this study utilized the deliberative discourse process for all civic engagements, including three forum sessions with citizens from

the Route 51 case study’s locale and the fourth with local municipal officials in the corridor. The process also included: three working sessions with the three programs and the study team; individual interviews; and attending deliberative forums on other subjects. These were conducted during Phase 1 of the Route 51 case study. The last of the citizen forums focused on the participants: what would engage their interest and sustain their involvement over the course of a corridor project planning process and what would sustain their interest should the project location involve several municipalities with different needs? The results from this research were positive. The participants appreciated the opportunity to engage in substantive dialogue while educating themselves on project issues facing them individually, their community, and neighboring communities. These findings are of particular importance since most planning projects contractually require citizen participation, yet many citizens have begun to disengage from public participation because of “engagement fatigue” and/or lack of significant results.

These were the results from the fourth forum as documented by the Program for Deliberative Democracy:

Participants and Why They Attend Public Meetings

Participants included long-term residents of the corridor community of Brentwood (50+ years), a nonresident business owner, and a nonresident who has shopped along the corridor for thirty years. Participants indicated significant civic engagement; they attended public meetings in their community of residence at least a dozen times a year and public meetings in communities adjacent to theirs at least once a year. All participants indicated that they attended public meetings for multiple reasons: to get information, to have their questions answered, to hear the views of other residents, and to share their views with decision makers, public officials and other residents. When asked why they might have chosen not to attend a public meeting in the past, participants indicate no one reason as being more significant than others; rather, individual participants identify different reasons, including the time and location of the meeting was inconvenient, making arrangements to attend the meeting would have been “too much of a hassle,” having a feeling that their voice would not be heard, or feeling that their input would have no impact on the decisions that would be made.

Who Should Send Invitations to Attend Public Meetings?

All participants indicate that they would be at least somewhat likely to respond to an invitation from a community development corporation or a community-based organization. Several participants indicate that they would respond to an invitation from researchers from a local university or professional consultants; although one participant indicated that he or she would be unlikely to respond to such an invitation. Several participants indicated that they would be at least somewhat likely to respond to an invitation from an elected official; although some indicated they are unsure whether they would.

How Participants Wish to be Notified of Public Meetings

Most participants indicate that they wish to be notified of public meetings through wish to be notified of public meetings through multiple channels, including flyers delivered to them personally via mail and email, social media (e.g., Facebook, Twitter), postings to community websites/message boards, and flyers posted in public buildings. In their comments during the Q & A with the resource panel, participants emphasized that meeting notices should use common language rather than the specialized language of academics,

planners, and policy makers. In addition, notices should make clear how the meetings will benefit residents and how results and information generated at the meeting will be incorporated into the planning process.

What Types of Meetings Are Participants Likely to Attend?

All participants strongly agreed that planners should use public meetings to inform residents and to solicit resident input in each phase of the planning process. All participants indicated that town hall Q&A, community conversations, or group working sessions are useful for all phases of a planning process and they would likely attend them. However, several also indicated that they are at least somewhat likely to attend an informational presentation in Phase 3 if there was more resident engagement in earlier phases.

How to Engage Residents of Multiple Municipalities in Large-Scale Corridor Planning Processes

Several participants indicate that planners should hold collaborative public meetings involving residents from every affected municipality in all phases of the planning process; however, some also indicated that planners should hold both

collaborative meetings and separate meetings in each municipality in each phase.

Considerations about Recruitment and Participation

Prior to convening a deliberative community forum for the second phase of this corridor planning study, organizers were counseled by local public officials and the director of a community development corporation that it would be difficult to recruit participants because residents along the Route 51 corridor were experiencing what they termed “engagement fatigue” as a result of multiple studies having been done along the corridor over the course of close to a decade.

Both a minimal turnout for the forum and the comments of those who did attend seem to confirm the concerns expressed to the organizers. Recruitment for the forum involved posting flyers in libraries and distributing invitations to over 400 individuals via email by public officials and the director of a community development corporation. In the event, the forum engaged six participants, five of which completed exit surveys. During the Q&A with the forum’s resource panel, participants indicated that they attended the forum in response to invitations they received via email. Participants also expressed their frustration with receiving

no information about the results of previous meetings and experiencing no action resulting from numerous studies.

The approach for the previous Phase 1 research involved identifying Route 51 corridor planning and improvement recommendations for use in formulating generalized corridor guidelines. The intention was to combine the findings with best practices research for the resultant guidelines contained in this report. Consequently, the public understood that specific design improvements were going to be developed for the case study area. The Phase 2 research reversed the approach process. The Route 51 findings, as a case study, were for purposes of evaluating the best practices research and to gain an understanding of how the process might be improved as a holistic endeavor. Specific design improvements for Route 51 were not in the scope nor desired. Unfortunately, the time lag between the Phase 1 and Phase 2 research was long enough that the local participant's expectations took precedence over any research intention. The lessons learned from this study included:

- + changing design or project direction mid-course is difficult for participants to understand and accept.
- + It is important to keep communications open and direct whenever there is a project delay or a change in project scope;
- + engagement fatigue is real and must be addressed by establishing a close working relationship between government, the community, and the planning team;
- + by developing a communication strategy; acknowledging that there are other engagements occurring simultaneously, in order to use citizen engagement time wisely.



RESOURCES

Endnotes

References

Photographs and Illustrations

ENDNOTES

1. Transportation Research Board, *Highway Capacity Manual*, 1985, referenced by the Local Government Commission in their *Livable Communities New Thinking for a New Transportation Age* fact sheet
2. Pennsylvania Department of Transportation, *Design Manual, Part 2 Highway Design*, (Publication 13M, DM-2: 2015).
3. Ibid
4. TransTech Management Inc., and Oldham Historic Properties, "Performance Measures for Context Sensitive Solutions - A Guidebook for State DOTs," *Transportation Research Board of the National Academies*, (2004).
5. Ibid
6. Chicago Department of Transportation, "Complete Streets Chicago Design Guidelines," (2012): 5.
7. McCann, Susan. "Complete Streets: Best Policy and Implementation Practices," *American Planning Association*, 57.
8. Pennsylvania Department of Transportation, *Pennsylvania's Traffic Calming Handbook*, (2012): 14.
9. Pennsylvania Transportation Advisory Committee, "Bicycle and Pedestrian Policy Study," (2016): 18-29.
10. Port Authority of Allegheny County, "TOD Guidelines", (2016), 4-5.
11. FHWA Regulations, 23 CFR 625, "Revisions of Thirteen Controlling Criteria for Design and Documentation of Design Exceptions," (May 5, 2016).
12. Davis, Steve. "Feds get out of the way of communities that want to design safer, more complete streets," *Transportation for America, Smart Growth America*, (May 12, 2016).
13. Bliss, Laura. "Now Seattle is moving to Lower Speed Limits," *CityLab*, (Sept. 2016).
14. Goodyear, Sarah. "The Swedish Approach to Road Safety: The Accident is not the Major Problem," *CityLab*, (Nov. 2014).
15. Peden, M., Scurfield, R. et al. eds. "World Report on Road Traffic Injury Prevention," *World Health Organization*, (2004): Chapter 1.
16. Johansson, Roger. "Vision Zero - Implementing a policy for traffic

17. safety," *Safety Science* 47, (2009): 826-831.
17. AASHTO, *A Policy on Geometric Design of Highways and Streets*, (2004), 17.
18. Pennsylvania Department of Transportation, *Design Manual, Part 2 Highway Design*, (Publication 13M, DM-2: 2015), 2-10 and 2-11.
19. Pennsylvania Department of Transportation, *Design Manual, Part 1 Transportation Program Development and Project Delivery Process* (Publication 10, DM-1: 2015).
20. Regenesi Group website, accessed at <http://regenesigroup.com>.
21. Argonne National Laboratory
22. Ibid
23. US Department of Transportation, Center for Climate Change and Environmental Forecasting, "Transportation and Climate Change Clearinghouse" webpage, accessed at <https://climate.dot.gov/about/transportations-role/overview.html>
24. Argonne National Laboratory
25. US Federal Interagency Climate Change Adaptation Task Force, "Climate Change Adaptation Guiding Principles" webpage, accessed at <https://www.fedcenter.gov/programs/climate/guidingprinciples/>
26. Olsen, J. Rolf, ed. "Adapting Infrastructure and Civil Engineering Practice to a Changing Climate," *American Society of Civil Engineers* (2015), 61-62.
27. Seskin, Kite, and Searfloss. "Evaluating Complete Streets Projects: A Guide for Practitioners," *Smart Growth America* (2015), 2-6.
28. Don Carter, Urban Design Associates
29. Leighninger, Matt. "Mapping Deliberative Civic Engagement," *Democracy in Motion*, (Nov. 2012).
30. The Program for Deliberative Democracy, Carnegie Mellon University.
31. Local Government Commission Center for Livable Communities, "New Thinking for a New Transportation Age" fact sheet, 5.
32. Transportation Research Board, *Highway Capacity Manual*, (1985).
33. United Nations Department of Economic and Social Affairs, "2015 Revision of World Population Prospects," (2015).
34. National League of Cities, "City of the Future, Technology, and Mobility," (2015), 4.
35. Pennsylvania Department of Transportation, *Community Impact Assessment Handbook*, Publication 217 (2005).
36. A current CMU research project is extending Surtrac to integrate bus prioritization into its core optimization model, using Designated Short Range Communication (DSRC) radio technology. It is expected that this approach will provide a more holistic approach to bus prioritization than standard Transit Signal Priority (TSP) systems, leading to better overall traffic flow more cost effectively than commercial TSP technology.
37. Hawks, A., "Traffic Control with Connected Vehicle Routes in Surtrac," (master's thesis, Carnegie Mellon University, May 2016)
38. New Jersey Department of Transportation and Pennsylvania Department of Transportation, *Smart Transportation Guidebook*, (2008), 44.
39. Ibid
40. Mayor's Office of Transportation and Utilities, *Philadelphia Complete Streets Design Handbook*, (2012).
41. Slaper, T. F. & Hall, T. J. "The Triple Bottom Line: What Is It and How Does It Work?," *Indiana Business Review* 86, no.1 (2011): 4.

REFERENCES

- American Association of Retired Persons and Smart Growth America, "Evaluating Complete Streets Projects: A guide for practitioners," 2015
- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highways and Streets, 2011 Edition and 2004 Edition
- American Institute of Architects, Center for Communities by Design, Allegheny County, PA SDAT The Route 51 Corridor: A Gateway to a Sustainable Future, October 2010
- Barter, Dr. Paul and Mulukutla, Pawan, Webinar: "Parking and Transit-Oriented Developments," Reinventing Parking, December 2014, <http://www.reinventingparking.org/>
- Boston Transportation Department, "Boston Complete Streets Design Guidelines," City of Boston, 2013
- Chicago Department of Transportation, "Complete Streets Chicago Design Guidelines," 2013 Edition
- Charlotte-Mecklenburg Planning Department, "Centers, Corridors and Wedges Growth Framework," 2010
- Citizens for Pennsylvania's Future (Penn Future), "The Citizen's Plan: An Alternative to the Pennsylvania Turnpike Commission's Plan to Complete the Mon-Fayette Toll Road," 2002
- City of Philadelphia, "Philadelphia Complete Streets Design Handbook," 2012
- City of Philadelphia, "City of Philadelphia Green Streets Design Manual," 2014
- Context Sensitive Solutions.org, "What is CSS," U.S. Department of Transportation, Federal Highway Administration, <http://contextsensitivesolutions.org/>
- Davis, Steve, "Feds get out of the way of communities that want to design safer, more complete streets," Transportation for America program of Smart Growth America, May 12, 2016

- Dunphy, Robert, Deborah Myerson, and Michael Pawlukiewicz, "Ten Principles for Successful Development around Transit," Urban Land Institute, 2003
- Federal Highway Administration, "Context Sensitive Solutions Primer," U.S. Department of Transportation, 2007
- Federal Highway Administration, "Factors Influencing Operating Speeds and Safety on Rural and Suburban Roads," Publication: FHWA-HRT-14-020, U.S. Department of Transportation, 2015
- Federal Highway Administration, "Flexibility in Highway Design," U.S. Department of Transportation, 2012
- Federal Highway Administration, "Integration of Context Sensitive Solutions in the Transportation Planning Process: Final Report," U.S. Department of Transportation, 2007
- Federal Highway Administration, "INVEST (Infrastructure Voluntary Evaluation Sustainability Tool) Version 1.2," U.S. Department of Transportation and CH2M Hill et al, September 2015, www.sustainablehighways.org
- Federal Highway Administration, "What is CSS," U.S. Department of Transportation, <http://contextsensitivesolutions.org/>
- Federal Transit Administration, Planning for Transit-Supportive Development: A Practitioner's Guide, June 2014
- Florida Department of Transportation District 5, "Multi-Modal Corridor Planning Guidebook," Version 1, August 2013
- Hawkes, A., "Traffic Control with Connected Vehicle Routes in Surtrac", MS Thesis, Robotics Institute, Carnegie Mellon University, May 2016
- Institute for Transportation & Development Policy, "TOD Standard v2.1," Despacio, March 2014
- Institute of Transportation Engineers and Congress for the New Urbanism, "Designing Walkable Urban Thoroughfares: A Context Sensitive Approach," 2010
- Kimley-Horn and Associates, Inc., "Designing Walkable Urban Thoroughfares: A Context Sensitive Approach," Institute of Transportation Engineers, Publication No. RP-036A, 2010
- Kulash, Walter, "Traditional Neighborhood Development: Will the Traffic Work," presentation at the 11th Annual Pedestrian Conference in Bellevue, WA, 1990
- Leighnenger, Matt, Mapping Deliberative Engagement, Democracy in Motion Local Government Commission, Center for Livable Communities, "New Thinking for a New Transportation Age," Fact Sheet
- Massachusetts Department of Transportation, "Transportation Impact Assessment (TIA) Guidelines," March 2014
- Massachusetts Highway Department, Project Development & Design Guide, Chapter 3 Basic Design Controls, 2006
- Mayor's Office of Transportation and Utilities, "Philadelphia Complete Streets Design Handbook," 2013
- Metropolitan Policy Program, "Population Growth in Metro America since 1980: Putting the Volatile 2000s in Perspective," Brookings, March 2012
- McCann, Barbara and Rynne, Suzanne, Editors, "Complete Streets: Best Policy and Implementation Practices," American Planning Association and the National Complete Streets Coalition, 2010
- New Jersey Department of Transportation and Pennsylvania Department of Transportation, "Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities," March 2008
- Olsen, J. Rolf, Editor, "Adapting Infrastructure and Civil Engineering Practice to a Changing Climate," Committee on Adaptation to a Changing Climate, American Society of Civil Engineers, 2015
- Pennsylvania Department of Transportation, "Community Impact Assessment Handbook," Publication 217 III-32, October 2005

Pennsylvania Department of Transportation, "Design Manual, Part 2 Highway Design," Publication 13M (DM-2), March 2015 Edition

Pennsylvania Department of Transportation, "Pennsylvania's Traffic Calming Handbook," Publication 383, 2012

Pennsylvania Transportation Advisory Committee, "Bicycle and Pedestrian Policy Study," 2016

Pittsburgh Community Reinvestment Group and Center for Transit-Oriented Development, "Transit-Oriented Development Typology Strategy for Allegheny County, 2013

Port Authority of Allegheny County, "Transit-Oriented Development Guidelines," 2016

PlaceMakers LLC, PlaceShakers and Newsmakers blog, "Walkable Streets: Considering common issues," blog, March 7, 2013, www.placemakers.com

Seskin, Stefanie et al, "Complete Streets Local Policy Workbook," Smart Growth America and National Complete Streets Coalition, Spring 2013

Slaper, Timothy and Hall, Tanya, "The Triple Bottom Line: What Is It and How Does It Work?" Indiana Business Review, Indiana University, Spring 2011

Smart Growth America, authors: Seskin, Stefanie, et al, "Complete Streets Local Policy Workbook," Smart Growth America and National Complete Streets Coalition, 2013

Smart Growth America, "(Re)Building Downtown: A Guidebook for Revitalization," 2015

Smith, S.F., G.J. Barlow, P. Shah, A. Hawkes and Z.B. Rubinstein, "Smart Signals along the Route 51 Corridor: Analysis of Potential Benefit" (integrated as a chapter in the Route 51 project Phase I report), 2015.

Southwestern Pennsylvania Commission, Mapping the Future: The Southwestern PA Plan, summary of The Regional Vision, Policies/Goals and Strategies

Texas Department of Transportation, "Landscape and Aesthetics Design Manual: Highway and Transportation Corridors," 2015

The Center for Transit-Oriented Development with the Pittsburgh Community Reinvestment Group, "Transit-Oriented Development Typology Strategy for Allegheny County," February 2013

The Federal Register, "Revision of Thirteen Controlling Criteria for Design and Documentation of Design Exceptions," FHWA regulations in 23 CFR 625, May 5, 2016

Transportation Research Board of the National Academies, "Multimodal Level of Service Analysis for Urban Streets," NCHRP Report 616, 2008

TransTech Management, Inc. and Oldham Historic Properties, Inc., "Performance Measures for Context Sensitive Solutions – A Guidebook for State DOT's," Transportation Research Board of the National Academies, October 2004

Tri-County Regional Planning Commission, Harrisburg Area Transportation Study, "Complete Streets Policy," 2014, <http://www.tcrpc-pa.org/Planning-Toolkit/Transportation/Pages/Complete-Streets-Policy.aspx>

U.S. Department of Transportation, Center for Climate Change and Environmental Forecasting, "Transportation and Climate Change Clearinghouse," <http://climate.dot.gov/about/index.html>

United Nations Environmental Programme, City-Level Decoupling: urban resource flows and the governance of infrastructure transitions, 2013

University of California Transportation Center: Macdonald, Elizabeth; Sanders, Rebeca; Anderson, Alia, "Performance Measures for Complete, Green Streets: A Proposal for Urban Arterials in California," 2009

Urban Design Associates, "City of Warren Michigan: Downtown Development Authority Primary Corridors Design Study," January 2002

Walker, Jarrett, "Human Transit," Island Press, 2012

Corridor Case Studies

Commercial Corridor, Philadelphia. A strategic investment framework for Philadelphia

Defining Broadway, Oakland, California. Planning to create an economic environment for this retail corridor and its nodes

Euclid Corridor Healthline Transportation Project, Cleveland. Transformation of a disinvested corridor into a BRT corridor that links the city's two largest commercial districts

Highway and Transportation Corridors from Landscape and Aesthetics Design Manual, Texas. Guidelines for designing corridors in rural and urban contexts with an emphasis on nature and physical design

I-95 Corridor Study, Hanover County and Town of Ashland. A planning-level study involving the collaboration of three municipalities to improve traffic safety and capacity

Life on State, Utah. Multi-jurisdictional collaboration vision project on revitalizing a former transportation, economic, and social center corridor, which serves as highway and traverses several cities

Reenergizing of Independence Boulevard, Charlotte. An urban-wide corridor planning study to reposition a limited access expressway that was a major arterial corridor. The planning seeks to provide appropriate land use and community economic development strategies

Penn Future, The Citizens' Plan: An Alternative to the Pennsylvania Turnpike Commission's Plan to Complete the Mon-Fayette Toll Road, 2002

Urban Design Associates for the Downtown Development Authority, Primary Corridors Design Study, City of Warren, Michigan, 2002

Transit-Oriented Development Reports, Case Studies, and Guidelines

Transit-Oriented Development Guidelines (Draft Version), Port Authority of Allegheny County, 2015

Transit-Oriented Development Typology Strategy for Allegheny County, Pittsburgh Community Reinvestment Group and The Center for Transit-Oriented Development, 2013

Pittsburgh Regional Transit-Oriented Development Strategic Plan + Typology: TOD Opportunities and Constraints, Pittsburgh Community Reinvestment Group and The Center for Transit-Oriented Development, 2012

TOD204: Planning for Transit-Oriented Development at the Regional Scale, The Center for Transit-Oriented Development, 2011

TOD203: Transit Corridors and Transit-Oriented Development, The Center for Transit-Oriented Development, 2010

TOD201: Mixed-Income Housing Near Transit, The Center for Transit-Oriented Development, 2009

TOD101: Why Transit-Oriented Development and Why Now?, Reconnecting America and the Center for Transit-Oriented Development

Principles and Practices of TOD, PowerPoint Presentation by Carlosfelipe Bogota of Infratrans Consultancy LAC S.A.S. for Despacio, 2013

TOD Score Calculator, Institute for Transportation & Development Policy, 2016
<http://www.itdp.org/tod-standard/>

TOD Standard v2.1, Institute for Transportation & Development Policy, 2016,
<http://www.itdp.org/tod-standard/>

Homewood Station Transit Oriented Development Study, Urban Redevelopment Authority of Pittsburgh and Pittsburgh City Planning, 2015, http://apps.pittsburghpa.gov/ura-files/HWTODStudy_Screen.pdf

East Liberty Station: Realizing the Potential, GSP Consulting and Others for Pittsburgh City Planning, 2011, <http://apps.pittsburghpa.gov/dcp/eLTRID.pdf>

Ten Principles for Successful Development Around Transit, Urban Land Institute, 2003

Route 51 Case Study Reports and Publications

The Route 51 Corridor: A Gateway to A Sustainable Future, SDAT, 2010.
Proposal for Route 51 as a sustainable corridor

Route 51 Corridors, CMU Master of Urban Design Studio, 2013.
Recommendations to increase transit ridership along the corridor

Rivers in Synergy, June 2009. A waterfront vision for the Pittsburgh Ohio basin

Saw Mill Run Flood Protection Project, US Army Corps of Engineers, January 1994. Feasibility study for the Saw Mill Run flood protection project

Request for Proposal for Integrated Watershed Planning in the Saw Mill Run Watershed, PWSA, November 2014

Saw Mill Run Review, Analysis, Assessment, Summary and Strategy Addressing Hydrologic Conditions and Associated Flooding, GAI Consultants, Inc., December 2005

Wet Weather Plan, ALCOSAN, January 2013

Commercial Development Revitalization Strategy, Urban Design Ventures, LLC, May 2008. A commercial development plan for the Boroughs of Brentwood, Baldwin, and Whitehall

Transit Service Guideline Draft, PAAC, May 2015

Pedestrian/Bicycle Connector Plan for the Boroughs of Brentwood, Baldwin, and Whitehall, Urban Design Ventures, LLC, May 2008

Articles and Presentations

Citisclope Global News, Why Helsinki's innovate on-demand bus service failed, Olli Sulopuisto, 2016

Frederick Law Olmstead, Notes on Parks and Recreation Facilities, Bridges and Tunnels of Allegheny County, Pennsylvania, report to The Pittsburgh Civic Commission, 1910 <http://pghbridges.com/article/olmstead/04parks/olm119.html>

Pittsburgh Post-Gazette, UPMC may be shopping for another site for South Hills hospital, February 27, 2016, <http://www.post-gazette.com/pittsburgharchives>

Reinventing Parking, Parking and Transit-Oriented Development, webinar PowerPoint presentation by Dr. Paul Barter and Mr. Pawan Mulukutla for The Hub of Embarq, India, www.reinventinaparking.org

Director Jesse K. Souki, Esq., Hot Topics Transit Oriented Development, PowerPoint presentation, State Hawaii Office of Planning, <http://planning.hawaii.gov>

Tribune Review Live (Home), Progress on Route 51 slow but seen, September 29, 2011, <http://triblive.com/home/>

Tribune Review Live (Home), Route 51 property owners ready to break with the past, March 6, 2008, <http://triblive.com/home/>

Tribune Review Live (Home), Route 51 streetscape district for Brentwood, Whitehall nears completion, February 11, 2016, <http://triblive.com/news/neighborhoods/southhills/9879735-74/development-whitehall-brentwood>

PHOTOGRAPHS AND ILLUSTRATIONS

Figure 1: Accessed at www.flickr.com

Figure 2: Accessed at www.flickr.com

Figure 3: Excerpted from PennDOT's Design Manual (2015)

Figure 4: Excerpted from PennDOT's Design Manual (2015)

Figure 5: Excerpted from PennDOT's Design Manual (2015)

Figure 6: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 7: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 8: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 9: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 10: Image by the Thinking Beyond the Pavement Workshop

Figure 11: Accessed at www.flickr.com

Figure 12: Image by the New Jersey and Pennsylvania Departments of
Transportation

Figure 13: Accessed at www.flickr.com

Figure 14: Accessed at www.flickr.com

Figure 15: Image by the Pennsylvania Department of Transportation

Figure 16: Accessed at www.flickr.com

Figure 17: Accessed at www.flickr.com

Figure 18: Courtesy of the Studio for Spatial Practice

Figure 19: Accessed at www.flickr.com

Figure 20: Adapted by the Remaking Cities Institute at Carnegie Mellon
University

Figure 21: Excerpted from PennDOT's Design Manual (2015)

Figure 22: Accessed at www.flickr.com

Figure 23: Images excerpted from the PennDOT Traffic Calming report and
www.flickr.com

Figure 24: Excerpted from PennDOT's Design Manual (2015)

Figure 25: Adapted from the Florida Department of Transportation's Multi-Modal Corridor Planning Guidebook (2013)

Figure 26: Accessed at www.flickr.com

Figure 27: Image by the Regenesi Group

Figure 28: Courtesy of the Argonne National Laboratory

Figure 29: Courtesy of the Argonne National Laboratory

Figure 30: Courtesy of US Department of Transportation, Transportation and Climate Change Clearinghouse

Figure 31: Accessed at <https://en.wikipedia.org/wiki/System>

Figure 32: Courtesy of the Sandia National Laboratories

Figure 33: Adapted by the Remaking Cities Institute at Carnegie Mellon University, from Transtech

Figure 34: Courtesy of the Federal Highway Administration

Figure 35: Accessed at www.flickr.com

Figure 36: Courtesy of EvolvEA

Figure 37: Accessed at www.flickr.com

Figure 38: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 39: Image by the Program for Deliberative Democracy at Carnegie Mellon University

Figure 40: Accessed at www.flickr.com

Figure 41: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 42: Image by the Local Government Commission

Figure 43: Image by AARP, Inc.

Figure 44: Courtesy of <http://www.thesourcemagazine.org/>

Figure 45: Accessed at www.flickr.com

Figure 46: Image by the Robotics Institute at Carnegie Mellon University

Figure 47: Accessed at www.flickr.com

Figure 48: Accessed at www.flickr.com

Figure 49: Accessed at www.flickr.com

Figure 50: Excerpted from the Philadelphia Complete Streets Handbook

Figure 51: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 52: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 53: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 54: Image by the Remaking Cities Institute at Carnegie Mellon University

Figure 55: Image by the Robotics Institute at Carnegie Mellon University

Figure 56: Image by the Robotics Institute at Carnegie Mellon University

Figure 57: Image by the Robotics Institute at Carnegie Mellon University

Corridor Guidelines and Appendix Case Studies figures created by the Remaking Cities Institute at Carnegie Mellon University, with source materials from Google.

Cover and Section images by Bennett Midland

Blank Page