ActiveTrans Priority Tool Phase I: Scoping

The goals of Phase I are to define the purpose of the prioritization effort, determine how community/agency values should be expressed through factor selection and weighting, and select variables to represent the chosen factors, while taking into account data availability and technical resources.

Step 1: Define Purpose

At the outset of a prioritization exercise, it is important to identify a clear purpose. Key questions include:

- **Mode.** Will the prioritization exercise address pedestrian improvements, bicycle improvements, or both?
- **Improvement Specific or Not Improvement Specific.** Does the agency have a specific type of improvement in mind, such as sidewalk retrofits or bicycle lanes, or is the aim to identify locations where improvements are needed but to determine the type of improvements later (e.g., roadway segments to receive ADA improvements)?
- **Goals.** What are the improvements intended to accomplish? Is the aim to increase the number of walking and biking trips, improve safety, or advance economic development? Is there a combination of goals defined in a master plan document?
- **Number of Improvement Locations.** In general, how many improvement locations will be prioritized? (Note that the precise number of improvement locations may not be known during this initial step.)
- **Improvement Location Type/Extent.** What type or extent of improvement locations will be prioritized? Are the locations confined to one spot or area (e.g., intersection improvements), roadway segments or corridors, or entire neighborhoods?

In some cases, an agency may approach the prioritization exercise with a good sense of the answers to these questions and will be able to move through Step 1 relatively quickly. In other cases, the agency may have to go through a process of deliberation or stakeholder engagement to arrive at the answers. The key outcome of Step 1 is that the purpose of the exercise is as clearly defined as possible before moving on to Step 2.

Step 2: Select Factors

Two key reasons for conducting a prioritization process is to make the most out of limited resources and to spend public funds in a transparent way that reflects community/agency values and priorities. These values and priorities will differ from community to community.

For example, one community/agency might choose to emphasize safety while another might prioritize demand over all other factors. Others may choose to incorporate multiple values in their prioritization process and weight factors in terms of their importance (see Step 3).

This APT methodology identifies nine factors that are commonly considered in prioritization processes and can be used to reflect a range of community/agency values. The factors include:

- Stakeholder Input.
- Constraints.
- Opportunities.
- Safety.
- Existing Conditions.
- Demand.
- Connectivity.
- Equity.
- Compliance.

These nine factors are included in the programmed spreadsheet that accompanies the APT.

The goal of Step 2 is to select which factors among those presented here, as well as others identified locally, are relevant given the established prioritization purpose. This section includes definitions for each factor along with general guidance regarding the factor's relevance for different prioritization purposes. The order in which factors are presented does not reflect their relative importance.

Agencies may choose to include other factors that more directly relate to a specific policy objective (e.g., public health, greenhouse gas reduction), funding source, or other community priority identified through a stakeholder process. Whatever factors are ultimately chosen, the process and rationale for selecting them should be documented so that they can be explained to stakeholders.

Table 1 shows how each of the nine factors described below may apply to some common pedestrian or bicycle prioritization purposes. The example prioritization purposes shown in Table 1 are not intended to be comprehensive, but are provided as illustrative examples.

Tip: Public Involvement

The Stakeholder Input factor is the place to quantify public input on each of the improvement locations. However, community members can also help shape the prioritization *process.* For example, the public can help to identify which factors are most relevant given the project purpose and community values (Step 2). They can also help to establish weights (Step 3). For example, as part of a public workshop, participants could recommend factors that should be used in the prioritization process and then participate in a weighting exercise. In the exercise, each participant could be given a set number of points that they would have to distribute among the factors, to indicate which are more important and should therefore be more heavily weighted.

Stakeholder Input

The Stakeholder Input factor considers the amount of public feedback in support of (or against) a pedestrian or bicycle improvement at a particular location. Stakeholder input is important to consider because most agencies serve in the public interest. When and how often an agency decides to incorporate stakeholder input into the prioritization process will depend on existing processes and protocols, as well as the nature of the projects being prioritized. The Stakeholder Input factor can be represented by a recommendation in an adopted local plan or by a citizen advisory committee, or via quantitative documentation of requests/comments from the public.

Constraints

This factor addresses the relative level of difficulty in implementing a pedestrian or bicycle project. Constraints are important to consider because they can

Table 1. Example prioritization purposes and relevant factors.

Common Prioritization Purpose Examples	Stakeholder Input	Constraints	Opportunities	Safety	Existing Conditions	Demand	Connectivity	Equity	Compliance
Corridor									
Given 20 high pedestrian-crash corridors in a region, identify four to receive grant funding for safety enhancements.	◐	◐	◐	●	●	●	○	●	◐
Given 10 candidate corridors for sidepath construction, identify the top three for implementation.	●	◐	●	●	●	●	●	◐	○
Segment									
Given a planned bicycle network consisting of approximately 500 miles of recommended facilities (bike lanes, cycle tracks, shared lane markings, etc.), select 50 miles for implementation in the next five years.	●	●	●	◐	●	●	●	●	○
Given a neighborhood where sidewalks are absent, select 30 segments to construct new sidewalks over the next three years.	●	◐	◐	●	●	●	◐	●	○
Intersection/Crossing									
Given a regional trail with 50 unsignalized roadway crossings, identify 12 to implement safety enhancements.	●	○	◐	●	●	◐	○	◐	●
Given 500 locations where curb ramps are missing in a municipality, identify an initial 50 locations for ramp installation using available grant funding.	●	◐	◐	◐	○	●	◐	●	○
Given a city with more than 500 signalized intersections, identify the 30 priority traffic signals to be converted to accessible pedestrian signals when they are upgraded or replaced.	●	○	◐	●	●	●	◐	●	●
Area									
Given a county with 30 elementary schools, rank the designated schools zones to determine which ones should be further evaluated for future pedestrian improvements.	●	○	◐	●	●	◐	○	●	●
Given a city that consists of 15 defined neighborhoods, prioritize two for the initial focus of a complete streets evaluation.	◐	○	○	●	●	●	●	●	●
Given a city with 20 neighborhood commercial centers, rank all 20 centers in terms of their need for additional bicycle parking.	●	○	◐	○	●	●	○	◐	○

● = Very relevant ◐ = Less relevant ○= Not likely relevant

drain agency resources when implementing pedestrian or bicycle projects. Many constraints are framed in terms of cost, and may include right-of-way acquisition, facility design, mitigation and construction, available funding (internal and external), environmental impacts, existing regulations and standards, tradeoffs among modes, and staff resources. The Constraints factor may be less quantifiable when improvements are unspecified or when the prioritization exercise applies to a relatively large geographic area, such as a neighborhood, school district, city or region. In these cases costs may be difficult or impossible to estimate. The Constraints factor may also be less relevant when prioritizing a list of improvements of similar cost. For example, cost may not be a highly relevant factor for marking crosswalks, because crosswalk projects are relatively inexpensive and can be implemented within the existing roadway right-of-way.

Opportunities

The Opportunities factor quantifies the ability of an agency to take advantage of resources that can support project implementation. These resources may be financial or political. They are important to consider because they save time and money when implementing pedestrian or bicycle projects. For example, financial opportunities include whether or not a proposed improvement is eligible for grant funding, can draw from a dedicated funding source, can be incorporated into a scheduled roadway reconstruction or resurfacing project, or can be provided by private developers through development requirements/agreements. Political opportunities could include support for pedestrian or bicycle improvements from elected representatives in different parts of the community or leaders of different local agencies.

Safety

The Safety factor accounts for the risk of a pedestrian or bicyclist being involved in a traffic collision (or crash). Safety is important because pedestrians and bicyclists are particularly vulnerable to being injured or killed when struck by a motor vehicle. In addition, concerns about safety can be a significant barrier to people choosing to walk and bicycle. In the APT methodology, the Safety factor is evaluated primarily in terms of reported pedestrian and bicycle crashes and crash rates. Pedestrian and bicycle crash types and location patterns are different and should be evaluated separately. Roadway characteristics play a significant role in determining where pedestrian and bicyclist crashes occur in a community. Therefore, as agencies consider priorities for pedestrian and bicycle improvements at different locations, it is important to assess pedestrian and bicycle crash risk.

Existing Conditions

The Existing Conditions factor includes physical conditions that have an impact on pedestrian or bicycle safety, comfort, or demand, such as whether or not a sidewalk exists, the number of travel lanes, or the presence of a buffer. The Existing Conditions factor also includes travel behaviors that influence conditions for walking and bicycling, such as motor vehicle volumes and speeds. Consequently, the Existing Conditions factor is likely to be highly relevant for the majority of prioritization purposes, especially those who emphasize Safety and Demand.

Demand

The Demand factor represents existing or potential pedestrian and bicycle activity levels. Demand is a key factor to consider if an agency's aim is to add new pedestrian or bicycle facilities where they will be most used. Likewise, if the aim of the prioritization process is to identify improvements that will have the greatest impact on reducing crash rates or pedestrian exposure, then the number of pedestrians who might benefit from each safety improvement is relevant.

Existing pedestrian and bicycle demand can be measured by counting the number of people on foot and bike at a given time and location. Potential or latent pedestrian and bicycle demand can be measured by considering the proximity of pedestrian or bicycle improvement locations to bicycle and pedestrian attractors or generators, such as schools, universities, parks, transit facilities, and mixed-use and high-density land uses.

An increasing body of evidence supports the concept of latent demand. For example, the Non-Motorized Transportation Pilot Program (FHWA) demonstrated that walking and bicycling investments often led to an increase in the total number and rate of people walking and bicycling in the community. Consequently, analyzing latent demand enables communities to focus resources and investments on areas with the greatest potential for multimodal trips, even if current levels of walking and bicycling trips are low.

Connectivity

The Connectivity factor accounts for the degree to which a project allows pedestrians or bicyclists to travel comfortably and continuously throughout their community. Connectivity is a relevant factor when prioritizing new pedestrian and bicycle facilities on existing roadways, such as new sidewalks and bicycle lanes, particularly when the new facility fills a gap between existing facilities. According to the literature review and agency survey conducted as part of the study that informed this guidebook (See the NCHRP Project 07-17 Final Report for details), connectivity tends to be more commonly considered by agencies for bicycle improvements along roadways than pedestrian improvements. The Connectivity factor may be less important when prioritizing improvements to existing pedestrian and bicycle facilities, which are likely to already be part of an existing pedestrian and bicycle network.

Equity

The Equity factor represents the degree to which opportunities for safe and convenient pedestrian and bicycle travel are distributed evenly to all groups within a community. Taking equity into account can help agencies ensure that pedestrian and bicycle improvements serve the needs of all transportation system users. The Equity factor includes socioeconomic characteristics such as age, income, automobile ownership, race/ethnicity, and health or disability status. For example, good pedestrian and bicycle facilities may be especially important in neighborhoods where driving is less common due to low levels of car ownership.

Compliance

The Compliance factor captures whether or not existing infrastructure is compliant with current pedestrian and bicycle standards and guidelines. This is sometimes an important factor for agencies because they may face a liability risk if their facilities do not meet existing local, state, or national codes or standards. For example, a key variable under the Compliance factor for pedestrian improvements is whether an existing facility is compliant with Public Right-of-Way Accessibility Guidelines (PROWAG). This could include non-compliant curb ramps or sidewalk locations where a utility pole blocks the pedestrian travelway. This factor could also encompass existing bicycle facilities that are not compliant with the latest national or state guidelines or standards (e.g., an existing bike lane that is only three feet wide). This factor overlaps with the Existing Conditions factor, but it is considered separately because Compliance is often a specific focus of prioritization efforts.

Step 3: Establish Factor Weights

The purpose of Step 3 is to assign weights to each of the factors selected in Step 2.

Weights are numbers used to indicate the relative importance of different factors based on community values and the prioritization purpose. For example, if a community decides that the Safety factor is more important than the Constraints factor, it would give the Safety factor a higher weight number. When the prioritization process is implemented in Phase II, the unweighted factor score will be multiplied by the weight number to determine the weighted factor score. Factors with higher weights receive higher weighted factor scores. The programmed spreadsheet that accompanies the APT allows users to establish factor weights and then automatically applies these weights to prioritization scores.

Before establishing weights, it may be helpful to consider the total number of relevant factors and the relative impact each factor will have if the factors are weighted equally. Figure 2 shows the relative importance of each factor when different numbers of factors are selected.

The next step is to decide whether some factors are more important given community values and the prioritization purpose, and to adjust the factor weights accordingly. There are many reasons to weight factors differently and there is no single “right” way to weight any particular

Tip: Weighting

The process of establishing weights leads agencies to think about which factors are really necessary for implementing the prioritization analysis. If a factor selected in Step 2 is given a particularly low weight relative to other factors in Step 3, that factor will have a correspondingly low impact on the final prioritization score. Agencies should ask if it's worth including such a low-weight factor in the final prioritization. If the answer is "yes," agencies should consider how many variables they select within the low-weight factor and the amount of effort they put into measuring those variables, since the relative impact of each variable may be very low.

Some agencies may wish to apply weights at the **variable level** rather than the factor level (note: variables are discussed in Step 4). Doing so may have advantages and disadvantages. Advantages include the ability to have an added level of refinement within a factor category. For example, the Demand factor may include multiple variables, including proximity to schools, proximity to transit, and employment density. If it is determined that proximity to schools is the most important of these variables, then it may make sense to weight the school variable more heavily than the other component variables of Demand. The disadvantage of weighting at the variable level is an added level of computational complexity, which may require additional staff resources and may be more difficult to explain to the public. The complexity of the calculations increases even more when weighting is done at both the factor level and the variable level. Therefore, it is generally recommended that agencies choose between assigning weights at the factor or variable levels rather than trying to apply weights at both levels. Whatever weighting scheme an agency ultimately decides to pursue, it is important to carefully document how the weights were applied, so anyone reviewing the process can understand how the weights influence the final outcome.

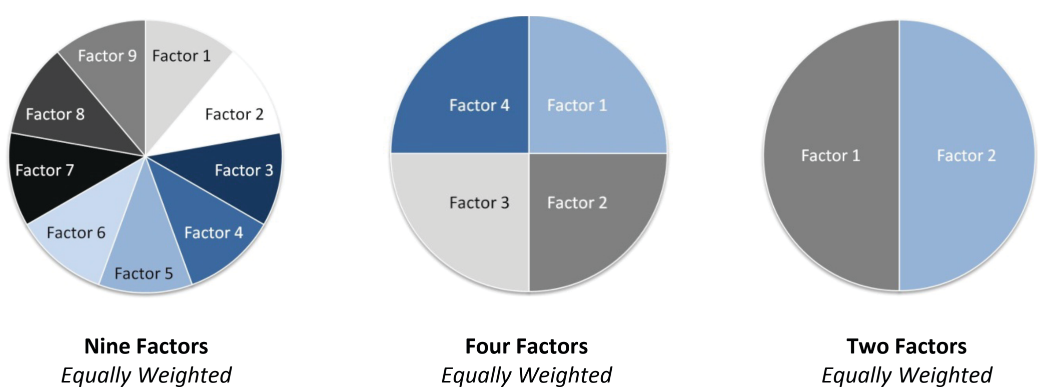


Figure 2. Relative impact of factors if factors weighted equally.

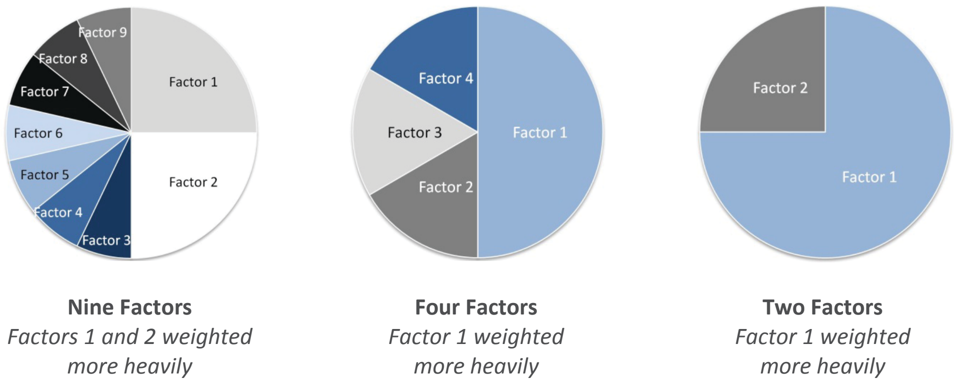


Figure 3. Relative impact of factors if factors weighted differently.

set of factors. That being said, the process should be transparent. Existing research and public input should be incorporated into weighting decisions where possible and applicable. Existing plans and policies can also provide a strong and defensible rationale for weighting decisions. Finally, the rationale should be carefully documented, so it can be explained to stakeholders. Figure 3 shows how applying different factor weights can impact the relative importance of the factor when different numbers of factors are selected.

Step 4: Select Variables

Variables are characteristics of roadways, intersections, neighborhood areas, and other features that can be measured. Variables are the core components of the prioritization process. Each prioritization factor is represented by a set of related variables. The selection of specific variables for each factor is informed by the prioritization purpose (Step 1), data needs and availability (Step 5), and an assessment of technical resources (Step 6). The example variables listed in each of the tables in this section are based on:

- The project literature review and agency survey (See the NCHRP Project 07-17 Final Report).
- Other best practice guidance from organizations such as NCHRP, Federal Highway Administration (FHWA), Association of American State Highway and Transportation Officials (AASHTO), National Association of City Transportation Officials (NACTO), and Institute of Transportation Engineers (ITE).
- The professional experience of the research team.

Practitioners who apply the prioritization method can choose to add other variables to suit their local needs.

Stakeholder Input

Stakeholder Input is often qualitative, involving informal discussions among elected officials, stakeholder groups, individual citizens, and agency staff. To ensure an objective, transparent prioritization process, stakeholder input should be well documented. Some input such as public comments or requests may be documented and quantified over an indefinite period of time (e.g., a telephone hotline) or as part of a targeted planning process (e.g., through surveys or public meetings).

With the advent of online tools such as electronic surveys, interactive mapping, and social media, agencies have the ability to inexpensively receive public input that can help identify where there are safety issues, demand for infrastructure, needed connections, etc. However, in

Tip: Variables

In addition to the guidance on variables provided below, there are general rules of thumb for selecting which variables to include under a given factor:

- Only include variables for which there are values for all improvement locations. In other words, it is not advisable to use the variable if you only have data for a portion of the locations. The value can be zero.
- Avoid variables that do not differ meaningfully across the range of improvement locations. In the absence of meaningful variation, the data cannot help distinguish between these locations.
- Avoid using too many variables. More variables do not necessarily create a better prioritization process. The more variables within a given factor category, the more time consuming the process and the less significance each individual variable will have. However, it is possible to weight individual variables to give certain variables more importance than others. (See *Tip: Weighting* in Step 3.)

NOTE: The programmed spreadsheet developed to accompany the APT allows practitioners to choose from among a list of the most relevant variables for each factor category based on the prioritization purpose and data availability.

many communities, the deployment of such tools should be supplemented by other outreach methods such as meetings, tabling, etc. that target populations that may not be reached using technological tools.

Stakeholder input may come in the form of complaints or comments about particular deficiencies such as missing sidewalks or through suggestions for facility improvements in specific locations (e.g., add a pedestrian crossing signal, stripe a bicycle lane). Some public suggestions for improvements may not be ideal for a specific location and may not meet specific engineering guidelines or safety standards. However, these suggestions may indicate an underlying issue that should be explored.

Data that is more qualitative in nature, such as the priorities of elected officials or recommendations of staff familiar with local constraints and opportunities, is also valuable when prioritizing projects. How this type of information is used depends on the size of the community and the decision-making power of elected leaders and agency staff. Where the community is in terms of implementation also matters; for instance, communities with less prior history implementing bicycle and pedestrian improvements may have more "low-hanging fruit" projects—those that can easily be identified with qualitative input from elected officials or staff. In other communities, the most straightforward projects may have already been implemented and an emphasis on quantitative methods may be more appropriate.

Table 2 shows example Stakeholder Input variables and their application.

Constraints

Constraints variables (Table 3) are limitations an agency may encounter when planning/designing pedestrian or bicycle improvements. Constraints variables are more nuanced than other categories of variables and often require case-by-case knowledge and evaluation. Constraints can often be expressed in terms of units of time, cost of construction, land acquisition, etc.

Table 2. Stakeholder Input variables.

Example Variables	Relevance*		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be, considering their purpose.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Number of public comments about specific issue received by phone or online from citizens	●	●	S, Cr, Co, A
Identification/inclusion of a particular improvement location in adopted plans	●	●	S, Cr, Co, A
Number of comments received at public meetings or through a public survey during a master planning process	●	●	S, Cr, Co, A
Supported by advisory committee or decision-making body	●	●	S, Cr, Co, A

Opportunities

Opportunity variables (Table 4) are attributes of projects that increase their potential to be implemented. While opportunities and constraints are both aspects of project feasibility, accounting for each separately allows agencies to assign different weight to Constraints and Opportunity variables depending on the prioritization purpose.

Cost/Benefit Considerations

Constraints and Opportunities are sometimes studied separately from the prioritization process through a cost/benefit analysis, which is more often done on a small number of priority projects rather than a longer list. Tools for evaluating the costs and benefits of individual projects require detailed data. Examples of these tools include:

- *NCHRP Report 552* (Krizek et al. 2006) provides guidelines to evaluate bicycle facilities based on their construction and maintenance costs and their environmental, economic, public health, and other benefits due to increased bicycle mode share. These guidelines have been

Table 3. Constraints variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Project implementation cost (including design, engineering, and construction costs, which depend on right-of-way availability, utility relocation, and topography)	●	●	S, Cr, Co
Presence of environmental or historic features that may create significant barriers to construction	◐	◐	S, Co, A
Staffing (time needed to plan and implement projects)	●	●	S, Cr, Co, A
Multi-jurisdictional coordination	●	●	S, Cr, Co
Life-cycle costs	◐	●	S, Cr, Co

Table 4. Opportunities variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Projects that are candidates for a specific funding source (e.g., grant, targeted improvement fund)	●	●	S, Cr, Co, A
Projects that could be implemented through future land development or roadway construction	●	●	S, Cr, Co
Planned roadway improvements that may accommodate pedestrian or bicycle facilities (e.g., repaving or reconstruction projects)	●	●	S, Cr, Co

operationalized as *Costs-Demand-Benefits Analysis Tool* available from the Pedestrian and Bicycle Information Center.

- The *New Zealand Transport Agency Economic Evaluation Manual* (2010) is one of the most advanced multimodal cost/benefit approaches available. However, it requires a thorough evaluation of each project, including (among other things) an analysis of the change in travel time for pedestrians and bicyclists, the predicted change in pedestrian and bicycle crashes and injury severity levels (from crash prediction models), and the change in noise levels experienced by pedestrians.

Macro-scale cost/benefit evaluations have been used to assess the impacts of pedestrian or bicycle infrastructure investments in a particular community over multiple years (Barnes 2004, Lawrie et al. 2006, Bicycle Federation of Wisconsin 2006, East Florida Regional Planning Council 2011, Gotschi 2011) and to estimate the impacts of different levels of national pedestrian and bicycle investment (Gotschi and Mills 2008). The World Health Organization, Regional Office for Europe (2011) has also developed a tool to evaluate the health impacts of pedestrian and bicycle investments at the community level. However, macro-scale cost/benefit approaches typically do not apply to the type of prioritization described in this report.

Safety

Safety variables (Table 5) can be evaluated using pedestrian or bicycle crash data. Most reported pedestrian crashes are collisions between motor vehicles and pedestrians, and most reported bicycle crashes are collisions between motor vehicles and bicyclists. However, some crashes involve collisions between pedestrians and bicyclists or are single-person incidents. These crashes are often underreported.

Pedestrian or bicycle crashes may be clustered in certain "hot spots," which may include specific intersections or roadway corridors. These "hot spots" may indicate the need for roadway design improvements. For example, there is a well-studied correlation between pedestrian crashes and roadway variables such as traffic volume, vehicle speed, and number of vehicle lanes (Zegeer et al. 2005). This relationship is discussed further in the Existing Conditions section.

It is also important to recognize that pedestrian and bicycle crashes tend to occur in locations with higher pedestrian and bicycle volumes. The risk of a pedestrian or bicycle crash occurring may actually be lower in some locations with many crashes than in other locations with few crashes (Schneider et al. 2009a; Schneider et al. 2012). Therefore, variables in the Safety factor category may also express the rate of pedestrian or bicycle crashes, which is the total number of

Table 5. Safety variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Total number of pedestrian/bicycle crashes	●	●	S, Cr, Co, A
Fatal and severe injury pedestrian/bicycle crashes	●	●	S, Cr, Co, A
Pedestrian/bicycle crash rate	●	●	S, Cr, Co, A
Proportion of pedestrians walking in the roadway	◐	○	S
Proportion of pedestrians complying with "Don't Walk" signals	◐	○	Cr
Proportion of bicyclists complying with red lights	○	◐	Cr
Proportion of motorists complying with right-turn-on-red restrictions	◐	◐	Cr
Proportion of motorists yielding to pedestrians in crosswalks	◐	○	Cr
Number of "near misses" involving pedestrians/bicyclists	◐	◐	S, Cr, Co, A

pedestrian or bicycle crashes during a specific time period divided by a measure of exposure for that time period. Examples of exposure measures include:

- The pedestrian crossing volume multiplied by the perpendicular motor vehicle volume at a crosswalk.
- The pedestrian crossing volume at a crosswalk or intersection.
- The total bicycle volume (including all right-, left-, and through-movements) at an intersection.
- Census tract pedestrian or bicycle commute-to-work mode share.
- Census tract population.

Individual variables or combinations of variables in the Demand category can also be proxies for pedestrian or bicycle exposure. The most accurate exposure variables have the most direct relationship with the actual risk of a crash, such as the time pedestrians or bicyclists spend in locations where they may come into contact with motor vehicles. However, specific data on pedestrian or bicycle volumes are usually not available, so more general measures of exposure are often used.

The severity of pedestrian and bicycle crashes can also be considered as a prioritization variable. Crash injury severity is often classified according to a scale, such as no injury, minor injury, severe injury (requiring hospitalization), or fatal injury. In general, pedestrian and bicyclist injuries are more severe when they involve vehicles traveling at higher speeds (Rosén et al. 2011). Therefore, fatal and severe injury crashes are often concentrated on higher-speed roadways. Fatal and severe injury crash rates can also be calculated, as described above.

Pedestrian and bicycle crashes are less frequent than motor vehicle crashes in most communities. However, only a fraction of pedestrian and bicycle crashes are reported to police (Stutts and Hunter 1998). Therefore, in some situations, it can be helpful to consider behaviors associated with pedestrian or bicycle crashes (Zegeer et al. 2004). Also, in some locations, it may be possible to observe behaviors that nearly cause a crash. These "near misses" can help represent the Safety factor in cases where pedestrian and bicycle crash data is unavailable or limited.

There are many variables listed under the Existing Conditions factor category that impact safety, such as traffic speed and roadway/intersection lighting. Agencies should consider including these variables if safety is a priority and may choose to do so under either the Safety or Existing Conditions factor.

Existing Conditions

Existing Conditions variables (Table 6) represent the characteristics of roadways and crossings. The identification of appropriate Existing Conditions variables depends on the prioritization purpose. For example, an effort to prioritize locations for new pedestrian signal heads would include crossing-specific variables, while a process focused on sidewalk gap prioritization would not. When selecting variables for the Existing Conditions category, it is not necessary (or advisable) to use all of the variables identified in Table 6. Instead, variables should be chosen carefully based on what is important to local stakeholders, data availability, and what variables provide differentiation between improvement locations.

Existing research and tools for evaluating bicycle and pedestrian level of service, comfort, and traffic stress can provide guidance when selecting Existing Conditions variables. The *Highway Capacity Manual* (HCM) Multimodal Level of Service Methodology includes Pedestrian Level of Service and Bicycle Level of Service tools to evaluate the suitability of roadway segments and intersections for walking and bicycling (Dowling et al. 2008). The Bicycle Level of Traffic Stress also provides a method for assessing the level of comfort for bicyclists on roadway segments and intersections (Mekuria et al. 2012).

Safety-based guidelines and tools, such as the FHWA marked crosswalk guidelines (Zegeer et al. 2005), the FHWA Pedestrian Intersection Safety Index and Bicycle Intersection Safety Index (Carter et al. 2006), and the FHWA Crash Modification Factors Clearinghouse (FHWA 2014) are also useful for informing the analysis of existing conditions. Variables used in these tools, such as the presence of a raised median or a right-turn-on-red restriction could be used as Existing Conditions variables.

Appendix C provides references for example Existing Condition variables listed in Table 6. Table 6 and Appendix C show how example Existing Condition variables correspond with variables used in common pedestrian and bicycle suitability assessment tools. For more design guidance on these variables and further support for including them in a prioritization process, see references such as the *AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities* (2004), *AASHTO Guide for the Development of Bicycle Facilities* (2012), *FHWA Pedestrian Safety Guide and Countermeasure Selection System* (2013), *FHWA Bicycle Safety Guide and Countermeasure Selection System* (2014), *NACTO Urban Bikeway Design Guide* (2012), and *NACTO Urban Street Design Guide* (2013).

Demand

Demand (Table 7) can be evaluated directly with variables such as pedestrian or bicycle counts and pedestrian or bicycle mode shares from household surveys. It is becoming more common for jurisdictions to conduct counts of pedestrian and bicyclists. However, neither counts nor surveys identify areas where more people would be walking or bicycling if conditions were better (latent demand). Demand can also be represented by proxy variables, such as population density, employment density, and proximity to attractors such as parks, schools, and employment centers.

Table 6. Existing Conditions variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose. Appendix C provides references for the variables listed in this table to assist practitioners in finding additional information.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Traffic speed[1]	●	●	Cr, S, Co
Traffic volume and composition (percentage of heavy vehicles)	●	●	Cr, S, Co
Right-turning traffic volume	◐	●	Cr
Right-turn-on-red restricted/allowed[2]	●	●	Cr
Signal timing (pedestrian and bicycle delay)[3]	●	●	Cr
Type of traffic control (e.g., traffic signal, stop sign)	●	●	Cr
Presence of crosswalk warning signage or beacons	◐	◐	Cr
Number of general-purpose travel lanes	●	●	Cr, S, Co
Number of designated right-turn lanes on the crossing at intersections	●	●	Cr
Total crossing distance	●	●	Cr
Curb radius	◐	◐	Cr
Presence of a median or crossing island	◐	◐	Cr
Presence and utilization of on-street parking[4]	●	●	S, Co
Width of outside through lane	○	●	S, Co
Presence and width of bicycle lanes	●	●	S, Co
Presence and width of paved shoulders	●	●	S, Co
Roadway pavement condition	○	●	S, Co
Presence/degree of separation/buffer separation between modes	●	●	S, Co
Frequency of driveway crossings	◐	●	S, Co
Presence and width of buffer between sidewalk and moving traffic	●	○	S, Co
Presence and width of sidewalk	●	○	S, Co
Presence of traffic calming measures (chicanes, speed humps, etc.)	◐	◐	Cr, S, Co

Existing Conditions Variable Notes:

[1]**Traffic Speed.** As motor vehicle speeds and volumes increase, pedestrians and bicyclists feel less comfortable walking and bicycling along roadways. Higher vehicle speeds result in less driver reaction time (higher potential for crashes) and more severe injury from vehicle collisions with pedestrians or bicyclists. Both pedestrians and bicyclists are more comfortable when they have more separation from moving motor vehicle traffic. More frequent driveways along a roadway segment (especially busy commercial driveways) increase the potential for conflicts between vehicles and pedestrians/bicyclists and may also reduce the level of comfort for pedestrians and bicyclists.

[2]**Right-Turn-on-Red Restricted/Allowed.** Right-turn-on-red restrictions are also important to consider because they have been associated with significant pedestrian and bicycle crash reductions (FHWA 2014).

[3]**Signal Timing (pedestrian and bicycle delay).** The length of time pedestrians are required to wait at a signalized crossing (delay) also impacts safety—the longer the wait time, the more likely it is that the pedestrian or bicyclist will cross the street against the signal.

[4]**Presence and Utilization of On-Street Parking.** The presence of occupied on-street parking tends to affect pedestrians and bicyclists differently. A line of parked cars provides a physical barrier between moving traffic and pedestrians, so it improves pedestrian comfort. However, on-street parking creates a risk of car doors being opened in front of bicyclists, which reduces bicyclist comfort.

Table 7. Demand variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose. Appendix C provides references for the variables listed in this table to assist practitioners in finding additional information.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Population density	●	●	S, Cr, Co, A
Employment density	●	●	S, Cr, Co, A
Commercial retail property density/proximity	●	●	S, Cr, Co, A
Transit station or stop density/proximity	●	●	S, Cr, Co, A
Density/proximity of attractors (grocery stores, restaurants, coffee shops, banks, parks, schools)	●	●	S, Cr, Co, A
Proximity to college/university campuses	●	●	S, Cr, Co, A
Bicycle facility density/accessibility (e.g., multi-use trail, bicycle lane, cycle track, bicycle boulevard)	○	●	S, Cr, Co, A
Number of boardings at transit stops	●	◐	S, Cr, Co, A
Proportion of residents living in poverty or without access to an automobile (NOTE: Socioeconomic characteristics may also be included under the Equity factor)	◐	◐	S, Cr, Co, A
Evidence of a worn path (in locations where sidewalks are missing)	◐	○	S, Co
Density/proximity of bike-share docking stations	○	◐	S, Cr, Co, A
Roadway slope	○	●	S, Co
Roadway density/connectivity	◐	●	A

Pedestrian Demand

Pedestrian demand tends to be fairly localized and is largely driven by the distribution and density of land uses that attract pedestrians. Several regression models have been created to estimate pedestrian volumes at intersections based on proxy variables (Schneider et al. 2012). The most common, statistically-significant proxy variables identified in existing pedestrian volume models are listed as "very relevant" in Table 7.

Bicycle Demand

In contrast to pedestrians, bicyclists typically travel longer distances, so the area from which a particular attractor may draw bicyclists from is larger. According to weighted data from the 2009 National Household Travel Survey (NHTS), approximately three-quarters of reported pedestrian trips are shorter than one mile. By contrast, approximately three-quarters of reported bicycle trips are shorter than three miles (FHWA 2009). Therefore, the demand for bicycling around a particular attractor (e.g., school, shopping district, transit station) should be assessed with a larger buffer than is used for pedestrian demand.

Bicycle facilities such as multi-use trails, cycle tracks, bicycle lanes, and bicycle boulevards may have a strong influence on bicycle demand in certain corridors because some bicyclists are willing to divert from the shortest possible route to use these facilities (Dill and Gliebe 2008).

Regression models have been developed to estimate bicycle volumes at intersections (Griswold et al. 2011). Common proxy variables for bicycle demand were identified and are listed as example variables for this methodology in Table 7.

Appendix C provides references for each of the example Demand variables listed in Table 7.

Connectivity

Connectivity variables (Table 8) represent the degree to which a particular improvement location relates to and improves the functionality of the existing pedestrian or bicycle facility network. Roadway network density and intersection density can also be used to represent Connectivity at a broader neighborhood or regional level. These types of density variables represent the number of different routes that pedestrians or bicyclists can travel from one location to another. Pedestrian and bicycle routes are generally more direct when there is a denser, more connected roadway system.

Equity

Equity includes socioeconomic variables that are integrated into the prioritization process to ensure pedestrian or bicycle improvements provide access to vulnerable populations or areas with low-income and/or minority populations. Data for these variables come from multiple sources, including the American Community Survey, public health agencies, regional planning agencies, and school districts. Socioeconomic data are typically collected from household surveys. Therefore this information is readily available for geographic areas (e.g., census tract or block group, jurisdictional boundaries). An entire area may be prioritized for pedestrian or bicycle improvements based on socioeconomic variables, or a specific corridor or intersection improvement that is located within a given underserved area may be prioritized. For example, areas with vulnerable populations (e.g., persons with disabilities, seniors, and children) may be target areas for curb ramp upgrades, median crossing islands, or special treatments such as leading pedestrian intervals.

Equity-related variables such as income and car ownership are also related to pedestrian and bicycle demand. For example, low-income populations typically rely more on transit and

Table 8. Connectivity variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Intersection density (number of four-leg intersections per square mile—represents the connectivity of the street network as a whole)	●	●	Co, A
Roadway segment density (miles of roadway per square mile—represents the connectivity of the street network as a whole)	●	●	Co, A
Pedestrian/bicycle barrier (e.g., heaved sidewalk sections, utility poles in sidewalk, no pedestrian/bicycle detection/activation at signalized crossing, no safe access across high-volume/speed road)	●	●	S, Cr, Co
Pedestrian/bicycle facility coverage (percentage of roadways with sidewalks/bicycle facilities)	●	●	Co, A
Connects to an existing pedestrian/bicycle facility	●	●	S, Cr, Co

Table 9. Equity variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Household automobile ownership	●	●	S, Cr, Co, A
Household income	●	●	S, Cr, Co, A
Percent unemployed	●	●	S, Cr, Co, A
Proportion of population under age 18	●	●	S, Cr, Co, A
Proportion of population over age 64	●	○	S, Cr, Co, A
Proportion of population with physical disabilities	●	○	S, Cr, Co, A
Minority populations	●	●	S, Cr, Co, A
Proportion of school children receiving subsidized lunches	◐	◐	S, Cr, Co, A
Proportion of population with asthma or diabetes	◐	◐	S, Cr, Co, A
Proportion of population that is overweight or obese	◐	◐	S, Cr, Co, A

walking, so the need for pedestrian facilities in neighborhoods with low-income households is higher. Table 9 provides a list of equity variables and their applications.

Many agencies are also concerned with geographic equity. These geographies may be defined by neighborhood boundaries, sectors or districts, municipal boundaries, county boundaries, or regional boundaries. Agencies can address geographic equity by:

- Assigning each improvement location an identifier that corresponds to its geographic area. The final prioritized list can then be sorted by geography and high-ranking improvement locations from each geographic area can be selected for implementation.
- Prioritizing geographic areas separately. For example, if an agency has four sub-areas, it could do a separate prioritization process for each sub-area. The agency could then make a separate policy decision about how much funding or resources to dedicate to each sub-area.

Compliance

Compliance variables (Table 10) indicate whether or not an improvement location meets current standards or guidelines. Compliance variables correspond with specific facility types such as sidewalks, curb ramps, and bike lanes. For some facilities such as curb ramps, compliance may be central to the prioritization purpose.

Step 5: Assess Data

The availability of data is a critical consideration in determining what variables to include in a prioritization exercise; data availability varies substantially across cities, towns, counties, metropolitan planning organizations (MPOs), and state DOTs. In an ideal world, data would be available in an easy-to-use format to represent all variables that are relevant and important to a given

Table 10. Compliance variables.

Example Variables	Relevance		Potential Location
	Ped	Bike	
Note: The relevance designations in this table are meant to provide general guidance. Ultimately, variable relevance depends on the prioritization purpose. Agencies are encouraged to review each variable and consider how relevant it may be considering their purpose.	● = Very relevant ◐ = Less relevant ○ = Not likely relevant		S = Segment Cr = Crossing Co = Corridor A = Area
Facilities not compliant with local, state, and federal design requirements or guidelines	●	●	S, Cr, Co
Sidewalk condition—segments that are not compliant with accessibility guidelines (e.g., clear width obstructions, vertical heave obstructions)	●	○	S, Co
Curb ramps that are not compliant with ADA guidelines (e.g., excessive slopes, lack of level landings)	●	○	Cr, Co, A
Bicycle facilities that are not compliant with national or state bicycle design guidelines or standards (e.g., AASHTO, NACTO)	○	●	S, Co, A

agency/community and project type; however, this is usually not the case. Data availability may constrain the possible options for prioritization. In addition, the availability of technical resources [e.g., technological tools such as geographic information system (GIS) and staff capabilities] may also determine what data can be used, and therefore, the breadth of prioritization options. The initial scoping effort (Phase I) typically involves an iterative approach in which data and technical capabilities lead to rethinking or reframing the original purpose, factors, and variables. Assessing technical resources is discussed in more detail under Step 6.

This section describes types of data that may be used to express the variables identified in Step 3 and offers guidance on sources of these data, including collecting new data, where necessary. The data assessment process is illustrated in Figure 4.

Data collection may occur both in Step 5 and Step 8. In Step 5, after an agency assesses its available data and identifies any data gaps, it may choose to revisit the selected variables and choose a suitable proxy variable for which it has data.

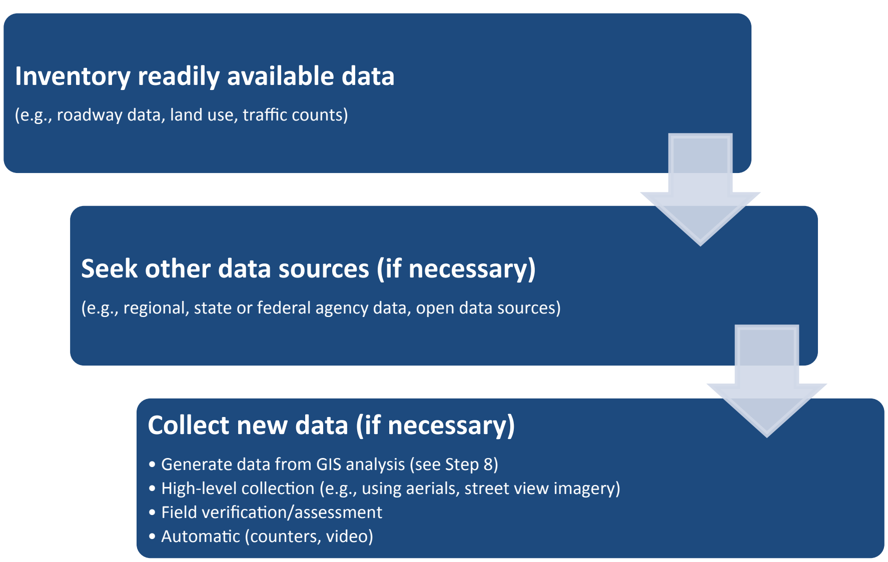


Figure 4. Data assessment process.

Alternatively, in Step 8, when an agency must input data into its prioritization tool, it may acquire data from other sources, generate data using GIS or other tools, or collect new data using other methods. Other potential sources include data that may have been collected by an agency for a different purpose; data that resides in a different department within the same organization (e.g., location of park facilities); or sources external to the organization, such as an MPO, school district, transit agency, or a data aggregator such as Data.gov.

Below is a discussion of the data that may be most appropriate for expressing variables identified under each factor category (Step 3). Tables provide a summary of potential data sources and/or methods for collecting or generating data for each key variable. The guidance is intended to help agencies be strategic about fulfilling their data needs. **It is important to keep in mind that a higher number of variables does not necessarily result in a more thorough prioritization.**

Stakeholder Input Data

Stakeholder input may be incorporated into the prioritization process both quantitatively and qualitatively (Table 11). The number of public comments/requests regarding a particular issue or facility may be documented and inputted as a raw data value. Qualitative stakeholder input such as staff knowledge of constraints and opportunities, political support, etc. is also valid to incorporate into a prioritization process. While qualitative stakeholder input data may also be incorporated into the scoring process, it may be more effectively used as a pre- or post-screen. For example, among 10 ranked improvement locations, those that have been vetted by staff from a feasibility point of view, or have strong support of an advisory committee or decision-making body may be moved to the top of the list.

Constraint Data

Most constraints can often be expressed in terms of monetary units for labor, time, materials, land acquisition, and other costs. However, in many cases, accurate costs require considerable effort to develop, and if the list of projects to be prioritized is long, it may not be possible

Tip: Regional Agencies

Regional agencies relying on local data to prioritize pedestrian or bicycle projects may face challenges related to the consistency of data across a region. For example, data may be available in some jurisdictions, but not others, or data may be formatted differently from jurisdiction to jurisdiction. Because of these inconsistencies, regional agencies may be forced to omit certain factors or variables they may want to use in a prioritization effort or commit resources to process or collect data in order to have consistent datasets.

Many regional agencies have Census, population, or employment data as well as police crash reports that can be used to evaluate the Demand and Safety factors. In addition, Stakeholder Input (e.g., is a project identified in a local plan) may be another factor regional agencies could easily include. Regional agencies may also have a unique perspective on opportunities such as planned projects at the state or local level that may have regional significance and choose to include these considerations under the Opportunities or Connectivity factors.

Table 11. Data considerations/sources for Stakeholder Input variable examples.

Example Stakeholder Input Variable	Data Considerations/Sources
Number of public comments about specific issue received by phone or online from citizens	Requests/complaints compiled on a map or in a database
Identification/inclusion of a particular facility or location in adopted plans	Comprehensive plans, master plans, transportation plans, etc.
Number of comments received at public meetings or through a public survey during a master planning process	Comments compiled on a map or in a database
Supported by advisory committee or decision-making body	Documentation such as meeting minutes, memoranda

to develop these cost estimates for every project. Therefore, in some cases, it may be useful to express constraints as an order of magnitude (e.g., low, moderate, high). Table 12 shows data considerations/sources for potential Constraints variables.

Opportunities Data

Data that are used to measure opportunities (Table 13) may be quantitative (e.g., amount of available funding) or qualitative (e.g., potential for development). As described earlier, opportunities are often studied separately through a cost/benefit analysis. However in situations where opportunities can be quantified as part of a prioritization process, the data sources below should be considered.

Table 12. Data considerations/sources for Constraints variable examples.

Example Constraints Variable	Data Considerations/Sources
Project implementation cost (including design, engineering, and construction costs, right-of-way availability, utility relocation)	Planning-level cost estimates; costs of comparable projects, or an actual cost estimate specific to a project. The Pedestrian and Bicycle Information Center (PBIC) has information on typical costs and cost considerations for different types of pedestrian and bicycle improvements. Alternatively, an order of magnitude cost (e.g., low, moderate, or high) may be used as long as it is made clear what each level means, and some adjustments are made for projects of different scales (i.e., a per-mile cost).
Presence of environmental or historic features that may create significant barriers to construction	Staff/agency knowledge or experience. Requires an understanding of regulatory requirements. Other sources of information may include mapped critical areas (e.g., streams, wetlands, steep slopes), previous environmental studies that encompass the improvement location.
Staffing (time needed to plan and implement projects)	Staff/agency knowledge or experience. Requires an understanding of all project components and staff time (or contractor services) needed to address each component.
Multi-jurisdictional coordination	Staff/agency knowledge or experience. Requires an understanding of plans and processes of overlapping or adjacent jurisdictions and time for coordination.
Life-cycle/maintenance costs	Staff/agency knowledge or experience. Requires an understanding of material life-cycles and maintenance considerations; public works staff may be able to provide insights and estimates.

Table 13. Data considerations/sources for Opportunities variable examples.

Example Opportunities Variable	Data Considerations/Sources
Projects that are candidates for a specific funding source (e.g., grant, targeted improvement fund)	Knowledge of grant sources and focus area, as well as funding levels
Projects that could be implemented through future land development or roadway construction	Development applications and permits, knowledge of regional projects, priorities, and working with partners
Planned roadway improvements that may accommodate pedestrian or bicycle facilities (e.g., repaving or reconstruction projects)	Knowledge of capital improvement plan and timing of planned roadway improvements

Safety Data

Pedestrian and bicycle crashes and injury severity are likely to be important variables under the Safety factor. Crash data typically consists of records of reported crashes. In order to be useful on a large-scale basis, these data must be geocoded (mapped) to specific locations. Pedestrian and bicycle crash data are often available from police crash databases (see Table 14). As stated previously, these databases include only crashes that are documented in police reports, so they tend not to capture crashes that do not involve a motor vehicle (e.g., falls, collisions with objects), or in some cases minor collisions between motor vehicles, pedestrians, and bicyclists (Stutts and Hunter 1998; Aultman-Hall and LaMondia 2004). In many communities, pedestrian and bicycle crashes in parking lots and on other private property are also not captured by police crash reports. In some cases, state DOTs or MPOs aggregate and organize crash data and provide crash datasets to local agencies.

Table 14. Data considerations/sources for Safety variable examples.

Example Safety Variable	Data Considerations/Sources
Total number of pedestrian/bicycle crashes	Police crash database, often available at the state or local level
Fatal and severe injury pedestrian/bicycle crashes	Police crash database, often available at the state or local level
Pedestrian/bicycle crash rate	Police crash database combined with measure of exposure (e.g., pedestrian/bicycle counts, pedestrian/bicycle demand proxy variables)
Proportion of pedestrians walking in the roadway	Pedestrian counts (generally manual counts in the field, with instruction to note pedestrians in roadway)
Proportion of pedestrians complying with “Don’t Walk” signals	Pedestrian counts (generally manual counts in the field, with instruction to note “Don’t Walk” compliance)
Proportion of bicyclists complying with red lights	Bicycle counts (generally manual counts in the field, with instruction to note red light compliance)
Proportion of motorists complying with right-turn-on-red restrictions	Vehicle counts (generally manual counts in the field, with instruction to note right-turn-on-red movements)
Proportion of motorists yielding to pedestrians in crosswalks	Vehicle counts (generally manual counts in the field, with instruction to note yielding rates)
Number of “near misses” involving pedestrians/bicyclists	Multimodal counts (generally manual counts in the field, or based on video footage of a location)

As discussed under Step 4 (Select Variables), the Safety factor may also be expressed using the crash rate, which is dependent upon exposure measures, such as pedestrian and bicycle counts, motor vehicle counts, or combinations of variables in the Demand category.

Since pedestrian and bicycle crashes are relatively infrequent, most communities should use several years of data to identify crash patterns. As a rule of thumb, patterns of pedestrian or bicycle crashes can be identified from three to five years of data, depending on the overall number of crashes each year. In general, communities should not consider more than 10 years of crash data, since older data may not reflect changes in pedestrian activity patterns or pedestrian facility improvements.

Obtaining Additional Safety-Related Data

When gathering pedestrian or bicycle crash data, agencies should consider the following steps:

1. Identify how many years of data are needed.
2. Get the crash data from an agency that has already mapped it.
3. If no data is available from existing sources, map crash locations using police reports. The FHWA Pedestrian and Bicycle Crash Analysis Tool (Harkey et al. 2006) can be applied to identify specific crash types.
4. Understand the limitations of the data. For example, police report assessments of injury severity may not be reliable and police officers may not file reports for all crashes involving pedestrians and bicyclists.

Field data collection is typically required to document behaviors that are associated with pedestrian or bicycle crashes and to observe "near misses." As a result, data for this type of surrogate Safety variable is often expensive to collect, and may only be feasible to use when prioritizing a small number of projects or locations.

A number of agencies, including Fort Collins, CO, and Madison, WI, have developed "close-call" reporting mechanisms that allow pedestrians or bicyclists to use a telephone hotline or website to report incidences in which their safety was compromised. Because bicycle- and pedestrian-related crashes are typically underreported, such mechanisms offer another way to collect safety-related data and address issues before they result in a crash. Self-reporting apps for smart phones have also been developed in a number of locations (e.g., the "Bike Accident Toolkit" app initially developed for Boston University). These apps allow users to efficiently capture important information following a crash or near-crash, and to indicate if the problem is related to a physical hazard in the roadway or a design issue that needs to be addressed.

Existing Conditions Data

The Existing Conditions factor encompasses many potential variables as described in Step 4. The data chosen for this factor will depend (perhaps more than any other factor) on the prioritization purpose. Data used to express the variables identified in Step 4 are typically compiled into datasets that contain multiple values representing different aspects of the roadway (Table 15). For example, roadway data may include pavement width, channelization, average daily traffic (ADT), and speed data that would be useful for a variety of pedestrian and bicycle prioritization purposes. In addition to roadway or centerline data, agencies may have specific inventories for infrastructure such as sidewalks, curb ramps, pedestrian signals, signage, crosswalks, and bicycle facilities. Agencies may not have complete inventories of these facilities for all locations being considered in the prioritization process. In cases for which no data or partial inventories are available, agencies may need to collect additional data or choose different variables that do not require the missing data. In some cases, it may be possible to identify a suitable proxy with complete data for all improvement locations.

Table 15. Data considerations/sources for Existing Conditions variable examples.

Example Existing Condition Variable	Data Considerations/Sources
Traffic speed	Posted speed as surrogate for actual speeds, or 85th percentile speeds based on speed studies
Traffic volume and composition (percentage of heavy vehicles)	ADT or annual average daily traffic (AADT) with percent truck volumes, often found in street centerline database
Right-turning traffic volume	May be attribute data within traffic volume database, but more typically obtained from targeted traffic study
Right-turn-on-red restricted/allowed	May be attribute of signal database, sign inventory
Signal timing (pedestrian and bicycle delay)	May be attribute of signal database
Type of traffic control (e.g., traffic signal, stop sign)	Signal database, sign inventory, street-level imagery
Presence of crosswalk warning signage	Sign inventory, street-level imagery
Number of general-purpose travel lanes	Typically an attribute within street centerline data, aerial imagery
Number of designated right-turn lanes on the crossing at intersections	Typically an attribute within street centerline data, channelization plans, aerial imagery
Width of outside through lane	Typically an attribute within street centerline data, aerial imagery
Roadway pavement condition	Pavement Condition Index or Survey, or must be field-collected
Total crossing distance	Curb-to-curb width typically an attribute within street centerline data, aerial imagery
Curb radius	Aerial imagery, or must be field-collected
Presence of a median or crossing island	May be attribute data within street centerline data, aerial imagery
Location is a transition between on-road and off-road bicycle facilities	Bicycle facility inventory data, aerial imagery
Presence and utilization of on-street parking	On-street parking lanes may be attribute data within street centerline data or a parking inventory, sign inventory may be used to identify parking presence or restrictions, parking utilization may be available where networked pay stations are in use, otherwise typically generated through field-based parking studies
Presence and width of bicycle lanes	May be attribute data within street centerline data or bicycle facility inventory, aerial imagery, or must be field-collected
Presence and width of paved shoulders	May be attribute data within street centerline data, aerial imagery
Presence/degree of separation/buffer separation between modes	May be attribute of sidewalk inventory, street centerline data, aerial imagery, or must be field-collected
Frequency of driveway crossings	Typically generated through field studies or aerial imagery
Presence and width of buffer between sidewalk and moving traffic	May be attribute of sidewalk inventory, street centerline data, aerial imagery, or must be field-collected
Presence and width of sidewalk	Sidewalk inventory, gap inventory (may be complete inventory or inventory targeted to specific purpose); street centerline data, aerial imagery
Presence of traffic-calming measures (chicanes, speed humps, etc.)	Aerial imagery, or specific database that has been created to inventory traffic calming measures
Sidewalk condition	Sidewalk inventory, gap inventory (may be complete inventory or inventory targeted to specific purpose), or must be field-collected

Existing Conditions datasets are commonly in digital format (spreadsheet or GIS), but some agencies may have data available only in hard copy. Depending on the level of complexity of the prioritization purpose (i.e., number of improvement locations, number of factors, number of variables), hard copy data may need to be digitized so it can be used in either a spreadsheet-based or GIS database prioritization tool.

Obtaining Additional Data to Measure Existing Conditions

Depending on the prioritization purpose and the variables that are selected, additional Existing Conditions data may be inventoried by a local agency for use in the prioritization process. Some of the desired data may be possible to collect from free, online imagery sources or through GIS analysis, while other data may require direct field observations.

Data collection often requires consideration of resources in terms of staff or contract labor. In general, inventories that can be completed using aerial imagery are less expensive than inventories from street-level imagery and much less expensive than inventories requiring direct field observations. Examples of inventories that might be completed using aerial imagery include sidewalk and bike facility inventories. Examples of inventories that might be completed using street-level imagery include the presence of signs, street furniture, or curb ramps. Collection of data in the field may be required for things such as curb ramp ADA compliance, curb radius, and sidewalk condition. Data elements such as traffic volumes and speeds and turning movements may be collected using automated technologies. While online imagery sources can save time and effort, measurements from these images are not as precise as field measurements and the images may be dated.

Table 16 suggests data sources or tools that can be used to inventory data for Existing Conditions variables.

Detailed roadway data may be impractical to consider for prioritization efforts that cover large geographic areas. Therefore, general roadway network characteristics can be calculated or

Table 16. Data sources/tools for inventorying data and related Existing Conditions variable examples.

Inventory Data Source/Tool	Can Be Used to Inventory Data for These Variables
Aerial imagery	• Sidewalk and buffer presence and width • Marked crosswalk presence and type • Median island presence and width • Bicycle facility presence and width • Lane width/shoulder width • Pedestrian crossing distance
Street-level imagery (e.g., video log, street view)	• Curb ramp presence • Truncated domes presence • Pedestrian/bicycle-related signage • Major sidewalk obstructions • Pedestrian signal heads • Pedestrian push buttons
Direct field observation (using technological data collection tools or manual observations)	• More precise lane width/shoulder width • Traffic volume • Traffic speed • Sidewalk condition • Crosswalk condition • Pavement condition • Curb ramp slope • On-street parking presence and occupancy

estimated for an entire neighborhood or district. Examples of general roadway network measures include:

- Percentage of households within X miles of a bikeway or walking route.
- Percentage of roadways with sidewalks on both sides (pedestrian).
- Percentage of roadways with sidewalks on one side (pedestrian).
- Percentage of roadways with no sidewalks (pedestrian).
- Percentage of arterial roadways with a designated bicycle facility (bicycle).
- Ratio of bicycle facility miles (including multi-use trails) to total roadway miles (bicycle).
- Percentage of roadways that are arterial roadways (pedestrian/bicycle).
- Percentage of roadways that have more than two lanes (pedestrian/bicycle).

These measures are often suitable for initial prioritization between neighborhoods or districts before a more specific prioritization process is undertaken within certain focus areas.

Demand Data

Pedestrian and bicycle demand can be measured directly through counts and surveys or through proxy data, such as population density and employment density.

Data Used to Measure Demand Directly

Demand can be measured directly using counts or survey data. Table 17 shows the differences between the two data sources.

One national-level data source, the ACS, gathers enough data over a five-year period to estimate the number of households without access to a vehicle and the percentage of workers who commute regularly by walking or bicycling in most census tracts in the United States. Census tracts are often small enough to provide neighborhood-level vehicle access data and commute data, either of which can be useful for representing Demand in a prioritization framework. However, it is important to recognize several ACS commute data limitations:

- Commute data include only trips to work. Shopping, recreational, and other types of trips are not represented.

Table 17. Differences between count and survey data to represent demand.

	Data Collection Scale	Information Available	Data Type	Examples
Count Data	Counts of bikes or pedestrians collected at roadway intersections, segments, or crossing locations	Existing activity levels at a specific location	Population (includes all people passing through the count location within a given time period)	Two-hour counts done manually by human counters at a particular location Continuous count data collection using automatic counter technology on a roadway or path segment
Survey Data	Survey data collected from households or individuals at national, state, regional, or local level	Overall pedestrian or bicycle mode share for a community	Sample (the survey polls a representative portion of the population and the results are extrapolated to the whole population)	National Household Travel Survey (NHTS) U.S. Census Bureau's American Community Survey (ACS) Local or regional-level household travel surveys

- Commute data represent only the most common, longest-distance mode that people used to travel to work during the week before the survey. People who walked or bicycled to work one or two days during the previous week and people who walked or bicycled as a part of a longer-distance automobile or public transit commute are not counted among walking or bicycling trips.

At the regional level, several studies have used GPS units to document the spatial travel movements made by survey participants (Dill and Gliebe 2008; Hood et al. 2011). Household Travel Surveys such as the Chicago Travel Tracker Survey (2008) have also collected travel routes using GPS. While GPS route data do not quantify the total number of people using a particular facility, this information can illustrate preferences for particular routes, which may be useful for prioritization.

Data Used as a Proxy for Demand

Demand can also be represented by proxy data. Common demand proxy variables and data sources are listed in Table 18. The practitioner should be aware of correlations that may exist among several of these variables. For example, where population density is high, it is likely that transit boardings are also high. Including correlated variables may result in an overweighting or double counting for the Demand factor.

Table 18. Data considerations/sources for Demand proxy variable examples.

Example Demand Proxy Variable	Data Considerations/Sources
Population density	Population of given geography divided by its area
Employment density	Employment is often compiled at the regional level and made available to local agencies by request from the Census Transportation Planning Package for traffic analysis zones. Density is calculated by dividing the number of employees by a measure of area Longitudinal Employer-Household Dynamics (LEHD) is another U.S. Census program that can provide employer/employee data estimates.
Commercial retail property density/proximity/accessibility	Parcel data
Transit station or stop density/proximity/accessibility	Point data typically maintained by transit agency
Density/accessibility/proximity of key attractors (schools, parks, community facilities)	Parcel data, point data layers for specific land use attractor types
Proximity to college/university campus	Parcel data
Bicycle facility density/accessibility	Facility inventory
Presence of sidewalk	Sidewalk inventory
Roadway density/connectivity	Street centerline data
Roadway slope	May be calculated using topographical data and length of segment, may also be part of street centerline data
Number of boardings at transit stops	Daily, monthly, or annual boardings may be available from the transit agency, or may be an attribute of stop location point data or transit route data; may include patrons with bicycles.
Socioeconomic characteristics (e.g., proportion of neighborhood residents living in poverty or without access to an automobile)	U.S. Census data (block group-level data may be most appropriate for projecting demand). Note: This type of data may also be used for variables within the Equity factor.
Proximity to or number of bike share docking stations	Point data layer of bike share stations

Obtaining Additional Data to Measure Demand

If a local agency does not have population density, employment density, or land use data, the county or regional planning agency may have some or all of this data available and may be able to provide it in a format that is usable for the prioritization process.

Guidance on methods and technologies for collecting pedestrian and bicycle count data has been developed (NCHRP 07-19; *NCHRP Report 797*) and is available through the Transportation Research Board.

Tools such as Walk Score, Bike Score, and Google Maps (discussed in more detail under Step 6), may also be used to provide data values and estimate demand for pedestrian and bicycle improvements.

Connectivity Data

Determining the degree to which a proposed pedestrian or bicycle facility improvement enhances Connectivity (i.e., the functionality of the pedestrian or bicycle network) is dependent upon having an accurate inventory of existing facilities and/or knowledge of barriers and facility gaps. Assessing pedestrian connectivity usually requires having a sidewalk inventory, which may include detailed information on the condition of existing sidewalks. For bicycles, assessing connectivity usually requires having an inventory of existing bicycle facilities, and perhaps additional knowledge of streets that are most suitable or utilized for biking. The latter information may be obtained through a planning process, through surveys, or through interactive mapping tools (Table 19).

Obtaining Additional Data to Measure Connectivity

Aerial imagery tools may be used to collect pedestrian and bicycle inventory data (see Step 6 for more information). Some agencies have used volunteers or paid staff to collect pedestrian facility extent data (Schneider et al. 2005). Such collection efforts may be citywide or focused in specific areas (e.g., within a half mile of all schools), and may include multiple attributes, such as sidewalks, pedestrian signals, curb ramps, lighting, crosswalks, and signage.

Table 19. Data considerations/sources for Connectivity variable examples.

Example Connectivity Variable	Data Considerations/Sources
Intersection density (represents the connectivity of the street network as a whole)	Street centerline data—number of intersecting roadway segments per square mile: three-way may be distinguished from four-way
Roadway segment density (represents the connectivity of the street network as a whole)	Street centerline data—miles of roadway per square mile
Pedestrian/bicycle barrier (e.g., non-ADA-compliant sidewalk sections, no pedestrian/bicycle detection/activation at signalized crossing, no safe access across high-volume/speed road)	May be attribute of sidewalk inventory or derived from field assessment, bicycle facility inventory, signal database, documented resident request/complaint
Pedestrian/bicycle facility coverage (percentage of roadway with sidewalks/bicycle facilities)	Pedestrian/bicycle facility as percentage of centerline mileage in defined geographic areas from a sidewalk or bikeway facility inventory and street centerline data
Connects to pedestrian/bicycle facility	Sidewalk or sidewalk gap inventory, bicycle facility inventory, signal database, or derived from field assessment, documented resident request/complaint

Table 20. Data considerations/sources for Equity variable examples.

Example Equity Variable	Data Considerations/Sources
Household automobile ownership	U.S. Census, ACS
Household income	U.S. Census, ACS
Proportion of population under age 18	U.S. Census, ACS
Proportion of population over age 64	U.S. Census, ACS
Proportion of population with physical disabilities	U.S. Census, ACS
Proportion of children receiving subsidized lunches	School district enrollment data
Proportion of population with asthma or diabetes	Public health agency community surveys or health profiles (geographic extent of this data may vary considerably)
Proportion of population that is overweight or obese	Public health agency community surveys or health profiles (geographic extent of this data may vary considerably)

Equity Data

Table 20 shows example data considerations and/or sources for Equity variables. Some types of Equity data, such as neighborhood automobile ownership overlap with pedestrian or bicycle demand proxy data. Equity data may be considered at different geographic extents (e.g., sector, neighborhood, within one mile of all schools). Generally, census tract–level data is most appropriate for measuring equity at the neighborhood level. Geography itself may also be an important Equity variable for agencies and the political interests they serve. Census boundaries are available as **Topologically Integrated Geographic Encoding and Referencing** (TIGER) boundary data, which can be downloaded from the U.S. Census website or Data.gov.

Compliance

Some agencies may want to prioritize pedestrian or bicycle improvements based on compliance with accessibility or other guidelines or standards. Many agencies maintain inventories of existing infrastructure that may include information about whether or not a particular feature such as a sidewalk, curb ramp, or bike facility is present, as well as information about the feature's condition (Table 21). Condition information may include whether or not the feature meets current standards or guidelines, such as ADA (PROWAG), AASHTO or NACTO.

Table 21. Data considerations/sources for Compliance variable examples.

Example Compliance Variable	Data Considerations/Sources
Sidewalk segments that are not compliant with accessibility guidelines (e.g., clear width obstructions, vertical heave obstructions)	Sidewalk width or presence of obstruction that results in non-compliant clear width may be attributes of sidewalk inventory; targeted field assessment.
Curb ramps that are not compliant with ADA guidelines (e.g., excessive slopes, lack of level landings)	Curb ramp condition, including ADA compliance may be attribute of a curb ramp or sidewalk inventory; targeted field assessment.
Bicycle facilities that are not compliant with national or state bicycle design guidelines or standards (e.g., AASHTO, NACTO)	Bike lane width may be attribute of bicycle facility inventory or street centerline data; remote or targeted field assessment.

Obtaining Additional Data to Measure Compliance

If existing data are not available, or are only partially complete in terms of geographic scope or needed data fields, some information may be obtained using aerial imagery that is widely available for free through online applications. For example, the presence of curb ramps at intersections, or sidewalks along a given corridor may be obtained by panning through the corridor using street-level imagery. However, other essential Compliance measurements, such as sidewalk cross-slope and vertical discontinuities, almost always need to be obtained from field assessment.

Step 6: Assess Technical Resources

The APT can be used by agencies with a range of available data, staff resources, and technical capabilities. The purpose of Step 6 is to select a technological platform (e.g., spreadsheet, GIS, manual tabulations) that will be used to implement the prioritization process. Each platform has advantages and disadvantages. As part of Step 6, agencies should assess their existing technical resources and capabilities to determine if existing resources are sufficient, or if new resources will be needed. If new resources are not available, then the purpose and/or prioritization variables will need to be modified.

The standard platform for the APT methodology is a spreadsheet (see Phase II discussion). While a programmed spreadsheet has been developed to accompany the APT, and may be used by many agencies, the prioritization framework can be implemented independently of the spreadsheet platform. For example, the framework that is illustrated in the programmed spreadsheet can also be applied using more manual approaches such as on paper or within a word processor application. Alternatively, agencies can use more advanced technologies, such as GIS as a platform for the prioritization process as a whole and to streamline individual components of the prioritization process, for example, to measure geospatial relationships. See Appendix B for guidance on applying this methodology using GIS.

Each of the technological platforms has advantages for prioritization processes with particular characteristics. Table 22 highlights these advantages. Additional information is provided below.

Spreadsheet

A programmed spreadsheet has been developed to accompany the APT, which agencies may use in its "off-the-shelf" form or choose to modify based on their needs. Built-in scaling formulas, weighting, and sorting capabilities of the spreadsheet make it relatively easy to implement the prioritization analysis process. While the programmed spreadsheet includes the nine factor categories and preloaded variables for each factor, the user may modify or add variables based on data availability and change the default weights for each factor category to better reflect community values. In addition, spreadsheet functions can also be used to create new variables. For example, if an agency has the number of pedestrian crashes reported at each intersection during the last five years in one spreadsheet column and the estimated number of pedestrian crossings at each intersection over the last five years in a second column, the spreadsheet can easily divide the first column by the second column for all rows to create a new variable representing crash rate at each intersection.

The prioritization spreadsheet accompanying the APT is organized so that the improvement locations are entered in the left-hand column and the desired prioritization variables (organized by common factor categories) are shown in the top rows, as shown in Figure 5. Data that quantify each variable for each improvement location can be gathered from various sources and

Table 22. Advantages of specific technological platforms in the prioritization process.

Prioritization Process Characteristics	Advantages of Technological Platforms
Process considers a large number of projects or locations and/or project considers many variables.	Electronic spreadsheet and GIS technologies are often more efficient than manual processes for handling large amounts of data.
Variables require spatial queries or other spatial analysis.	GIS can be used to measure these relationships from existing GIS datasets. GIS can do spatial measurements for all prioritization locations simultaneously. Alternatively, spatial relationships may be determined manually using online aerial imagery tools or rectified aerial photography.
New variables are calculated from existing data.	Spreadsheets can copy data efficiently from other existing electronic sources and can be used to calculate new variables. Spatial analysis tools in GIS can also be used to create new variables.
Weights are applied to identify top-priority projects or locations.	Built-in spreadsheet functions are ideal for calculating rankings and sorting projects or locations with the highest priority scores. Note that it is typically easier to do these calculations and sorting tasks in a spreadsheet than on paper or in a GIS database.
Results need to be communicated clearly on maps.	Results of prioritization can be displayed on maps produced by GIS. GIS maps can also show spatial relationships between the prioritization variables and final results, improving transparency of the process.

entered in each cell of the spreadsheet. Each location can be ranked and sorted easily to identify top priorities.

A spreadsheet approach also has several disadvantages:

- For an agency that is not familiar with spreadsheet capabilities, it may take some time to learn how to enter data into a spreadsheet and use spreadsheet techniques, such as sorting functions. In this case, if a prioritization effort is very simple and only involves a small number of locations, it may be preferable to implement the prioritization framework by hand.

		Stakeholder Input	Safety	Demand	
ID	LOCATION	Number of Requests/Comments	Total Bike Crash	Population Density	Proximity to Attractor 1
1	CENTRAL AVE	15	8.0	9539.0	3.0
2	WASHINGTON/JEFFERSON CORRIDOR	10	3.0	9068.0	2.0
3	3RD ST	23	5.0	4664.0	4.0
4	12TH ST	2	7.0	3018.0	4.0
5	15TH AVE	1	5.0	4505.0	4.0
6	ENCANTO BLVD	15	5.0	6586.0	0.0
7	OSBORN RD	21	6.0	8924.0	7.0
8	OAK ST	9	6.0	7426.0	7.0
9	20TH ST	5	8.0	7115.0	8.0
10	3RD/5TH	3	1.0	7084.0	8.0
11	DEER VALLEY DR	8	8.0	8382.0	6.0
12	UNION HILLS DR	12	3.0	9459.0	0.0
13	19TH AVE	14	3.0	6766.0	7.0
14	32ND ST	21	1.0	7858.0	3.0
15	40TH ST	8	4.0	4678.0	5.0

Figure 5. Example spreadsheet prioritization application.

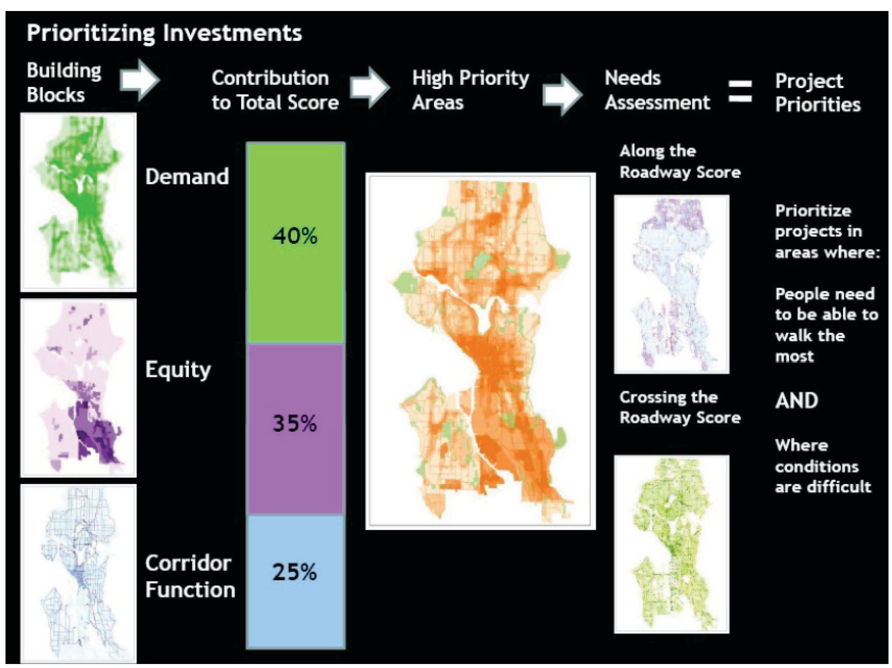
- Using a spreadsheet allows users to perform calculations and functions that may not be readily transparent to a public audience.
- On its own, a spreadsheet may not communicate top priorities as quickly and clearly as a map.

Geographic Information Systems

GIS is a tool that can be used to organize data, conduct spatial analysis, and create maps that display data and prioritization results. With these capabilities, GIS can improve the prioritization process by making data collection, measurement, organization, and analysis more efficient, particularly for large datasets and complex analyses. GIS has the added value of enabling the user to run multiple analyses and to change the parameters of an analysis easily. Because of this, many planning departments at the local, regional, and state level are familiar with GIS.

GIS is useful for organizing and measuring data and spatial variables. For example, all of the intersections within a council district can be grouped together, or street segments can be numbered from west to east. Many prioritization variables can also be created in GIS because they have a spatial dimension. For example, the density of employment within a 0.25-mile radius of each improvement location, the distance between each improvement location and the closest rail station, and the number of retail stores within a 0.25-mile radius of each improvement location are variables that require spatial measurement. GIS can measure distances, measure areas, create buffers at a certain distance from an improvement location, count the number of points within buffers, and do other spatial calculations that are helpful in prioritization processes. Further, GIS can do spatial measurements for an entire set of prioritization locations at once. The results of these measurements can be entered into a GIS database simultaneously rather than one by one, saving significant time.

GIS can be an effective tool for presenting individual components and results of the prioritization process. GIS maps help make the prioritization approach easier to visualize and understand. For example, individual maps can be created to show spatial relationships between high and low values of individual prioritization variables. For example, one map may show locations near key destinations, and another map may show socioeconomic factors (Figure 6). Viewing the maps



Source: City of Seattle, 2009

Figure 6. Example GIS prioritization application.

side-by-side can help illustrate why those two variables lead to top-priority sidewalk retrofit projects near high concentrations of employment.

GIS also has several disadvantages:

- GIS software is required and can be expensive, both in terms of the cost of the software and the cost of a GIS specialist who has the skills to use the software.
- Data used to measure variables in the prioritization process must be in GIS format or geocoded into a GIS-compatible format. Basic roadway and transit route data are often available in GIS, but other types of data such as curb ramp locations, sidewalk widths and conditions, and bicycle facility widths and pavement conditions are less common. Entering this kind of data into a GIS database can be time intensive if the number of locations is large.
- Locations that are being considered for prioritization may not be divided into discrete elements in the same way that the GIS data are organized. For example, an agency may want to prioritize several one-mile corridors, but the existing roadway data are divided into separate segments at each intersection. These individual roadway segments need to be aggregated to the corridor level. Therefore, using a GIS framework for prioritization may require manipulating existing GIS files and geocoding new data files into GIS format.
- Although GIS software allows users to manipulate data using mathematical formulas, it does not store the formulas themselves. As a result, it may be difficult for agencies to review calculations for important steps in the prioritization process, such as scaling and weighting, if the calculations for these steps are performed using GIS software.

Spreadsheets tend to be easier than GIS databases for calculating weights, sorting the final list of projects, and producing tables of prioritized locations for reports. Spreadsheets also retain a record of the formulas used to make mathematical calculations, which can be useful when reviewing prioritization calculations. Fortunately, most agencies with GIS capabilities can convert between spreadsheet and GIS database formats easily.

Appendix B offers additional guidance on using GIS when applying the APT.

Hybrid

It is possible to include elements of different technological approaches in a single prioritization process. For example, some data may be collected manually and then entered into a spreadsheet or GIS database for further analysis. Or, it is possible to collect and organize all of the data needed for a prioritization process in a GIS database and then export the database to a spreadsheet for analysis. This allows an agency to take advantage of the spatial organization capabilities of GIS and the computational analysis capabilities of a spreadsheet.

Examples of Use of Other Tools to Measure Variables

As discussed above, spreadsheet and GIS platforms can be used to measure and create new variables during a prioritization process. There are a number of other tools available for free online and from professional sources that may be useful to measure variables (see Step 7 of the prioritization process). Several of these tools can be used to measure individual variables, while others produce a single output that can be used to summarize the influence of a set of variables.

Google Earth

Google Earth is a free tool that is available to anyone with a computer and Internet to access it. It provides aerial imagery of the entire planet as well as a measuring tool that can be used to obtain dimensional data. The images have sufficient resolution in most urban areas of the

United States to allow users to measure the width of streets, sidewalks, lanes, and other features to the nearest foot (in some cases, the nearest half-foot). In addition, it is possible to measure distances between prioritization locations and other visible features, such as libraries, schools, parks, and transit stations. Therefore, agencies can use Google Earth to identify the presence of facilities like sidewalks and bicycle lanes, measure facility widths, and measure other distances and enter this information into a prioritization database. The aerial imagery in certain locations may be several years old, so it may not show roadway changes or new pedestrian and bicycle facilities that have been added recently. For more information on this tool, see http://www.google.com/earth/index.html.

Google Street View

Google Street View provides images of nearly all streets in the United States from the perspective of cameras mounted on top of cars that capture panoramic shots of the street environment. This tool does not have measurement capabilities, but it allows users to see the presence of features along the roadway. For example, signs, traffic signals, and curb ramps can be identified in specific images. Information about these features can be entered into the prioritization database. Note that this particular tool may work well for collecting specific information about a few locations, but it is time-consuming to view many different roadway segments and intersections. In addition, the Street View images may be several years old, so they may not show roadway changes or new pedestrian and bicycle facilities that have been added recently. For more information on this tool, see http://maps.google.com/intl/en/help/maps/streetview/#utm_campaign=en&utm_medium=van&utm_source=en-van-na-us-gns-svn.

Walk Score®

Walk Score is an online tool that computes an index representing the "walkability" of a location in terms of proximity to local amenities. The walkscore.com website can be used to provide the walkability for any address in the United States, Canada, and many other countries. It can also generate a map showing Walk Score values for an entire community. The locations of amenities used to calculate Walk Score values come from sources such as Google, Education.com, Open Street Map, and Localeze, so the values are updated as the locations of amenities change. Therefore, the accuracy of a Walk Score value depends on the information available from these sources.

Agencies that choose to use Walk Score in a prioritization process should not include separate variables for proximity to activities such as commercial retail and parks, since this would cause them to be double-counted (i.e., counted once as a part of the Walk Score value and counted again as individual variables). It should be noted that the specific algorithms for standard Walk Score or Street Smart Walk Score are not described in detail on the Walk Score website at this time. Therefore, the outcomes cannot be adjusted, or fully explained to stakeholders. In addition, the standard algorithm has changed in the last few years and could change again.

Bike Score™

Bike Score is an online tool developed by the same team who developed Walk Score and measures whether a location is good for biking on a scale from 0 to 100 based on four equally weighted components:

- Presence of bike lanes.
- Presence of hills.
- Destinations and road connectivity.
- Bike commuting mode share.

Unlike Walk Score, Bike Score is currently not widely available. Bike Score is being developed for more locations and its development for specific locations can be requested for a fee. See http://www.walkscore.com/bike-score-methodology.shtml.

Professional Planning and Engineering Tools

There are a number of existing planning and engineering tools that can be integrated into the prioritization framework. For example, *NCHRP Report 616* (Dowling et al. 2008) provided pedestrian level of service (LOS) and bicycle LOS models to evaluate the suitability of urban street segments, intersections, and midblock crossings. These LOS models have been adopted in the 2010 HCM. They use several variables included in the Existing Conditions factor category in this methodology to express pedestrian or bicycle suitability on an A (best) through F (worst) scale. Both of these methods provide an assessment of a pedestrian or bicyclist's feeling of comfort or safety given the existing condition of the roadway (methods also exist to measure delay, however these are not frequently used except in extremely congested conditions). While these LOS models provide a way to quantify the effects of a combination of several variables (e.g., number of lanes, automobile volume, sidewalk width, and bicycle lane width) rather than assessing each variable individually, they require collecting and organizing a large amount of data. The initial multimodal LOS developed for *NCHRP Report 616* may also be updated in the future to provide greater sensitivity to certain roadway design variables.

The list below provides examples of professional planning and engineering tools that could be used to create summary variables in particular factor categories:

Safety

- FHWA Crash Modification Factors (FHWA 2014).
- *Pedestrian Environmental Quality Index*, San Francisco Department of Public Health (San Francisco Department of Public Health 2008).
- *Bicycle Environmental Quality Index*, San Francisco Department of Public Health (San Francisco Department of Public Health 2007)

Existing Conditions

- Pedestrian Segment Level of Service, Developed from *NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets* (Dowling et al. 2008)
- Pedestrian Intersection Level of Service, Developed from *NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets* (Dowling et al. 2008)
- Bicycle Segment Level of Service, Developed from *NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets* (Dowling et al. 2008)
- Bicycle Intersection Level of Service, Developed from *NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets* (Dowling et al. 2008)
- Uncontrolled Midblock Crossing Level of Service, Developed from *NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets* (Dowling et al. 2008)
- Low-stress Bicycling and Network Connectivity, MTI Report 11-19 (Mekuria et al. 2012)
- Pedestrian Environmental Quality Index, San Francisco Department of Public Health (San Francisco Department of Public Health 2008)
- Bicycle Environmental Quality Index, San Francisco Department of Public Health (San Francisco Department of Public Health 2007)

Demand

- Local Pedestrian Demand Model Spreadsheets: e.g., San Francisco, CA (Schneider et al. 2012); San Diego County, CA (Jones et al. 2010); Alameda County, CA (Schneider et al. 2009a)

- Local Bicycle Demand Model Spreadsheets: e.g., San Diego County, CA (Jones et al. 2010); Alameda County, CA (Griswold et al. 2011)
- Pedestrian Environmental Quality Index, San Francisco Department of Public Health (San Francisco Department of Public Health 2008)
- Bicycle Environmental Quality Index, San Francisco Department of Public Health (San Francisco Department of Public Health 2008)

Constraints

- BikeCost Tool, Developed from *NCHRP Report 552: Guidelines for Analysis of Investments in Bicycle Facilities* (Krizek et al. 2006)
- Costs for Pedestrian and Bicycle Infrastructure Improvements (Bushell et al. 2013)

The advantage of using an existing, accepted model is that it already incorporates specific weights that reflect the relative importance of each variable, as identified through empirical research.

Phase I: Conclusion

The first six steps of this process (Phase I) are intended to guide agencies and reduce the time needed in setting up an effective prioritization process. These six steps are considered iteratively, which allows agencies to identify factors and variables that are suitable for the data and technical resources available, and vice versa. The initial scoping steps performed in Phase I are implemented in Phase II, which is described in the next section. By the end of Phase I, an agency should be able to:

- Clarify the purpose of the prioritization effort.
- Know the type and number of improvement locations that will be considered for analysis.
- List the variables within each general factor that will be analyzed to determine priorities.
- Identify the data sources that will be used as inputs during the prioritization process.
- Select the type of the technological platform (e.g., text file, spreadsheet, GIS) that will be used to input data and calculate prioritization rankings in Phase II.