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GUIDELINES FOR PRIORITIZING CURB RAMP RETROFITS UNDER THE AMERICANS WITH DISABILITIES ACT

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Each year, the Virginia Department of Transportation (VDOT) invests millions of dollars retrofitting curb ramps to put them in compliance with the Americans with Disabilities Act. In 2019, VDOT's Traffic Engineering Division (TED) completed an inventory of accessibility barriers, finding that approximately 80% of VDOT's 80,000 curb ramps were noncompliant. As part of its Americans with Disabilities Act Transition Plan, VDOT has developed a plan to retrofit these curb ramps. To prioritize ramp improvements, TED uses a functional condition rating system that is based on ramp width, type of detectable warning surface, and material condition. The purpose of this study was to identify—for a curb ramp improvement program—best practices in prioritization, investment, and program management. The scope was limited to curb ramps, with the prioritization of sidewalk improvements generally falling outside that scope.

The study entailed the following seven tasks: (1) reviewing existing state and national standards and guidance, (2) reviewing the literature related to curb ramps and prioritization processes, (3) gathering information from other states and VDOT districts regarding curb ramp prioritization processes, (4) conducting a survey of Virginia agencies and organizations that work with people with vision or mobility impairments and/or older adults, (5) assessing quantitative prioritization approaches, (6) comparing prioritization processes explored in the prior two tasks, and (7) identifying program performance metrics and developing program guidelines.

The study found that VDOT's current condition-based ramp classification system considers factors different from those of other states' classification systems. The survey yielded no consensus regarding which elements are most important for prioritizing curb ramp upgrades. Study results did indicate, though, that condition was rarely the sole consideration and that respondents tended to consider connectivity. At the local level, officials commonly used the prioritization criterion of transit. For a statewide program, however, such a criterion may be impractical. Virginia is composed of nine diverse VDOT districts; at the state level, a prioritization process should afford these districts sufficient flexibility to apply engineering judgment as they develop factor weights to best meet the needs of their communities. The curb ramp prioritization process would be enhanced by comprehensive sidewalk and crosswalk data, allowing officials to consider connectivity.

The study recommends that VDOT's Central Office TED should, with assistance from the Virginia Transportation Research Council, use this report's guidelines to generate a prioritized set of curb ramps within a curb ramp tracker tool and distribute it to district partners. The study also recommends that TED communicate with district partners and develop training materials to help improve the curb ramp prioritization process. A third recommendation is for TED to monitor technological advancements that might allow for the creation of a statewide inventory of crosswalks to supplement VDOT's existing sidewalk and curb ramp inventories.

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ABSTRACT

In order to bring curb ramps into compliance with the Americans with Disabilities Act (ADA), the Virginia Department of Transportation (VDOT) invests millions of dollars each year in retrofitting them. In 2019, VDOT's Traffic Engineering Division (TED) completed an inventory of accessibility barriers, finding that approximately 80% of VDOT's 80,000 curb ramps were noncompliant. As part of its ADA Transition Plan, VDOT has developed a plan to retrofit these curb ramps. To prioritize ramp improvements, TED uses a functional condition rating that is based on ramp width, type of detectable warning surface, and material condition.

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INTRODUCTION

Curb ramps are universally beneficial. When municipalities implement curb ramps, they improve access for not just people with disabilities but also those using strollers, carts, and luggage, as well as runners and pedestrians. A study of pedestrians at a shopping mall in Sarasota, Florida, showed that nine out of ten “unencumbered pedestrians” went out of their way to use a curb ramp (Blackwell, 2017). Though small when compared to some large-scale transportation projects, curb ramps play a large role in making transportation facilities available and accessible for all users.

Each year, the Virginia Department of Transportation (VDOT) invests millions of dollars in retrofitting curb ramps to bring them into compliance with the Americans with Disabilities Act (ADA). With the third largest state-maintained highway system in the U.S., Virginia has approximately 80,000 ADA curb ramps on VDOT roads (not including ramps on either side of commercial entrances). On a quarterly basis, the Civil Rights Division reports retrofits to the Chief Engineer, so data are available on where improvements have occurred. Once marked as improved, a ramp will not be re-inspected for compliance, though it may require future condition assessments and/or repairs through VDOT’s maintenance and asset management processes.

Title II of the ADA outlines requirements for existing and new facilities operated by a public entity (U.S. Department of Justice, 2010b). The ADA also requires public entities with more than 50 employees to develop an ADA Transition Plan. The plan should contain a self-evaluation, a list of physical barriers in the entity's facilities; methods, a detailed description of how the barriers will be removed; and a schedule for taking necessary steps towards compliance. In spring 2019 and led by the ADA Coordinator in the Civil Rights Division, VDOT published its ADA Transition Plan (VDOT, 2019). Subpart D of Title II of the ADA provides specific requirements for improving facilities and becoming compliant (U.S. Department of Justice, 2010b). Facilities that were compliant with the 1991 ADA Standards for Accessible Design need not be compliant with the 2010 ADA Standards for Accessible Design. Once the facility is altered, however, it must comply with 2010 standards. If strict compliance to the standards is not feasible, facility owners should try to achieve the maximum level of compliance possible. A newly constructed facility should be accessible by 2010 standards.

In 2019, VDOT completed an inventory of barriers using a video log and desktop review of sidewalks and curb ramps visible in these roadway images. The inventory found that sidewalks were mostly ADA-compliant but curb ramps were not, with approximately 80% of the 80,000 falling short. VDOT has developed a plan to retrofit these curb ramps as part of its ADA Transition Plan (VDOT, 2019). The inventory of barriers follows a curb ramp classification scheme that was outlined in a 2017 Instructional and Informational Memorandum (I&IM). VDOT's Traffic Engineering Division (TED) developed the scheme in light of ADA requirements for maintenance and alteration projects (VDOT, 2017). In the scheme, ramps are assigned a functional condition rating based on ramp width, type of detectable warning surface (DWS), and material condition. Maintenance projects include surface sealing, patching, sidewalk repair, and sign repair; ADA upgrades are not required on facilities that are compliant with 1991 standards. Alteration projects do require upgrading items such as curb ramps and include open-graded surface courses, mill and fill, reconstruction, and pedestrian signal installation.

To help determine which curb ramps should be improved first, the I&IM provides a prioritization process. Authorities should improve a curb ramp if it "provides access to a street level crossing that has been paved or otherwise altered and rated in functional condition B, C, or D" (VDOT, 2017). Curb ramps that are not part of an existing or planned project are prioritized based on the functional condition they were assigned. Addressed first are Grade D curbs, where no curb ramp exists in a location that needs one, followed by Grade C and then Grade B ramps, which entails retrofitting or replacing non-compliant curb ramps. Some VDOT districts use methods for prioritizing curb ramp retrofits different from those required through roadway resurfacing projects.

Within a sidewalk network, a missing curb ramp is essentially, for a person with a disability, a missing link. From that perspective, prioritizing the retrofitting of curb ramps is on a par with prioritizing sidewalks, for which a tool does exist—the ActiveTrans Priority Tool (APT). The APT provides a step-by-step process for prioritizing active transportation projects (Pedestrian & Bicycle Information Center, n.d.). The tool allows users to establish a prioritization process that addresses the needs of individual communities by weighting factors and selecting, or adding, relevant variables for the data they want to consider. Depending on the amount of data maintained as part of the curb ramp program, officials may, prior to using the APT, need to use geographic information systems (GIS) to spatially associate data with the curb ramps. Officials could also use GIS to make network calculations, such as sidewalk connectivity.

Exploiting these capabilities, officials could ultimately generate a comprehensive analysis of pedestrian infrastructure.

To ensure that decision-makers make the most of available funding, they should assess the needs of multiple user groups and develop a curb ramp program that reflects those needs.

PURPOSE AND SCOPE

The purpose of this study was to identify existing best practices in prioritization, investment, and program management for an ADA curb ramp improvement program using VDOT's 2019 inventory of barriers.

The scope of the analysis was limited to curb ramps, with the prioritization of sidewalk facility improvements generally being outside its scope. However, when no studies were found that directly addressed prioritization processes for curb ramp improvements, we expanded the literature review to include that topic. Furthermore, if one is considering pedestrian connectivity, one cannot completely decouple sidewalks and crosswalks from curb ramps. This study was also coordinated with a recent research study (Zhu et al., 2020) to avoid overlapping scopes. This study focused on curb ramp prioritization processes rather than on the development of a more complete inventory.

METHODS

To achieve the objectives, this study carried out the following seven tasks:

1. Conduct a background review of state and national standards and guidance related to curb ramps.
2. Conduct a literature review of relevant studies related to curb ramps and prioritization processes.
3. Gather information from other states and VDOT districts regarding their curb ramp prioritization processes.
4. Explore user preferences by conducting a survey of Virginia agencies and organizations that work with older adults or people with vision or mobility impairments.
5. Assess quantitative prioritization approaches using GIS and the ActiveTrans Priority Tool.
6. Compare prioritization processes explored in Tasks 4 and 5.
7. Identify program performance metrics and develop program guidelines.

Conducting the Background Review of Standards and Guidance

To obtain relevant information regarding ADA guidelines and requirements, the research team carried out a background review of standards and guidance related to curb ramps. The review included ADA Accessibility Guidelines and Public Right-of-Way Accessibility Guidelines. VDOT standards and guidelines for ADA compliance were also reviewed.

Conducting the Literature Review

To obtain relevant information regarding curb ramps, the research team carried out a review of the literature using the Transport Research International Documentation database. This review included studies of how people with visual and mobility impairments interact with curb ramps as well as studies of prioritization processes for similar facilities such as sidewalks and accessible pedestrian signals (APS).

Gathering Information from Other States and VDOT Districts

State DOTs and localities have developed various approaches to create prioritization processes based on curb ramp inventories. They include these in their ADA transition plans. With help from the American Association of State Highway and Transportation Officials (AASHTO) Research Advisory Committee, the research team contacted representatives of all 50 state DOTs and the District of Columbia DOT. Those who responded shared what methods their DOTs were using to prioritize curb ramp upgrades and retrofits. The research team also aimed to get a sense of the average cost for curb ramp retrofits around the country.

The literature review found no research studies that directly addressed the curb ramp prioritization process. Therefore, the research team reviewed the ADA transition plans of several counties, cities, and towns outside Virginia. The team’s objective was to determine what priorities each entity incorporated into its process. The search for ADA transition plans was conducted with the goal of finding a selection of localities that were diverse in terms of both geography and population. The team excluded transition plans that included no curb ramp prioritization process.

For ADA issues, VDOT’s TED provided a list of contacts—typically infrastructure, pavement, or construction managers—for all VDOT districts, consisting of Northern Virginia, Fredericksburg, Culpeper, Richmond, Lynchburg, Bristol, Hampton Roads, Salem, and Staunton. To gather information regarding curb ramp prioritization practices at VDOT districts, the research team contacted, by email, these managers. The managers were asked to provide their respective district’s current process for prioritizing curb ramps, as well as how the district incorporated citizen requests for curb ramp improvements. Information was collected through email responses and follow-up phone calls.

Conducting a Survey of Virginia Agencies and Organizations

This task involved collecting information from representatives of agencies in Virginia about perceived ideal prioritization processes for curb ramp upgrades. The representatives work with, or advocate for, older adults and/or individuals with mobility or vision impairments. If VDOT assesses the needs of different populations, it could develop a comprehensive curb ramp prioritization process that best meets the needs of all users while staying within budgetary constraints. The survey distributed to agencies and organizations had the following goals:

1. Assess which physical features of curb ramps are most important for accessibility.

2. Identify which destinations and road types are perceived as a higher priority.

3. Ascertain opinions on ramp conditions and connectivity relative to prioritization.

4. Identify approaches for prioritizing VDOT sample ramps.

Developing and Testing the Survey Instrument

Interview questions were developed to gather information on the needs and preferences of the vision-impaired and mobility-impaired communities, particularly their ideal prioritization processes for curb ramp upgrades. The interview questions were pilot tested with VTRC staff to assess clarity and estimated completion time. The COVID-19 pandemic and the associated stay-at-home orders in Virginia (beginning in March 2020) prevented the research team from carrying out the planned in-person interviews. The interview questions were converted into an online survey, with the format of several questions being changed. The survey content was reviewed by VTRC staff with survey expertise and by the University of Virginia Institutional Research Board.

The survey was constructed in Qualtrics. Additional pilot-testing was necessary to ensure accessibility for respondents with vision impairments. To ensure accessibility of the survey platform and question types, a Rehabilitation Teacher at the Virginia Department for the Blind and Vision Impaired reviewed the survey. As a result, language was added to the introduction page of the survey recommending compatible software programs for use by individuals with vision impairments.

To enable follow-up questions, the first page of the survey collected contact information including name and email. It also asked respondents to indicate if they worked for a disability agency and if they had a mobility and/or vision impairment. Based on answers to these questions, skip logic was used, allowing a unique path through the survey based on each participant’s answers. The full text of the survey can be found in Appendix A.

Questions Displayed to All Respondents

All respondents were presented with questions in the following three sections: accessibility, prioritization categories, and a prioritization exercise.

The accessibility section first assessed the respondent's familiarity with the Americans with Disabilities Act Accessibility Guidelines (ADAAG) and the Public Rights-of-Way Accessibility Guidelines (PROWAG) on a scale from 1 to 3 (1 = have never heard of it and 3 = have read at least one section and/or reference it frequently). Respondents were then asked to select which element(s) in the built environment were most important to them for accessibility (i.e., sidewalks, crosswalks, curb ramps, and APS), and which specific feature(s) of curb ramps (i.e., running slope, cross slope, DWS, level landings, visual contrast, width, and flush transitions).

The prioritization categories section assessed respondents' opinions on which destinations and road types should be assigned higher priorities for curb ramp upgrades. Respondents were asked to choose which condition ramp should be prioritized first—missing ramps (Grade D) or non-compliant ramps (Grade B or C). Participants were also asked how decision-makers, when prioritizing curb ramp upgrades, should consider connectivity of the sidewalk network.

The final section of the survey was a prioritization exercise in which respondents were asked to prioritize a selection of six VDOT curb ramps of varying conditions and locations. To minimize the amount of information being considered at one time and to make the survey accessible to those with vision impairments, researchers used a pairwise comparison process; every two-ramp combination of the six ramps was presented separately (15 total combinations). Included in the survey was a curb ramp information sheet that provided recent images of each ramp along with a text description. The description conveyed information about the ramp's condition rating, road type, destinations served, and additional information. Each question asked respondents to choose which of the two ramps they would prioritize and to explain why. A final question asked respondents to summarize which factors were most influential overall in determining which ramps to prioritize.

Additional Questions Based on Responses

Based on skip logic, respondents answered up to three additional sets of questions; these were designed for agencies, for individuals with mobility impairments, and/or for individuals with vision impairments. Agency representatives were asked to indicate their agency, their position at the agency, and what population group(s) their agency served. Individuals who indicated having either a mobility or vision impairment were asked which, if any, assistive devices they used to travel.

Conducting the Survey

The research team compiled a partial inventory of Virginia groups and organizations whose members included high numbers of older adults or people with vision or mobility impairments. A list of potential contacts was obtained from a recent VTRC study that worked with similar groups (Zhu et al., 2020). Web searches were conducted to find any additional Virginia agencies serving the targeted groups. In cases where a specific contact was not found, an agency's general contact information was used.

Fifty-five agencies and advocacy groups were emailed with a description of the study and a link to the survey (Table 1). If responses were not received within one week, researchers made follow-up telephone calls to agencies and organizations. Because some agencies further distributed the survey to members or related groups, some responses were from individuals not affiliated with an agency.

Table 1. Agencies and Groups Responding and Contacted to Complete the Survey

Agencies/Groups That Completed Survey[a]	Agencies/Groups Contacted That Did Not Respond to Survey
• Access Independence, Inc. • Access to Employment and Information • Accessible Design for the Blind • Alexandria Commission on Aging • American Foundation for the Blind • Blue Ridge Independent Living Center (2 responses) • Chesterfield County Citizen Information and Resources Mobility Services • Department of Education Assistive Technology Group • Department of Veteran Affairs • Disability Resource Center (5 responses) • Endependence Center of Northern Virginia • Greater Richmond Transit Company • Jefferson Area Board for Aging • National Aging and Disability Transportation Center • National Federation of the Blind • National Library Service for the Blind and Print Disabled • Piedmont Senior Resources Area Agency on Aging • Senior Connections • Southern Area Agency on Aging • Unified Human Services Transportation Systems, Inc. (2 responses) • United Spinal Association of Virginia • Valley Associates for Independent Living • Virginia Department for the Blind and Vision Impaired (6 responses) • Individuals not affiliated with an agency (11 responses)	• ADA National Network • Administration for Community Living • Alexandria Division of Aging and Adult Services • American Association for People with Disabilities • American Council of the Blind • Appalachian Independence Center • Arlington Agency on Aging • Centers for Independent Living • Central Virginia Alliance for Community Living • Charlottesville ADA Advisory Committee • Clinch Independent Living Services • Disability Rights and Resources Center • District Three Governmental Cooperative • Eastern Shore Center for Independent Living • Endependence Center, Inc. • Fairfax Area Agency on Aging • Independence Empowerment Center • Independence Resource Center • Independent Resource Center • Junction Center for Independent Living • Lake Country Area Agency on Aging • Loudoun County Area Agency on Aging • Lynchburg Area Center for Independent Living • Muscular Dystrophy Association • National Council on Disability • National Multiple Sclerosis Society • New River Valley Agency on Aging • New River Valley Disability Resource Center • Peninsula Agency on Aging • Peninsula Center for Independent Living • Prince William Area Agency on Aging • Resources for Independent Living, Inc. • Shenandoah Area Agencies on Aging • United Cerebral Palsy of D.C. and Northern Virginia • United States Access Board • University of Virginia Student Disability Access Center • Valley Program for Aging Services • Virginia Association of Area Agencies on Aging • Virginia Board for People with Disabilities

[a] At least 54% completion, i.e., the first two sections of the survey

Analyzing Survey Responses

Prior to performing analyses, researchers performed several data cleaning and data reduction tasks. These included the following:

- *Anonymizing responses.* To protect the privacy of respondents, researchers separated survey responses from the contact information provided.

- *Analyzing incomplete responses.* Researchers removed from the analysis responses with less than 54% completion (i.e., the first two sections of the survey—accessibility and prioritization categories—were incomplete). Included in the analysis of those two sections were partial responses with the first two sections completed but without the completed prioritization exercise.

- *Grouping responses by disability group.* Respondents with disabilities were placed in one of three analysis groups—vision impairment, mobility impairment, or both vision and mobility impairments. Agency representatives who represented a single disability group (i.e., individuals with vision impairments or individuals with mobility impairments) were placed with that respondent group for analysis. Agency representatives who represented all population groups were placed in a separate, fourth analysis group.

- *Applying keyword analysis to qualitative responses.* Qualitative responses were received for two questions in the first half of the survey and all 16 questions in the second half of the survey. To categorize responses, researchers identified key words and phrases in each answer.

Responses to each question were analyzed as a whole and by disability group to identify, among individuals with different disabilities, similarities and differences in prioritization preferences.

Prioritization Exercise

Each respondent's answers to the fifteen questions in the prioritization exercise were transformed into a priority ranking. One point was awarded to the ramp chosen from each pair; the ramps were ranked based on the number of points awarded (highest number of points = highest priority).

In addition to the analysis of individual questions, the prioritization exercise was analyzed to develop one comprehensive ranking to compare to VDOT's current ranking process. For each of the 15 curb ramp pairs, the ramp that was selected by the most participants was deemed a higher priority for improvement. A single ranked list was derived from these results in the same manner as the individual priority rankings above were derived.

Assessing Quantitative Prioritization Metrics

Prioritization metrics were developed using GIS and the ActiveTrans Priority Tool. Several datasets were gathered to represent pedestrian demand, the prevalence of aging and disabled populations, and pedestrian safety (Table 2). Curb ramp condition data were obtained from the ADA Inventory of Barriers completed by VDOT in 2019. In the state and local prioritization processes that were gathered and reviewed, these data types were identified as commonly utilized, and they were readily available for use. The data layers were comprised of different types of features; therefore, each dataset was linked in a different way to the curb ramps. Attributes from polygon features were joined to the ramps located within the same census tract or block. Point and line data were joined with the ramps located within a specified search radius.

Table 2. Data Sources for Analyses of Quantitative Prioritization Metrics

Name	Type	Source	Details	Role in Analysis
Jobs	Polygon	Census Longitudinal Employer-Household Dynamics[a]	Total number of jobs by census block	Pedestrian generator/attractor
Demographics	Polygon	American Community Survey Statistics[b]	% of Census tract population older than age 64	Prevalence of vulnerable pedestrians
			% of Census tract population with a disability	Prevalence of vulnerable pedestrians
Activity Centers	Point	VTrans[c]	Locations of designated Activity Centers	Pedestrian generator/attractor
Transit	Point	Virginia Department of Rail and Public Transportation	Locations of transit stops in Virginia	Pedestrian generator/attractor
Pedestrian Crashes	Point	VDOT[d]	Locations of pedestrian-involved crashes from January 1, 2013 to July 31, 2020	Areas in need of safety improvement
Paving Projects	Line	VDOT	Locations of planned paving projects in Virginia	Nearby projects that could include ramp upgrades

[a] (U.S. Census Bureau, 2018)
[b] (U.S. Census Bureau, 2020a) (U.S. Census Bureau, 2020b)
[c] (VTRANS, 2019)
[d] (VDOT, 2020c)

The maximum area that people will access by walking is generally accepted to be a 10-minute walkshed. Therefore, a search radius of 0.5 miles was used for activity centers (DRPT, 2020). The average person is also willing to walk approximately 0.25 miles to a transit stop, which is the corresponding search radius (Federal Highway Administration, 2008). Researchers captured ramps within 0.25 miles of a planned paving project, as this would allow crews to complete ramp upgrades without substantial remobilization costs. Ramps within 250 feet of a pedestrian crash were identified to capture potential pedestrian safety issues at intersections that may warrant additional consideration.

The curb ramps and spatially associated data were exported and prioritized using a simple weighted scoring system in Excel. The data were also exported to the ActiveTrans Priority Tool programmed spreadsheet. Each prioritization method was evaluated for its potential for scaling to the state or district level, as well as its prospects for automation.

Comparing the Prioritization Processes

This task involved assessing several prioritization processes explored throughout the study to determine how they compare with the existing VDOT process, and what differentiates each. The assessment of quantitative prioritization metrics established two methods for prioritizing ramps, and survey respondents prioritized a sample set of ramps, which were aggregated into a comprehensive list of priorities. The existing VDOT prioritization process is part of the agency's ADA Transition Plan.

Each of these four prioritization processes was applied to a comparison set of six VDOT curb ramps in the Northern Virginia District. Ramps were chosen to represent condition and location characteristics that were similar to those utilized in the survey prioritization exercise. Two ramps were selected for each of the three condition categories—Grade B, Grade C, and Grade D. Researchers identified ramps with destinations similar to those in the survey. For example, at least one ramp provided access to a medical facility, and at least one ramp provided access to a school.

Identifying Program Performance Metrics and Developing Program Guidelines

Program performance metrics were identified by assessing, through the literature review and survey, what elements of curb ramps were most important to track as a measure of progress for the ADA program. Based on the results of the tasks above, guidelines for prioritizing curb ramp retrofits were developed for consideration by VDOT.

RESULTS AND DISCUSSION

Background Review of Standards and Guidance

National and state-level standards and guidance related to curb ramps included the following:

- ADA requirements, implementation guidelines, and proposed guidelines
- VDOT standards and guidelines for ADA compliance

National Standards and Guidance

When it comes to implementing accessibility requirements, there are two sets of federal design guidelines—ADAAG (United States Access Board 2015) and PROWAG (United States Access Board, n.d.). VDOT has adopted PROWAG as a standard (VDOT, 2018) and is also guided by the 2010 ADA Standards for Accessible Design (U.S. Department of Justice, 2010a), which include ADAAG.

Americans with Disabilities Act Accessibility Guidelines

The ADA of 1990 prohibits discrimination against individuals with disabilities. Title II of the ADA applies specifically to state and local government programs and services, with different requirements for existing and new facilities (U.S. Department of Justice, 2010b). ADAAG outlines specific requirements for the design of buildings and facilities to comply with the ADA and is the basis for the regulations enforced by the U.S. Departments of Justice and Transportation (United States Access Board, 2015). ADAAG was first published in 1991 and was the basis for the 1991 ADA Standards for Accessible Design. An updated ADAAG published in 2004 was later adopted as part of the 2010 ADA Standards for Accessible Design (U.S. Department of Justice, 2010a). ADAAG contains specifications for curb ramps including running, cross, and counter slopes; flared sides; width; and landings (Figure 1). Specifications are also provided for DWS, such as contrast and dome size and spacing.

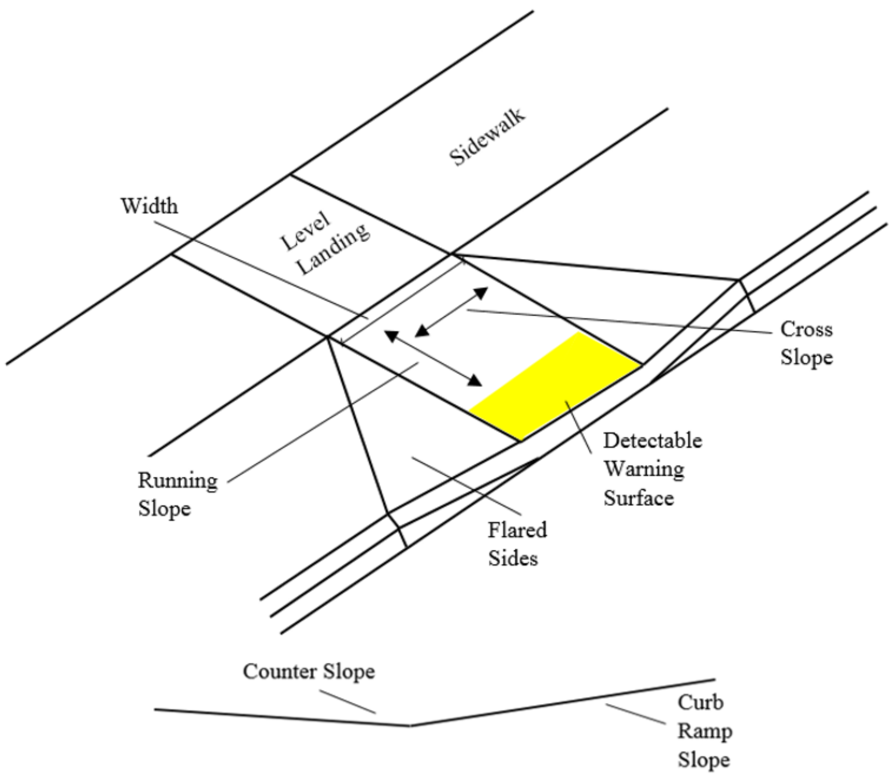


Figure 1. Diagram of Curb Ramp Elements Addressed in Federal Guidelines

Public Rights-of-Way Accessibility Guidelines

Many localities and state DOTs (including VDOT) have adopted PROWAG (United States Access Board, n.d.) as a set of design standards. However, the federal government has yet to adopt it as a set of enforceable standards. Similar to ADAAG, PROWAG covers curb ramps as well as many other elements in the public right of way, such as APS, street furniture, and on-street parking. Specifications for curb ramps in PROWAG include running, cross, and counter slopes; flared sides; width; and turning space. Specifications were also provided for DWS dome size, spacing, and alignment; visual contrast; and DWS size. The DWS specifications were at a level of detail not necessary for this report. Table 3 shows the design guidelines for curb ramps outlined in PROWAG vs. ADAAG.

Table 3. PROWAG vs. ADAAG Physical Specifications for Curb Ramps

Element	PROWAG Specification	ADAAG Specification
Location	Shall connect the pedestrian access routes at each pedestrian street crossing	Provided wherever an accessible route crosses a curb
Running Slope	5% minimum, 8.3% maximum	Shall not exceed 1:12 (8.3%)
Cross Slope	2% maximum	Shall not exceed 1:48 (2.1%)
Clear Width	1.2 m (48 in) minimum	Minimum width shall be 36 in
Surface	Firm, stable, and slip resistant	Firm, stable, and slip resistant
Sides of Curb Ramps	Flared sides 10% maximum slope	Flared sides, where provided, shall not exceed 1:10 (10%)
Top Landing	Minimum 1.2 m (4 ft) x 1.2 m (4 ft) Running slope not greater than 2%	Minimum 36 in clear length, clear width at least as wide as ramp, excluding flared sides
Counter Slope	5% maximum	Shall not exceed 1:20 (5%)
Clear Space	1.2 m (4 ft) x 1.2 m (4 ft) within the width of the pedestrian street crossing and wholly outside the parallel vehicle travel lane	4 ft x 4 ft within marked crossings, if present, and outside of active traffic lanes [a]

PROWAG = Public Rights-of-Way Accessibility Guidelines; ADAAG = Americans with Disabilities Act Accessibility Guidelines.
[a] Only specified for diagonal curb ramps

VDOT Standards and Guidance

VDOT's I&IM 376.1 outlines the requirements for assessing and prioritizing ADA curb ramps within the Commonwealth (VDOT, 2017).

Functional Condition Rating

VDOT established a protocol for assessing the functional condition of curb ramps based on the ramp width, material condition, and DWS (VDOT, 2017). Ramps are given a rating of A through D, with A being fully compliant with VDOT standards and the 2010 ADA Standards for Accessible Design for those three criteria. Grade D is assigned to a location that requires a ramp but has none. Grade N/A is used for locations where ramps are not needed, due to a lack of either a sidewalk or a curb. Table 4 outlines the general requirements for curb ramps in Virginia.

Table 4. VDOT Functional Condition Rating Criteria for Curb Ramps

Grade	Ramp Width	Detectable Warning Surface	Material Condition
A	48 in or greater	Truncated Dome	Fair or Better Condition
B	>36 in to <48 in	Exposed Aggregate Surface	Poor Condition
C	36 in or less	No detectable warning surface	Very Poor Condition
D	A curb ramp is needed but does not exist at the location to access an existing sidewalk where it crosses a curb.		
N/A	A curb ramp is NOT needed at the location.		

A ramp rated as Grade A must meet all of the above criteria. If one or more of the B or C criteria are met for a ramp, the maximum grade the ramp can receive is the lower grade. A ramp that has no DWS, for example, cannot receive a rating higher than Grade C, regardless of its other characteristics, because it meets at least one criterion for a C rating. These criteria do not address all of the specifications outlined in ADAAG or PROWAG, but rather focus on certain elements to characterize condition. Complete design standards for curb ramp retrofits and installations are included in the VDOT Road and Bridge Standards (VDOT, 2020a).

Implementation and Prioritization

If an existing transportation facility is compliant by the 1991 ADA Standards for Accessible Design, VDOT requires ADA assessments and improvements when completing alteration projects but not maintenance projects. Alterations include mill and fill projects and signal replacement; maintenance operations include sidewalk repair and slurry seals (VDOT, 2017). If full compliance with the 2010 ADA Standards for Accessible Design is not feasible due to right-of-way or other constraints, compliance to the maximum extent feasible should be achieved (U.S. Department of Justice, 2010a). All new construction is expected to include curb ramp facilities compliant with the 2010 ADA Standards for Accessible Design.

Other than planned repaving projects, which (as alterations) require curb ramp improvements, VDOT has specified a prioritization process for determining which ramps should receive limited funding in a given year. The priorities are based on the functional rating of the ramps, as outlined below:

1. Installation of Grade D ramps (needed but do not currently exist)
2. Grade C curb ramps – retrofit or replace
3. Grade B curb ramps – retrofit or replace

VDOT specifies that ADA Improvement Funds, distributed to the districts by TED, should not be used to improve or install Grade N/A ramps, because these do not serve existing sidewalks. Additionally, VDOT notes that these funds are intended to be used to complete low-cost, high-benefit improvements; individual projects with substantial constraints may be deferred in favor of more feasible projects—even if the latter were assigned a lower priority rating.

Literature Review

The results of the literature review cover two main topics related to curb ramps: how people with visual and mobility impairments interact with curb ramps, and prioritization processes for related improvements (i.e., sidewalks and APS).

How People with Disabilities Interact With Curb Ramps

Much of the research surrounding curb ramps has been focused on the effectiveness of DWSs and how people with visual and mobility impairments interact with different surface types. Four studies were reviewed. One looked at the built environment and barriers for adults with mobility disabilities. The other three analyzed the detectability and negotiability of DWSs and the perception of these surfaces by people with visual and mobility impairments. These interactions could inform the design of a prioritization process for curb ramp improvements.

Barriers in the Built Environment

A study performed in King County, Washington, involved 35 participants over age 50 who used assistive mobility devices (Rosenberg et al., 2013). Participants wore a GPS tracking device for three days. They were then interviewed about their built environments, particularly in reference to trips that were recorded via GPS. Participants frequently noted that curb ramps were often only on one side of the road or were absent at some crossings along the sidewalk, resulting in them having to travel in the road until curb ramps were available. Also important were the condition of curb ramps; participants avoided broken or steep ramps. Some participants indicated that the DWS was helpful but also slippery when wet. Overall, interviewees affirmed that the presence of curb ramps promoted mobility.

Detectable Warning Surfaces

In 1994, the Federal Transit Administration published a study evaluating DWSs for detectability by users with visual impairments and negotiability by users with physical impairments (Bentzen et al., 1994). In that study, blind participants tested 13 DWSs, which varied in dome size and spacing, for detectability underfoot. In at least 95% of the trials, users detected the 12 commercially available options underfoot; a surface that was not commercially available was detected in 88% of the trials. The study concluded that DWSs can have a range of dome sizes and spacings that vary from ADAAG specifications and still be highly detectable. Participants also used a cane to test detectability again for four of the surfaces, representing extreme cases of detectability. Three of the surfaces were detected in 100% of the trials; the remaining surface was detected in 98% of trials. It was concluded that surfaces that are readily detectable underfoot are also readily detectable by users with a long cane.

Forty participants with physical disabilities tested the relative safety and negotiability of nine detectable surfaces, comparing them to a brushed concrete ramp. Participants used a variety of mobility aids, and seven used no aid. Those using travel aids encountered the fewest difficulties on surfaces with small, widely spaced, horizontally and vertically aligned domes. Users of wheeled devices experienced fewer cases of wheel entrapment with horizontally and vertically aligned domes than with diagonally aligned domes. Considering the negative impact on safety and negotiability that users with physical disabilities experienced, the authors recommended that installed DWSs surfaces with truncated domes) should be limited in width to no more than the width required for users with visual impairments.

A 1995 VTRC study tested 7 DWSs (O’Leary et al., 1995) of varying materials for detectability and negotiability. The detectability of the surfaces was tested by 52 participants with visual impairments. Most used a cane, guide dog, or sighted guide; some used multiple aids, while others used none at all. Participants found domed surfaces far more detectable than aggregate surfaces. The surfaces most often identified as being “very easy” or “easy” to detect were black concrete domes and yellow composite domes.

Six participants with mobility impairments used their mobility aids (wheelchairs, crutches, canes, or human assistants) to test the same 7 DWSs for negotiability. The least preferred DWS was the domed surface, with some participants indicating that they would avoid any domed surfaces when traveling. All participants indicated that lateral domes (corduroy) made movement unstable and that the surfaces easiest to maneuver were aggregate ones.

Another study looked at how truncated dome detectable warnings impacted travelers using wheelchairs (Lee, 2011). Twenty-one participants, using either a manual or a power wheelchair, rated the safety and negotiability of three ramps—one with no DWS, one with squarely aligned domes, and one with diagonally aligned domes. Preferences of manual wheelchair users were split between squarely aligned truncated domes and ramps without domes. Power wheelchair users had a strong preference for the ramp without domes. More than half the participants preferred the diagonal domes least. A statistically significant increase in effort was observed when manual wheelchair users went up ramps with diagonally aligned domes, as compared to ramps with squarely aligned domes.

Prioritization Processes

Although no studies were found that directly addressed prioritization processes for curb ramp improvements, researchers identified studies of, summaries of, and tools for prioritization processes for related pedestrian infrastructure elements, that is, sidewalks and APS.

Sidewalk Prioritization Processes

Researchers reviewed five different prioritization processes for sidewalks. Each used different methods to determine which sidewalk segments should be improved first. The methods used a wide range of data sources, from generalized information about a site to specific data collected for the prioritization process.

In 2013, researchers at Georgia Tech collected sidewalk quality data around the City of Atlanta's Midtown neighborhood using an automated tablet-based system they developed through an Android™ app, Sidewalk Sentry™ (Frackelton, 2013). The app collected GPS-enabled video data as well as information from the accelerometer and gyroscope in the tablet, which was attached to a manual wheelchair. Student researchers and community volunteers recorded sidewalk data for an area covering over 659 roadway miles. A weighted ranking system was proposed in which the data from the app would be combined with pedestrian activity data and demographic data to prioritize projects based on a pedestrian potential index (PPI) and a pedestrian deficiency index (PDI). The PPI assessed variables including pedestrian activity, population density, and transportation mode share. The PDI included sidewalk width and pedestrian crash density. To determine the rank sum, each census block was assigned a rank for each variable, and variables were summed within the PPI and PDI. For each census block, the authors totaled the rank sums for the PPI and PDI and ranked these sums to determine the composite rank for the census block. This method eliminated sidewalk-width data points that represented "no sidewalk"; the Georgia Tech authors indicated that future analyses should include absent sidewalks, which could improve the accuracy of the prioritization.

Another Georgia Tech app, Sidewalk Scout™, allowed users to input measurements of sidewalks, curb ramps, bus stops, and crosswalks (Boyer et al., 2018). All of the data from the apps were uploaded to a Georgia Tech server. Using a semi-automated process, raw data from Sidewalk Scout™ and Sidewalk Sentry™ were aggregated in GIS and assigned to 50-foot sidewalk segments. The sidewalk asset management system compared raw sidewalk data with ADAAG requirements to determine the compliance status for each element. The researchers developed a Sidewalk Prioritization Index (SPI) that prioritized sidewalk links across three categories—safety, mobility, and accessibility. Each category was further broken down into factors such as locations of pedestrian injury, employment district, and presence of an obstruction in the sidewalk. These factors were then weighted based on input from over 1,000 survey respondents to accurately reflect community interests. Final rankings were determined by summing the scores for each factor within each of the three categories and averaging the category scores. To determine which segments should be the highest priority, researchers ranked the final score for each sidewalk segment.

The City of Falls Church, Virginia, created a sidewalk prioritization process that required data about the surrounding area and the physical condition of the sidewalks (City of Falls Church 2012). To categorize the sidewalks, the city identified the following five priority areas:

1. public input requests,
2. sidewalks along transit routes and primary routes to Metrorail stations,
3. sidewalks in commercial corridors,
4. sidewalks along primary and secondary safe routes to schools and the park connectivity plan, and
5. all other sidewalks.

Within each of the five priority areas, the sidewalks were ranked based on the following factors: an ADA compliance score, the number of obstacles along the segment, and the number of noncompliant driveways within the segment. An engineering firm conducted a field review of 441 sidewalk segments in Falls Church. The ADA compliance score was calculated as follows:

$$\text{Compliance Score} = \frac{\text{Length of deficiencies on sidewalk segment (ft)}}{\text{Length of sidewalk segment (ft)}}$$

Deficiencies were determined based on variances from ADAAG requirements. Obstacles were defined as anything that reduced the sidewalk width to less than 36 inches. A noncompliant driveway was characterized by a sidewalk with a cross-slope greater than 2 percent. The final score used to rank the sidewalks was calculated by summing the compliance score, which could range from 3 to 30, and the scores determined from Table 5, based on the characteristics of each sidewalk segment.

Table 5. Point System for Ranking Sidewalk Projects, City of Falls Church, Virginia

Criteria	Score	Measurement
Obstacles	10	Every obstacle that reduces sidewalk width <36 in
Driveways	20	5 or more noncompliant driveways
	10	3-4 noncompliant driveways
	5	1-2 noncompliant driveways

The City's Transition Plan (City of Falls Church, 2012) indicated that the scores were to be used as guidance for developing a repair schedule. The Plan encouraged the repair of entire street lengths, rather than upgrading isolated segments that may not create a continuous accessible path.

The city of Charlotte, North Carolina, had a sidewalk prioritization method in its pedestrian plan (City of Charlotte Department of Transportation, 2017). Eligible sidewalk projects were ranked based on proximity to pedestrian traffic generators, safety factors, connectivity with other sidewalks, cost, and proximity to disadvantaged populations. City staff developed the point system associated with these factors before ranking project lists. The staff could, over time, change the ranking criteria and point values, resulting in projects being reprioritized. Sidewalks on non-thoroughfares were not automatically eligible for ranking; instead, at least 25% of the property owners from both sides of the street were required to nominate them. Sidewalk projects that presented unique circumstances, such as high traffic volumes or speeds, accessibility to transit, or pedestrian safety concerns, could be exempted from the ranking process altogether and moved to the top of the priority list.

A study prioritized 2,349 miles of missing sidewalks in San Antonio, Texas using an Absent Sidewalk Prioritization Model (Anderson, 2018). A focus group provided input to help develop this model, which used the following four indices: a Policy Score, a Demographic Score, a Pedestrian Attractor Score, and a Pedestrian Safety/Health Score. Together, these indices comprised a total of 27 criteria. The Policy Score was composed of two binary elements—location of the missing sidewalk within Regional Centers and within Corridors. The Regional Centers were areas targeted for improvement to facilitate the rapid growth of the city; the Corridors were major connections between the Regional Centers and were targeted for transformation into multimodal corridors (SA Tomorrow Comprehensive Plan, n.d.). The Demographic Score included elements such as residential population density, median household income, and number of persons with disabilities. The Pedestrian Attractor Score included proximity to schools, parks, government offices, healthcare facilities, and retail establishments. The Pedestrian Safety/Health Score captured pedestrian crashes and injuries as well as the functional classification of the street. Each index was weighted equally in determining every sidewalk segment's final score, which was used for prioritization. The author suggested that a future model could incorporate a gap analysis, scoring sidewalk segments based on the length of continuous sidewalk that would result if constructed.

APS Prioritization Processes

Two methods were reviewed that provided processes for prioritizing the installation of accessible pedestrian signals (APS).

In 2003, VTRC published guidelines (developed with VDOT's Northern Virginia District) in response to a request for APS at an intersection in Falls Church (Arnold and Dougald, 2003). These guidelines were established with guidance from VDOT, the Federal Highway Administration, the Virginia Department for the Blind and Vision Impaired, and the blind/visually impaired community. The guidelines first established the basic requirements that must be met before an accessible signal can be prioritized. Such requirements include there being a demonstrated need for APS as well as a submitted request form. For the request to be considered, intersections must be signalized and equipped with pedestrian signals. When evaluated, intersections were assigned points based on the following characteristics:

- Configuration of intersection
- Width of crossing
- Posted speed limit on street to be crossed
- Heavy right-turn volumes that affect crossing
- Free-flow right-turn lane that affects crossing
- Leading or exclusive pedestrian phases; mid-block exclusive pedestrian signals
- Proximity of intersection to pedestrian generators or attractors
- Requesting party’s need is related to work or school
- Length of time intersection has been waiting for funding
- Other special traffic and mobility conditions

Six of the characteristics were binary and when present that characteristic was awarded 15 points. The remaining points were assigned based on the crossing width (2-10), posted speed limit (1-5), proximity to pedestrian attractors (2-10), and time in queue (2-24). The sum of all of these scores could be used to prioritize crossings for a given fiscal year or a long-range plan.

In 2007, NCHRP published the APS Prioritization Tool. This tool uses observable characteristics of individual crosswalks and intersections to determine the crossing difficulty for blind pedestrians (Harkey et al. 2007). Scores calculated with this tool can be ranked. The highest score represents the highest priority, so decision-makers can determine where to invest in APS or on what to prioritize funding allocations for a given year. An intersection is evaluated and assigned tiered point values based on the following characteristics:

- type of intersection (0-14 points)
- type of signalization (0-8 points)
- proximity to transit (0-5 points)
- proximity to facility for visually impaired, including libraries, schools, and rehabilitation centers for the blind (0-10 points)
- distance to major pedestrian attraction (0-5 points)

The scores for each factor are summed to determine the score for an intersection. After scoring the intersection, each crosswalk is evaluated individually. Crosswalks are evaluated and assigned tiered point values based on the following characteristics:

- crosswalk width (0-5 points)
- speed limit (0-5 points)
- crosswalk geometry (1-7 points)
- pedestrian signal control (4-8 points)
- vehicle signal control (2-8 points)
- off-peak traffic presence (1-6 points)
- distance to alternative APS crossing (0-4 points)

- location of pedestrian push-button (3 points)
- requests for APS (0-6 points)

Unlike the intersection-scoring approach, there can be multiple selections for factors of crossing geometry, pedestrian signal control, vehicle signal control, and the pedestrian push-button location. The crosswalk score is determined by summing the points assigned for each factor. To determine the total crosswalk score, the intersection score is added to the crossing score, resulting in a score that accounts for the characteristics of both the crosswalk and the intersection. This tool was designed to evaluate an individual crosswalk rather than an entire intersection. Indeed, rating the intersection as a whole could dilute the score for the most critical crossing, resulting in inaccurate prioritization.

Summary of Literature Review

Needs and preferences regarding DWSs varied greatly by the user's disability; wheeled users preferred aggregate surfaces or no DWS, while visually impaired users needed high-contrast domed surfaces. Studies have shown that diagonally aligned and lateral domes cause unstable movement or require increased effort to navigate and should be avoided in favor of squarely aligned domed surfaces.

The prioritization methods reviewed used a variety of scoring systems. In most cases, factors were weighted to reflect their importance. Both sidewalks and APS were prioritized using characteristics of the infrastructure as well as characteristics of the surrounding area (demographics, pedestrian generators, etc.). No studies were found that directly addressed prioritization processes for curb ramp improvements.

Information from Other States and VDOT Districts

Prioritization processes for curb ramps have been developed at the state and local levels. Some VDOT district practices differ from or build on VDOT's official process.

Curb Ramp Prioritization Processes at State DOTs

Via the AASHTO Research Advisory Committee, the research team distributed to state DOTs the following questions:

- What factors does your state consider when deciding which curb ramps to retrofit in a given year? (Examples include citizen requests, ramp condition, proximity to transit, etc.)

- What has been the average unit cost associated with curb ramp upgrades and retrofits?

Fourteen states responded to the email survey. Seven did not indicate a specific process for prioritizing curb ramp upgrades outside of planned paving projects. Three of the states that lacked a specific process—Delaware, New Jersey, and Vermont—did indicate that they prioritized citizen requests when received. The criteria used for prioritization by each responding state were grouped into the categories shown in Table 6.

Table 6. Prioritization Criteria for Curb Ramps Reported By State DOTs

State	Requests	Condition/ Compliance	Connectivity	Demand/ Pedestrian Generators	Transit
Alabama [a]	-	-	-	-	-
Delaware [a]	X	-	-	-	-
Illinois	X	X	-	X	-
Maine	X	X	X	-	X
Massachusetts	X	-	X	X	X
Montana	X	X	-	X	-
New Hampshire	X	X	-	-	-
New Jersey [a]	X	-	-	-	-
Pennsylvania [a]	-	-	-	-	-
Ohio [a]	-	-	-	-	-
South Carolina	X	X	-	X	X
South Dakota	-	X	-	X	-
Vermont [a]	X	-	-	-	-
Wyoming [a]	-	-	-	-	-

X = State reported using the criterion; - = State did not report using the criterion
[a] State did not provide a specific prioritization process

Table 7 shows the responses received from states regarding the typical costs of upgrading or retrofitting curb ramps. These costs are not necessarily comparable. Some are construction costs per ramp; some are unit costs for ramp components; and some include additional costs such as design. Additionally, some retrofits essentially replace entire ramps while others replace (or add) only certain components.

Table 7. Typical Costs of Curb Ramp Retrofits Reported By State DOTs

State	Cost per Ramp	Notes
Alabama	\$100/SY Curb Ramp \$60/SF DWS [a]	-
Delaware	\$4000 - \$25,000	Depends on complexity, right of way acquisition, drainage
Illinois	\$3250/\$4900	Southern counties/Chicago and surrounding counties
Maine	\$2000 - \$10,000	Depends on side of street, grade, material
Massachusetts	\$16,000	-
Montana	\$13,500	Includes survey and design
New Hampshire	\$3500	-
Ohio	\$14.50/SF	-
Pennsylvania	\$5500	Larger sidewalks in downtown areas can be much higher
South Carolina	\$2600	-
South Dakota	\$2000-\$15,000	-
Vermont	\$1000	-
Wyoming	\$2500	-

- = No notes provided
[a] Detectable warning surface

Curb Ramp Prioritization Processes in Counties, Cities, and Towns

Three county-level ADA transition plans were reviewed (Ada County Idaho Highway District, 2019; City and County of San Francisco Department of Public Works, 2008; Sacramento County, 2013). All three plans introduced a prioritization process based on both the physical condition of the curb ramps as well as the characteristics of the ramp location. Two of the counties—Ada (in Idaho) and San Francisco (in California)—utilized a matrix system that placed ramps in prioritized categories based on a combination of location and condition factors. Sacramento County implemented a Priority Score that combined an Activity Score, a rating of expected pedestrian use, and a Barrier Score—an assessment of the ramp's relative compliance with state and federal standards. The criteria used for prioritization by each county are shown in Table 8.

Table 8. Prioritization Criteria for Curb Ramps Used By Counties

County	Requests	Condition/ Compliance	Connectivity	Demand/ Pedestrian Generators	Transit
Ada County, Idaho	X	X	-	X	X
San Francisco County, California	X	X	-	X	X
Sacramento County, California	X	X	-	X	X

X = County used the criterion; - = County did not use the criterion

Twelve ADA transition plans were reviewed for cities and towns around the United States (City of Loveland [CO], 2015; City of Mesa [AZ], 2016; City of Frisco [TX], 2014; City of Bellevue [WA], 2009; City of Euless [TX], 2020; City of Redmond [OR], 2017; City of Shoreline [WA], 2018; City of Clayton [MO], 2014; Baltimore City Department of Transportation, 2016; City of Portland [OR], 2014; City of San Jose [CA], 2008; Concord Public Works, 2016). Each city and town had a unique prioritization process; nevertheless, several common methods became apparent. Four cities and one town used a scoring system, assigning points for traits that a ramp did or did not possess, including location and condition. Five cities utilized fixed categories to prioritize ramps. Categories were considered high, medium, or low priority and were associated with certain characteristics of ramps. To determine priority, locality staff sorted ramps into categories. One city developed a prioritization matrix combining both location and condition information to prioritize ramps. One city used a system of both categories and scores to create a priority list for curb ramp upgrades. The criteria used for prioritization by each city and town are shown in Table 9.

Curb Ramp Prioritization Processes at VDOT Districts

Prioritization processes were successfully collected for all nine VDOT districts. Two districts—Northern Virginia and Richmond—used the prioritization process outlined by the Traffic Engineering Division (S. Hossain, unpublished data; C. Copeland, unpublished data). This process, described above, involves prioritizing Grade D ramps first, followed by Grade C, then Grade B. The Richmond District respondent noted that the district had not received any citizen requests, but that requests would likely trigger a traffic engineering study to determine how best to prioritize the requested ramp. Additionally, the Richmond District tries, as funds are available, to address corridors with relatively high volumes of pedestrian traffic that require multiple ramp retrofits.

Table 9. Prioritization Criteria for Curb Ramps Used by Cities and Towns

City/Town	Requests	Condition/ Compliance	Connectivity	Demand/ Pedestrian Generators	Transit
Loveland, Colorado	X	-	-	X	X
Mesa, Arizona	X	X	-	X	X
Frisco, Texas	X	X	-	X	X
Bellevue, Washington	X	X	-	X	X
Euless, Texas	X	-	-	X	-
Redmond, Oregon	X	X	X	X	X
Shoreline, Washington	-	X	-	X	X
Clayton, Missouri	X	X	-	X	X
Baltimore, Maryland	X	X	-	X	X
Portland, Oregon	X	X	X	X	X
San Jose, California	X	X	-	X	X
Concord, Massachusetts	-	X	-	X	-

X = City/town used the criterion; - = City/town did not use the criterion

Three VDOT districts—Culpeper, Fredericksburg, and Hampton Roads—reported that they reached out to their residency offices to identify ramps that needed to be improved or hot spots for ADA concerns (R. Ridgell, unpublished data; B. Mosier, unpublished data; A. McGilvray, unpublished data; L. Sewell, unpublished data). Culpeper District also searched for clusters of nearby ramps that were in need of improvement. Hampton Roads District assessed ramps near upcoming paving projects (i.e., at adjacent intersections not being repaved) to determine if upgrades could be included in the paving project. Both Culpeper and Hampton Roads received occasional citizen requests at the residency level, which were addressed as funding allowed. An additional option noted in Hampton Roads was maintenance program funding for safety and operational improvements in the counties, which could be used to address ADA accessibility within a larger planned effort. These funds, however, were limited, with other projects vying for the same money.

The remaining four VDOT districts—Bristol, Lynchburg, Salem, and Staunton—did not have a formal process in place for prioritizing curb ramp upgrades (R. Ratliff, unpublished data; M. Bond, unpublished data; R. Keeler, unpublished data; W. Mann, unpublished data). Bristol District had, at the request of elected officials, installed ramps at a reopened theater and at a park-and-ride lot. Depending on funding availability, Salem District reported focusing on areas of relatively high foot traffic; areas around businesses that serve people with disabilities; and areas around hospitals, schools, and community meeting places. Additionally, the district prioritized locations where ramps were needed but non-existent before replacing existing but non-compliant ramps. Staunton District noted that the majority of its curb ramps were within independent cities and thus outside VDOT's jurisdiction. Three of the districts expressed that a lack of funding outside of planned paving projects limited the number of retrofits they could complete each year.

Summary of Reviewed Prioritization Processes

The prioritization processes reviewed indicated that condition is rarely the only consideration in determining which curb ramps to upgrade or retrofit. Demand, or location of pedestrian generators, was used by all counties, cities, and towns reviewed, as well as 5 of the 7 states that provided a methodology. Transit was frequently used as a factor in prioritization processes at the local level but may be less practical at the state level (only three states used transit). Even within VDOT, where TED's prioritization process is based solely on condition, other factors were often considered. Districts have prioritized ramp upgrades based on pedestrian demand, destinations, and planned paving projects.

Surveys of Virginia Agencies and Organizations

Fifty-five agencies and groups were contacted to complete the survey; some agencies further distributed the survey to members or related groups. Complete responses were received from 24 respondents. Likely due to the length of the survey, 21 additional respondents completed the first two sections of the survey but did not complete the prioritization exercise. These partial responses are included in the analysis of the first two sections.

Respondents who provided complete responses included 18 agency representatives, three of whom had a mobility impairment, four of whom had a vision impairment, and one of whom had both mobility and vision impairments. Of those respondents who provided a complete response and did not work for an agency, one had a mobility impairment, two had a vision impairment, and two had both. One respondent did not work for an agency or identify as having an impairment.

Respondents providing only partial responses included 15 agency representatives, two of whom had a mobility impairment, three of whom had a vision impairment, and one of whom had both. Of those respondents not working for an agency, three had mobility impairments and three had vision impairments.

Agency representatives who indicated that they worked primarily with people with vision impairments or people with mobility impairments were grouped with the respective respondent group for analysis. For example, responses from an agency representative who worked primarily with individuals with mobility impairments were grouped with the responses of individuals with mobility impairments.

Accessibility

The accessibility section consisted of four questions. Respondents were first asked to rate their familiarity with federal accessibility guidelines. Respondents were also asked to select which element(s) in the built environment, and which specific feature(s) of curb ramps, were most important to them for accessibility. This section was completed by all 45 participants.

How familiar are you with the federal Americans with Disabilities Act Accessibility Guidelines (ADAAG)? Public Rights-of-Way Accessibility Guidelines (PROWAG)?

These two questions asked participants to rate their familiarity with ADAAG and PROWAG on a scale of 1 (I have never heard of it) to 3 (I have read at least one section and/or reference it frequently). Most respondents (93%) had heard of ADAAG. Of the 42 respondents who had heard of ADAAG, 30 had read at least one section and/or referenced it frequently. Two-thirds of respondents had heard of PROWAG. Of the 30 respondents who had heard of PROWAG, 11 had read at least one section and/or referenced it frequently. Several participant comments throughout the survey reflected a familiarity with federal standards and guidance.

What elements of the built environment do you think are most important for accessibility?

This question allowed multiple selections. As shown in Figure 2, nearly all respondents (41) selected sidewalks as an important element for accessibility. Curb ramps had the lowest number of selections (33) but was still selected by more than two thirds of respondents. Separating responses by population group (Figure 2), no clear preference emerged for one element over another; respondents identified all as being important for accessibility.

Respondents could also select "Other" and provide additional elements that were important to accessibility. Seven respondents listed features including road or intersection design, accessible signage, door openers, and accessible driveway slopes.

The survey results show relatively small differences in the number of responses for each choice. The fact that every element was important for accessibility for over two-thirds of respondents is unsurprising, given that pedestrian facilities work together as a network.

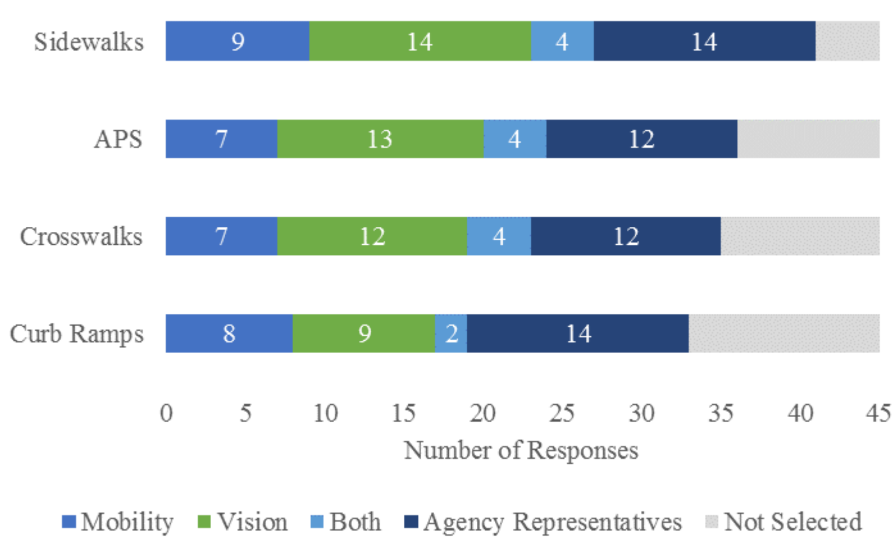


Figure 2. Features of the Built Environment Identified as Important for Accessibility

Which physical features of curb ramps are most important for accessibility?

This question allowed multiple selections. DWSs (29 responses) and running slope (28 responses) were most frequently selected as important features of curb ramps (Figure 3). Cross slope and width were selected by the fewest respondents, with 17 and 16 responses, respectively. One respondent commented that all features are important and are included in ADAAG and PROWAG. All features were important to at least one-third of respondents.

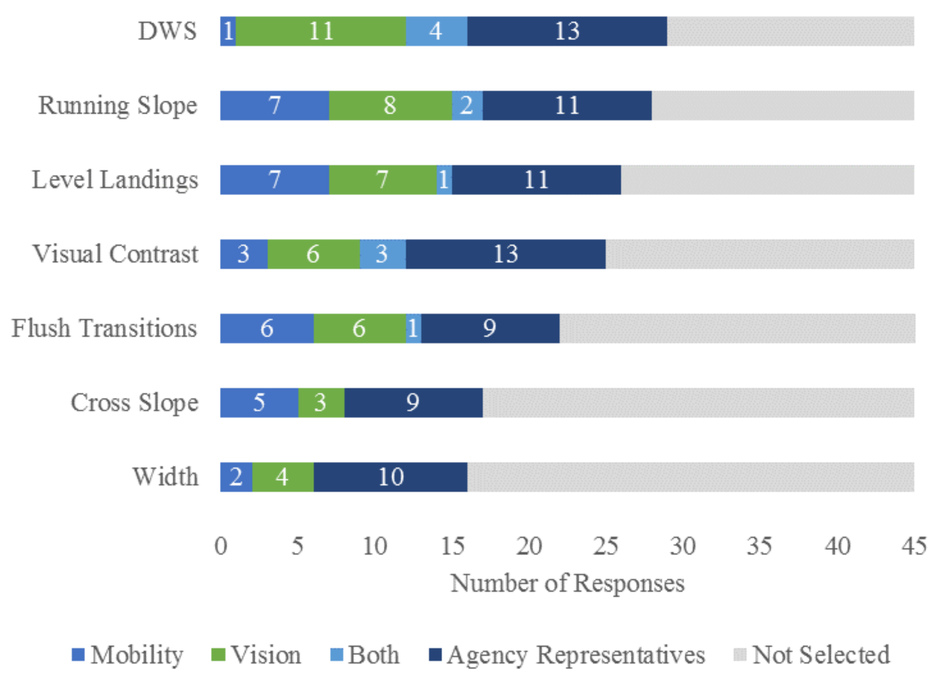


Figure 3. Features of Curb Ramps Identified as Most Important for Accessibility

Separating responses by respondent disability, Figure 3 shows the differing importance of various curb ramp features to different disability groups. Respondents with mobility impairments most frequently selected running slope and level landings, whereas only one of nine respondents with mobility impairments selected DWS. Conversely, DWS was the most frequently selected choice by respondents with vision impairments (11 of 15 respondents). One respondent commented that the answer would depend on whether the user is someone who uses a wheeled mobility device or has vision impairments. Respondents with both mobility and vision impairments selected DWS and visual contrast as the most important features for accessibility. Responses from agency representatives who represented all groups did not indicate a clear preference for one feature over another, which could suggest that when considering all users' needs, there is no single most important feature.

Respondents could also select "Other" and provide additional features of curb ramps that were important for accessibility. One respondent included an additional feature—the ramp angle and alignment with the far-side curb ramp.

Prioritization Categories

The prioritization categories section of the survey contained four questions and asked respondents to consider how curb ramps should be prioritized based on proximity to destinations, road type, connectivity, and physical condition. All 45 respondents completed this section.

Which destinations should be assigned higher priority for curb ramp upgrades?

This question allowed multiple selections. Commercial sites and schools were selected by the most respondents (36 and 35 responses, respectively). The least selected choice (30 respondents) was residential. Separating responses by population group (Figure 4), no clear preference emerged for prioritizing curb ramps serving any particular type of destination, with one exception. While commercial was the most-selected destination type for most population groups, it was the least-selected among agency representatives who worked with all groups.

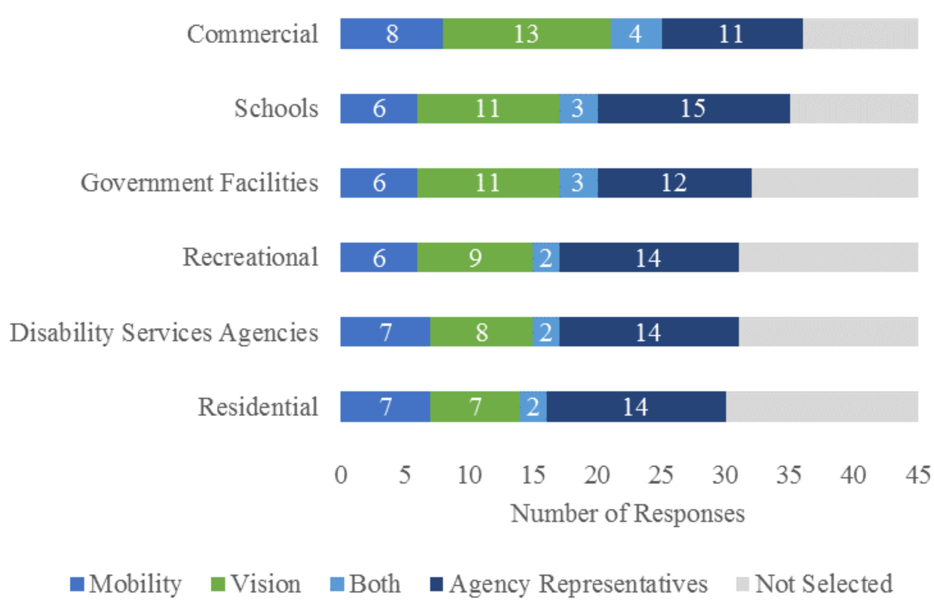


Figure 4. Destinations Identified as Highest Priority for Curb Ramp Upgrades

Respondents could also select Other and provide other types of destinations that should be considered for curb ramp upgrades. Four respondents included additional destinations—health care facilities, major road corridors, and essential services. Two respondents indicated that it is important to have access to all types of destinations.

Again, due to the relatively small differences between answer choices and the varied number of selections made by each respondent, there is no destination type that respondents thought should clearly be prioritized over another.

Which road type should be assigned higher priority for curb ramp upgrades?

This question asked respondents to select one of the following road types as highest priority for curb ramp upgrades:

- roads with speed limits of 35 MPH and below, low traffic volumes, and direct access to buildings and other destinations adjacent to the road
- roads that offer a balance between access and mobility, with moderate speeds
- major roads with speeds of 35-55 MPH, high traffic volumes, traffic lights, and sometimes transit routes

As shown in Figure 5, no one single road type emerged as a clear preference, although roads that balance mobility and access were selected by the fewest respondents.

Figure 5. Road Type Identified as Highest Priority for Curb Ramp Upgrades

Respondents who represent the vision-impaired community expressed a clear preference for prioritizing high-speed, high-volume roads for curb ramp upgrades. All respondents with both vision and mobility impairments selected low-speed, low-volume roads as the top priority. Respondents with mobility impairments selected either low-speed, low-volume roads or roads that provide a balance between access and mobility. Agency representatives did not express a clear preference for one road type over another.

When there is limited funding for curb ramp improvements, should connectivity be considered when prioritizing curb ramp upgrades?

This question allowed for a short response; eight participants did not provide an answer. As shown in Figure 6, the majority of respondents stated that connectivity should be considered when deciding which ramps to improve. Six of these respondents indicated that access to destinations and pedestrian demand should be considered in conjunction with connectivity. Only five respondents did not think connectivity should be considered.

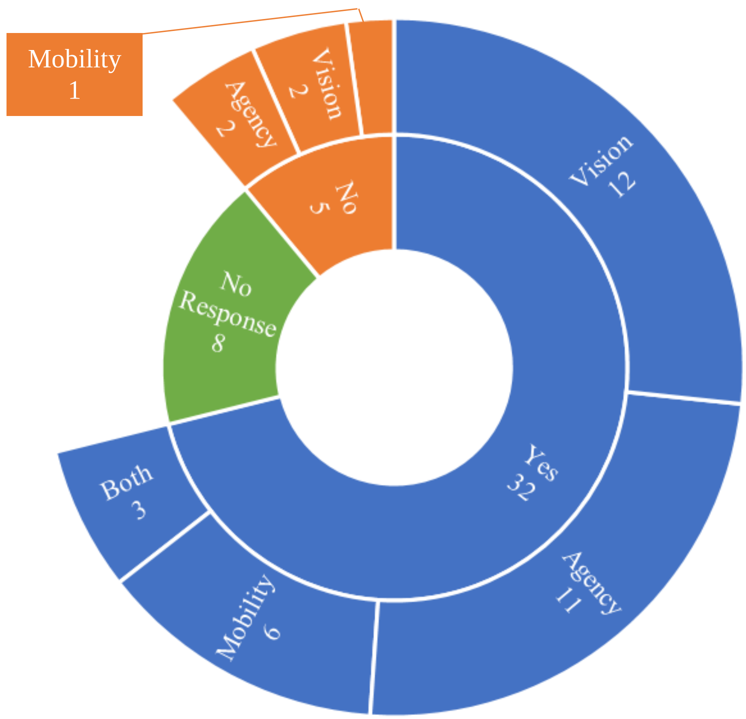


Figure 6. Connectivity as Consideration for Prioritizing Curb Ramp Upgrades

More than 50% of every analysis group favored considering connectivity when prioritizing curb ramps. These results indicated fairly broad agreement among survey respondents that connectivity should be considered in determining which ramps to prioritize within funding constraints.

If you had limited funding for curb ramp improvements, would you first improve existing non-compliant ramps rated B or C, or build ramps where none exist (condition D)?

This question allowed for a short response and was prefaced by a description of the VDOT curb ramp grading system, ranging from A (ADA compliant) to D (non-existent), with B and C representing varying levels of non-compliance. Four respondents did not provide an answer. Key words and phrases were identified and used to categorize responses as either Install Missing Ramps or Upgrade Existing Ramps. Phrases such as “build ramps where none exist” were categorized as Install Missing Ramps; phrases similar to “non-compliant ramps” were categorized as Upgrade Existing Ramps. Three responses did not fit into either of these categories and were categorized as Other.

As shown in Figure 7, most respondents would install a missing ramp before upgrading existing ramps. Approximately one-quarter of respondents would upgrade existing non-compliant ramps first.

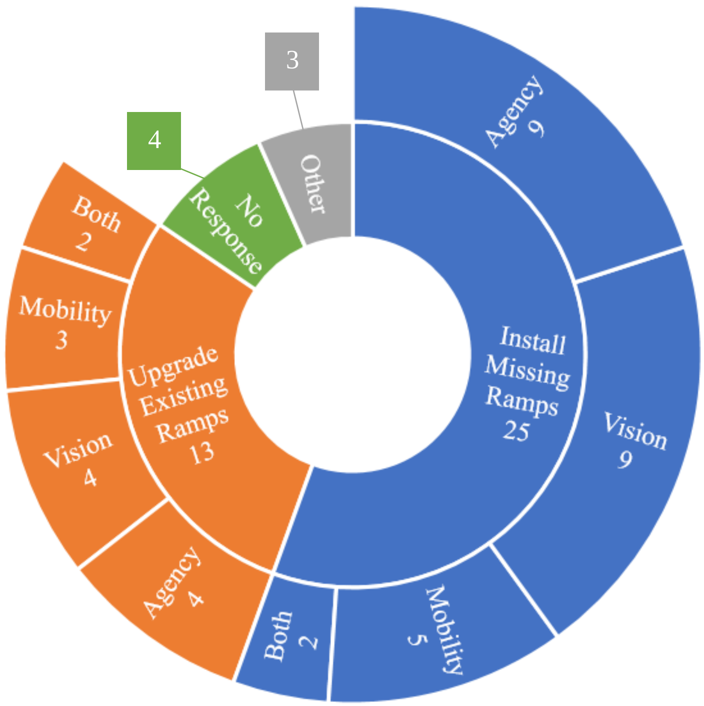


Figure 7. Condition as Consideration for Prioritizing Curb Ramp Upgrades

Of the three responses that were categorized as Other, one stated that each ramp should be evaluated independently, and that consideration of condition would depend on the particular situation (e.g., other factors being considered). The other two responses were unclear. One noted the overall importance of maintaining accessible features and that all ramps need to be a priority. The other said that Grade A ramps should be prioritized (but Grade A ramps are compliant and do not require upgrades).

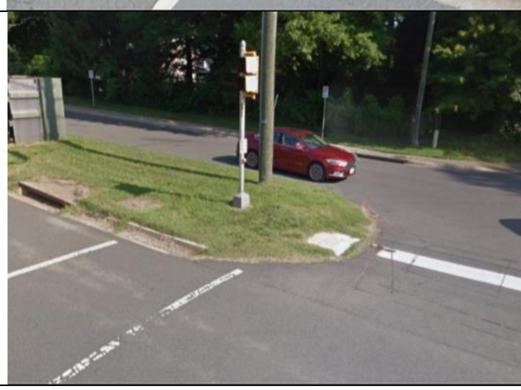
Separating responses by population group, disability groups, aside from respondents with both vision and mobility impairments, preferred to first install missing ramps. Two such respondents chose to prioritize upgrading existing non-compliant ramps, and the other two indicated that they would prioritize installing missing ramps.

Prioritization Exercise

The prioritization exercise was a series of 16 questions and was completed by 24 respondents. The first 15 questions provided every two-ramp combination of six VDOT ramps and asked respondents to choose which of the two ramps they would prioritize and to indicate why they chose that ramp. As described in Methods, respondents were provided with information about the curb ramps. This information is presented in Table 10. The curb ramp information sheet, as presented to respondents, is available from the authors. The final question asked respondents to summarize which factors were most influential in prioritizing the ramps.

Table 10. Curb Ramp Information Provided to Survey Respondents

Ramp No. (Condition Rating)	**Photo** [a]	**Road Type**	**Destinations Served**	**Additional Information**
Ramp 1 (Grade B)		8-lane divided roadway, 40 MPH speed limit	Condo community, shopping center, office park, 12 transit stops	Curb ramp used to cross driveway; not aligned with crosswalk; completes lengthy pedestrian access route established by previous improvements
Ramp 2 (Grade B)		2-lane undivided roadway, 30 MPH speed limit	Hospital, nursing home, single-family residences, 11 transit stops	Curb ramp used to cross driveway, not aligned with the crosswalk, crosses to ramp of similar condition
Ramp 3 (Grade C)		6-lane divided roadway, 45 MPH speed limit	Restaurants, shopping center, hotel, 11 transit stops	Curb ramp used to cross side street, ramp crosses to a Grade B ramp

Ramp 4 (Grade C)		7-lane divided roadway, 45 MPH speed limit	Single-family residences, 11 transit stops	Curb ramp used to cross roadway, aligned with existing crosswalk, connects to Grade A ramp across the street
Ramp 5 (Grade D)		2-lane residential street, 25 MPH speed limit	Elementary school, park, single-family residences, church	Curb ramp used to cross roadway, at existing crosswalk, currently using private driveway as curb ramp
Ramp 6 (Grade D)		4-lane divided roadway, 45 MPH speed limit	Single-family residences, church, community college, 7 transit stops	Curb ramp needed to cross roadway, at existing crosswalk, no sidewalk present on the other side, has pedestrian push-button, near planned paving project

[a] *Image captures © 2021 Google: October 2016 (Ramp 1), May 2018 (Ramp 2), June 2018 (Ramp 3), September 2014 (Ramp 4), April 2012 (Ramp 5), and July 2018 (Ramp 6)*

Figure 8 shows which ramp was selected by the most participants out of each pair, broken down by respondent group. Ramp 6 was consistently chosen while most participants were consistent in not choosing Ramp 5.

As discussed in Methods, one point was assigned to the ramp in each pair that was selected by the most respondents. For pairs that were tied, half a point was assigned to each. Based on these selections, points were assigned as follows: Ramp 1 (1.5 points), Ramp 2 (1.5 points), Ramp 3 (4 points), Ramp 4 (3 points), Ramp 5 (0 points), Ramp 6 (5 points). The final priority ranking from the survey's prioritization exercise was as follows: ramp 6 was the top priority, followed by ramps 3, 4, 1 and 2 (tied), and 5.

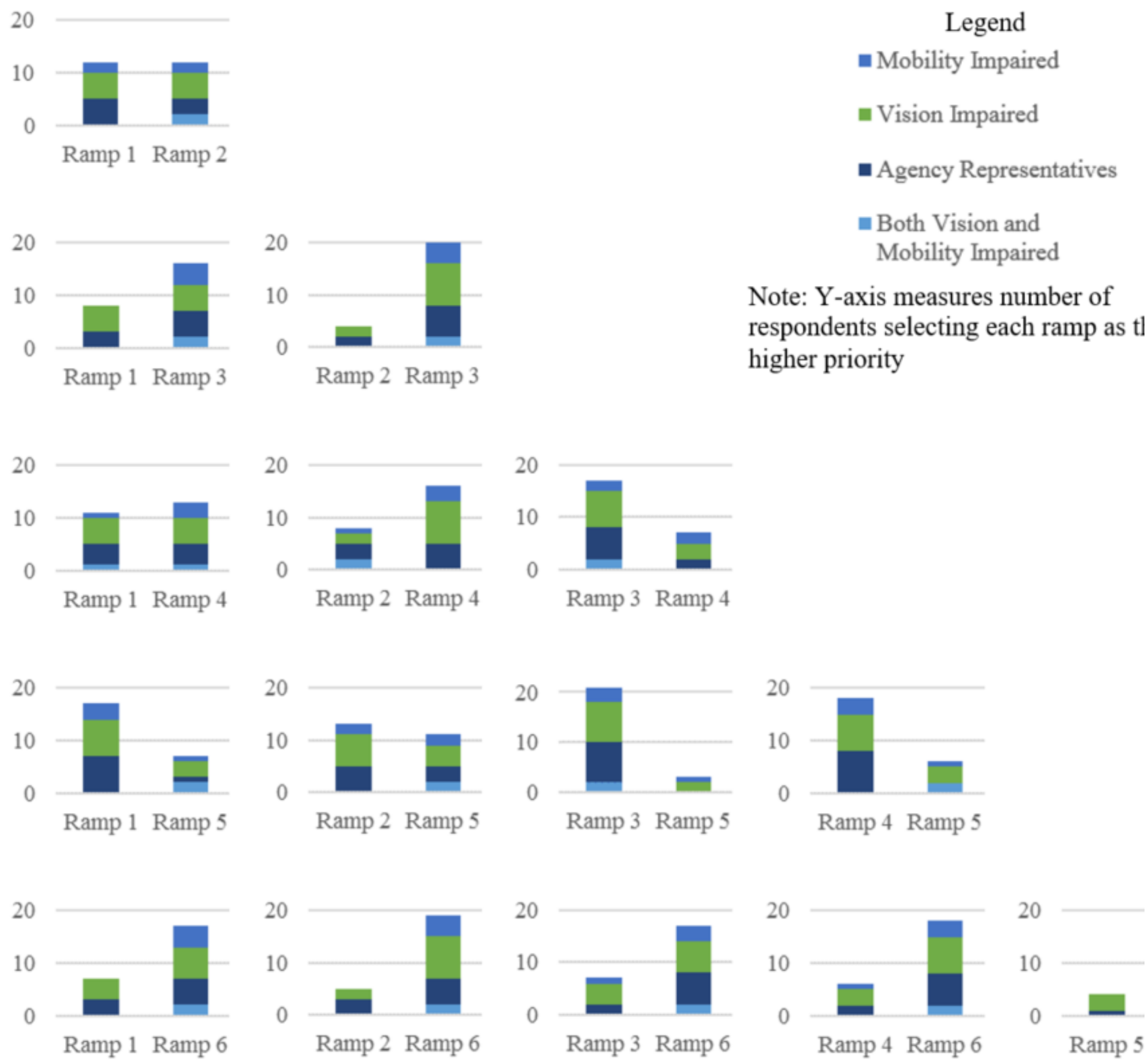


Figure 8. Results of Pairwise Ramp Prioritization Exercise by Respondent Group

Respondents provided justification for each pairwise selection, as well as their overall priorities for curb ramp improvements. The most frequently cited justification was condition; this included uneven surfaces, lips, DWS, cross slope, and obstacles. Another common justification was type and number of people served, which respondents derived or assumed from the quantity or type of destinations served by the ramp. For example, ramps located in dense residential areas or located near medical facilities were prioritized in part due to the people they were likely to serve. Other common justifications included the following: road type, completing or lengthening a pedestrian access route, orientation of the ramp with the crosswalk, destinations served, transit stops served, and the need for additional roadway improvements.

Ramp 6 was frequently chosen for its condition rating as well as the need for other roadway improvements (missing sidewalk, inaccessible pedestrian push-button). Conversely, many respondents stated that they chose one ramp over another because the other was “too bad,” suggesting a threshold at which respondents deemed a ramp in too poor a condition, or in need of too many improvements, to award it the higher priority.

Quantitative Prioritization Metrics

GIS Analysis

An initial review of the curb ramp layer indicated that there were several ramps that had been mapped multiple times. Researchers removed 1,537 identical entries from the dataset, so there was only one entry representing each ramp. Grade N/A ramps are "not needed at the location under evaluation" (VDOT, 2017). Given that these locations need not be prioritized for improvement, 13,807 Grade N/A ramps were removed from the layer. Neither do Grade A ramps require upgrades, so 14,355 such ramps were removed from the prioritization sample. The remaining sample consisted of 57,161 ramps, tagged as Grade B, C, or D.

All data layers were clipped to capture a small sample area (reducing processing time) to identify the potential for application of the analysis process on a larger scale. The sample area was 100 square miles in the Northern Virginia District (Figure 9). The Northern Virginia District was identified from the inventory of barriers as a location with densely located ramps. An area within this district was arbitrarily selected to capture approximately 10,000 curb ramps. The diversity of ramp conditions, land uses, and destinations within the sample area allowed for a complete evaluation of the analysis process without requiring a statewide analysis.

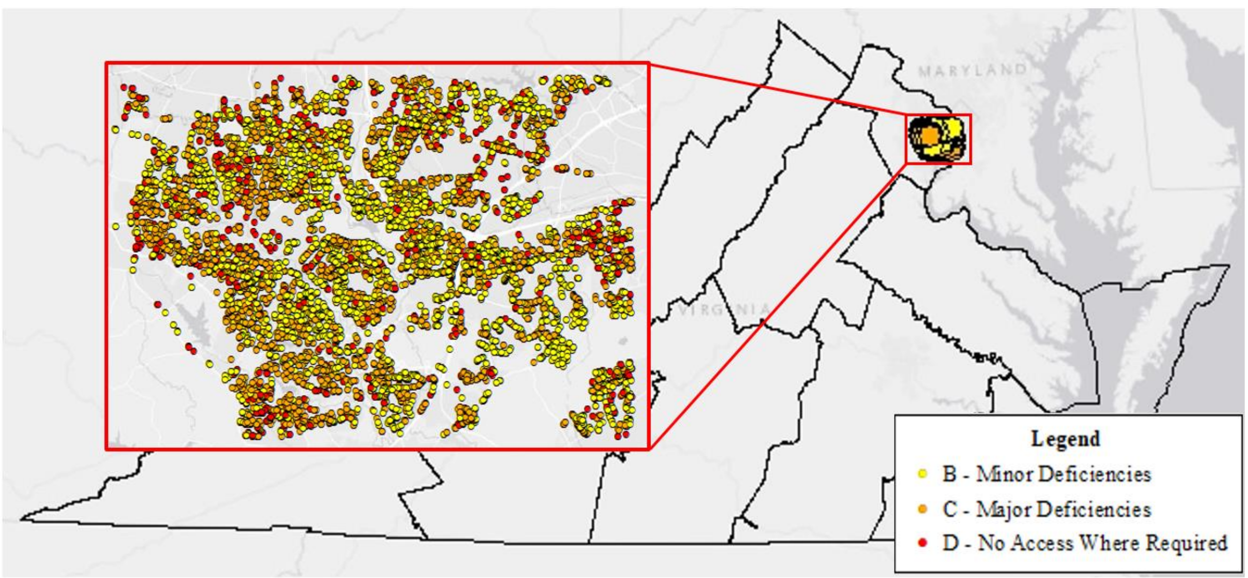


Figure 9. Sample of Curb Ramps in Northern Virginia for GIS Analysis

All selected data sources were linked to the curb ramp layer based on a proximity analysis. Table 11 shows the search radii used to associate different data sources with the curb ramp layer. Due to incomplete pedestrian network data, all search radii were measured using a Euclidean distance rather than a network distance.

Because calculations within a GIS attribute table are not saved, the spatial data were exported to an Excel spreadsheet to perform calculations. Each dataset was converted from raw values to rank scores, ranging from one to the number of ramps being prioritized (11,191 in the sample). Identical values were assigned the same rank score. To determine a final priority score, category rank scores were weighted and summed across all variables.

Table 11. Search Radii for GIS Analysis

Category	Data Layer	Feature Type	Radius
Equity	Demographics	Polygon	Not Applicable
Compliance	Inventory of Barriers	Point	Not Applicable[a]
Destinations	Jobs	Polygon	Not Applicable
	Activity Centers	Point	0.5 miles
Safety	Crashes	Point	250 feet
Opportunities	Paving Projects	Line	0.25 miles
Transit	Transit	Point	0.25 miles

[a] Ramp condition was already assigned to curb ramps in the Inventory of Barriers GIS layer.

Development of Weights

The results of the survey were used to develop weights for each category for use in the GIS analysis (Table 12). Of the justifications that survey respondents identified in the prioritization exercise, only five had available data sources, and varying percentages of responses cited each category. To arrive at the GIS weight, researchers took the following steps:

1. The percentage of responses representing each category was calculated.
2. Survey respondents cited transit as a justification but did so the least frequently of all cited justifications. Each category's percentage of responses was converted to a "factor of transit" by dividing each category's percentage of responses by transit's percentage of responses (thus, transit's "factor of transit" was 1).
3. Data were available for paving projects to represent the category of Opportunities, but no survey respondents cited it as a justification for their prioritization choices. Given the unknown importance of incorporating paving into the prioritization, the Opportunities category was assigned equal importance to transit.
4. Revised percentages for each category were calculated to account for the addition of paving projects into the analysis.
5. The new percent values were rounded up or down to whole-number weights, for ease of use, such that all integer GIS weights summed to 100.

Table 12. Development of Weights for GIS Analysis

Category	Percent of Responses	Factor of Transit	Revised Percentages	GIS Weight
Equity	28.6	5	27.0	27
Compliance	25.7	4.5	24.3	25
Destinations	22.8	4	21.6	22[a]
Safety	17.1	3	16.2	16
Opportunities	-[b]	1	5.4	5
Transit	5.7	1	5.4	5

[a] The weight for the Destinations category is applied to the average of the scores for Jobs and Activity Centers.
[b] Opportunities (i.e. paving) was not cited by any respondents in the survey

Given that the weights were derived from a small-sample survey, adjustments could be made in the future to reflect the needs of the state or a specific community.

Final Priority Scores

The above weights were applied to rank scores in each category, and final priority scores were calculated by summing the weighted category scores for each ramp. Final priority scores were imported back into GIS and associated with ramps based on a unique Ramp ID. Priority scores were divided into five quantiles and color-coded (Figure 10). This allowed for the visualization of both individual ramp priority and where concentrations of high-priority ramps exist.

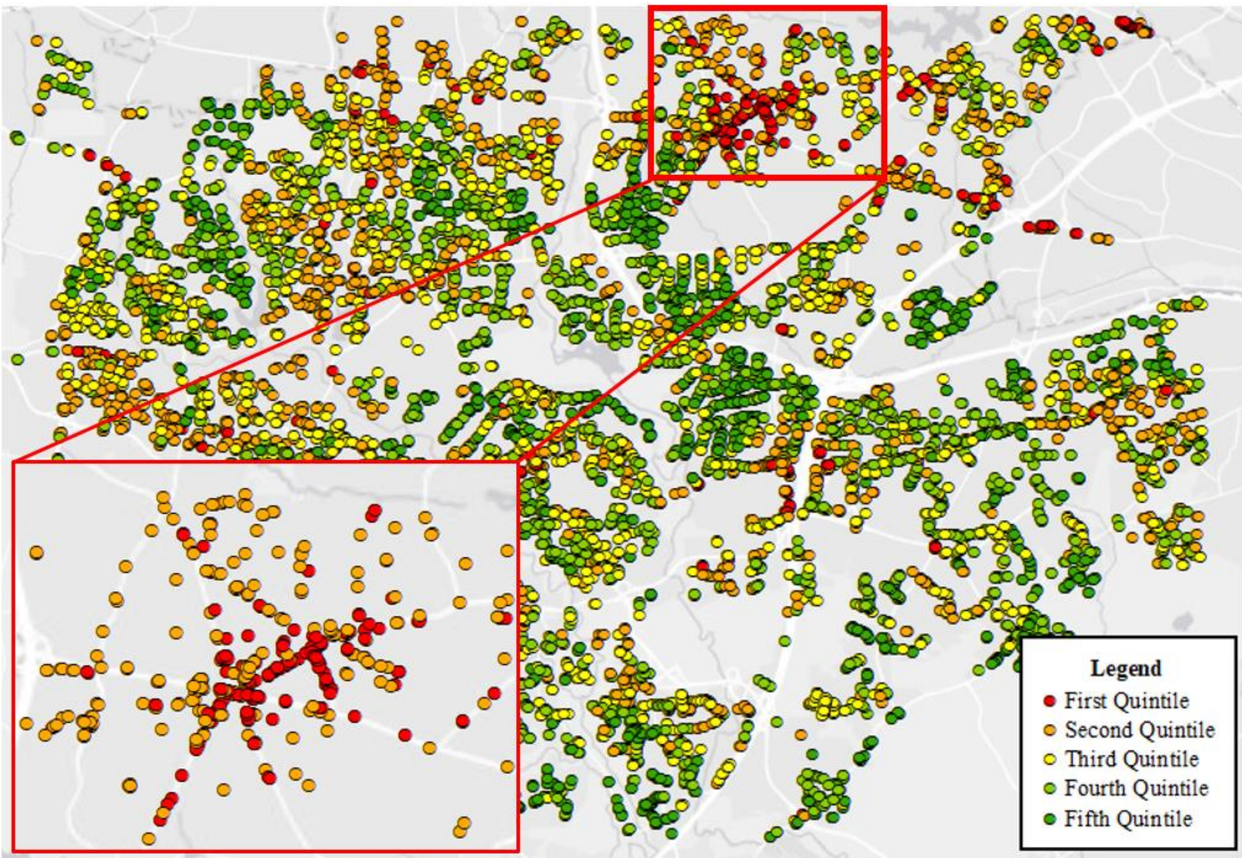


Figure 10. Results of GIS Analysis for Sample Curb Ramps; Inset Highlights Cluster of High-Priority Ramps

One possible reason for the existence of a cluster of high-priority ramps (such as that shown in the inset of Figure 10) is that a neighborhood's roadways could have been developed during a time before current curb ramp standards were in place. An efficient way to address these clusters of high-priority ramps may be the corridor-based approach that results from VDOT upgrading ramps along with repaving projects. That approach could also explain clusters of lower priority ramps, which might be in corridors where ramps were recently upgraded along with repaving.

Analysis in GIS allows for the visualization of the spatial relationships between curb ramps, sidewalks, land uses, and paving schedules, among other factors. Although more efficient than some methods, GIS processing time could become burdensome if applied at too large a scale. (To process, on a consumer-grade computer, the 100-square-mile sample area took less than one hour). Future analysis could be automated in GIS using ModelBuilder. ModelBuilder stores workflows, allowing geoprocessing tools to be executed consecutively, using the results of one tool as the input of the next. The models can be stored or shared, which would allow for consistent processes in subsequent analysis periods and across Virginia. New or updated data sets could be added to the model as they are released.

ActiveTrans Priority Tool

The APT's programmed spreadsheet is equipped with nine factors to use, each with several variables into which data is classified, whereas specific categories were defined for the GIS analysis to reflect the available data (Lagerwey et al., 2015). The Demand factor in the APT encompasses both the Destinations and Transit categories from the GIS analysis. The tool also allows project-specific variables to be added to the analysis; for this analysis, number of transit stops, proximity to activity centers, and number of jobs were added. Table 13 shows the factors and variables used in this analysis; the same data sources were used as those in the GIS analysis.

Table 13. Inputs for ActiveTrans Priority Tool Analysis

Factor	Variable	Data Source	Factor Weight
Equity	% with Disabilities	American Community Survey Disability Statistics	10[a]
	% Older than Age 64	American Community Survey Population Statistics	
Demand	Number of Transit Stops	Virginia Department of Rail and Public Transportation Transit Stop Data	10[b]
	Proximity to Activity Centers	VTrans Activity Centers	
	Number of Jobs	Census Longitudinal Employer-Household Dynamics database	
Compliance	Non-Compliance with State Standards	VDOT Inventory of Barriers	9
Safety	Total Pedestrian Crashes	VDOT Traffic Engineering Division Crash Application	6
Opportunities	Implement with Future Construction	Paving schedule	2

[a] *The weight for the Equity category is applied to the average of the scores for % with Disability and % Older than Age 64.*
[b] *The weight for the Demand category is applied to the average of the scores for Number of Transit Stops, Proximity to Activity Centers, and Number of Jobs.*

The APT requires that, prior to using the spreadsheet, data already be linked to each ramp. GIS provides an efficient method for spatially associating the data sources and curb ramps, as described above. Curb ramps and the associated data were exported from GIS for use in the APT.

Each factor shown in Table 13 was weighted from 0 to 10 indicating its relative importance for determining curb ramp prioritization. Weights were determined by scaling the weights derived for the GIS analysis (originally from the survey results; see Table 12) to fit the 0-to-10 scale used by the APT. The highest priority factors identified in the survey—Equity and Demand (destinations and transit combined)—were assigned a factor weight of 10. A scale factor of 2.7 (GIS weight for Equity divided by APT weight for Equity) was calculated to scale the remaining weights between 0 and 10. These calculations were rounded to whole numbers, as required by the APT spreadsheet.

The APT offers several options for scaling, which adjusts raw variable data to fit a common scale, typically 0 to 10. Rank order, quantile, and proportionate scaling were all used in this analysis as follows:

- Rank order scaling calculates the rank for each value and scales the rank values proportionally from 0 to 10. Rank order scaling was used for variables that were likely to have outliers but were also likely to have many duplicate values. This method eliminates disproportionately high or low scores for outliers and assigns the same score to identical values. (Quantile scaling also accounts for outliers, but duplicate values may span multiple quantiles.) Rank order scaling was used for variables in the Opportunities, Safety, and Demand (Transit and Activity Centers variables only) factors.

- Quantile scaling divides the data into equal groups (quantiles) and assigns scores proportionally; this analysis used 10 quantiles and scored the values from 0 to 10. Quantile scaling was used for data that included outliers but were not likely to have duplicate values; too many duplicate values could result in the same value being placed in two different quantiles, causing potential disparities in the final rank scores. This method was used for variables in the Demand (Number of Jobs variable only) and Equity factors.

- Proportionate scaling assigns scores on a scale from 0 to 10, proportionate to the raw data. The lowest data value is assigned a score of 0, and the highest data value is assigned a score of 10. This method was used to scale the Compliance factor variable, which had values ranging from 0 to 3 with no outliers.

Table 14 shows a sample of ramps from the analysis and their corresponding variable scores. Each of the categories shown was scaled differently. Transit Stops were scaled using rank order scaling; Number of Jobs were scaled using quantile scaling; and Design Compliance was scaled using proportionate scaling. All scaling methods result in scores ranging from 0 to 10.

The Demand and Equity factors had multiple variables. Therefore, the scaled scores were averaged to determine one score for each factor. Table 15 shows a sample of ramps, each of the three scores for the Demand variables, and the final averaged Demand score.

Table 14. Example of Scaling Variable Scores with ActiveTrans Priority Tool

Ramp	Transit Stops	Transit Stops Scaled	Number of Jobs	Number of Jobs Scaled	Design Compliance	Design Compliance Scaled
2522	3	3.6	15	5.6	2	6.7
3383	3	3.6	0	1.1	1	3.3
3384	2	2.7	82	7.8	1	3.3
3463	1	2.0	94	7.8	0	0
3465	2	2.7	4	3.3	2	6.7

Table 15. Example of Averaging Demand Scores with ActiveTrans Priority Tool

Ramp	Activity Centers Scaled	Transit Stops Scaled	Jobs Scaled	Demand Score
2522	0	3.6	5.6	3.0
3383	0	3.6	1.1	1.6
3384	0	2.7	7.8	3.5
3463	0	2.0	7.8	3.3
3465	0	2.7	3.3	2.0

To determine the final ranking, researchers weighted and summed all factor scores, resulting in a prioritization score for each ramp. These results can be put back into GIS to visualize the spatial relationships between the ramps and identify locations of concern. Figure 11 shows the results of the ActiveTrans Priority Tool, divided into five color-coded priority groups.

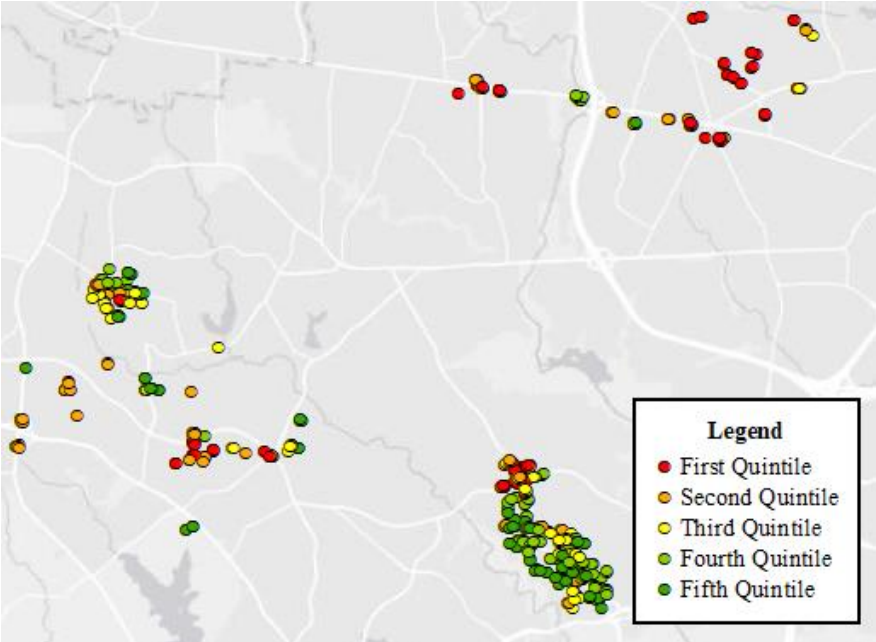
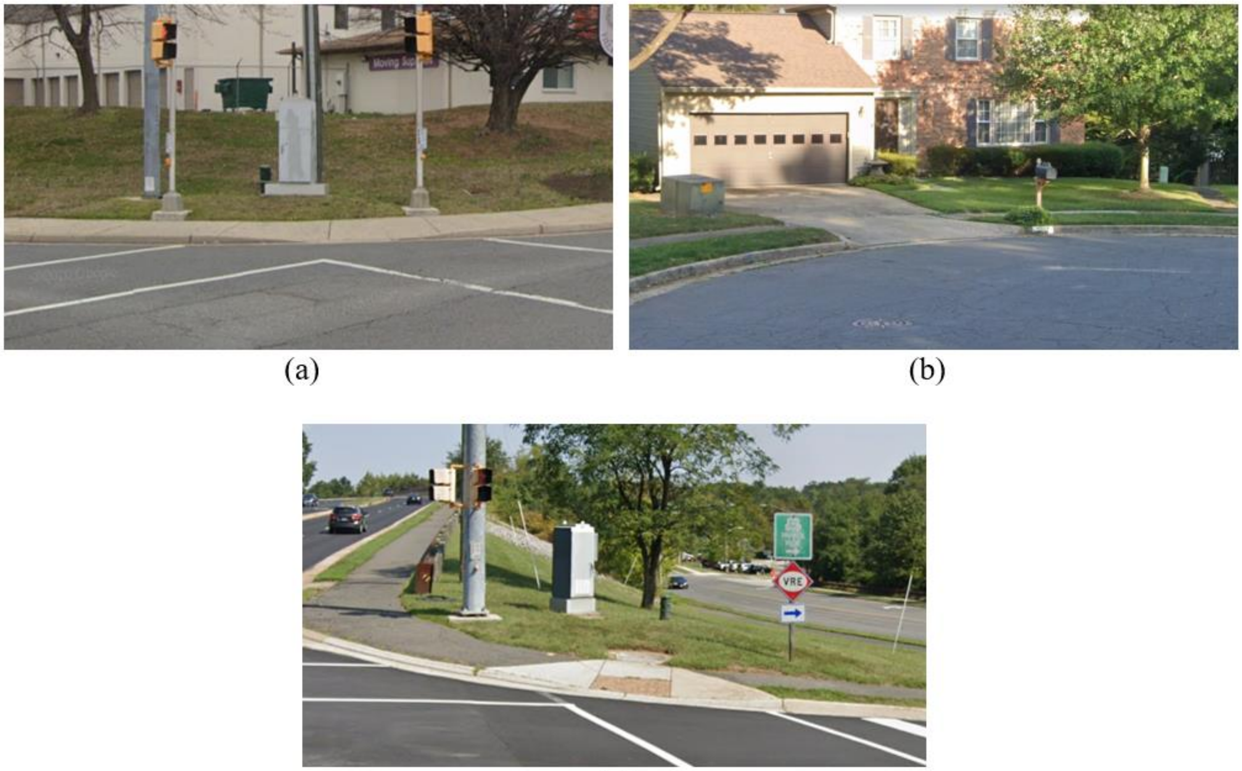


Figure 11. Results of ActiveTrans Priority Tool Analysis

Of the 500 ramps that were prioritized using the APT, the top priority ramp was a Grade C ramp located in a dense commercial area (Figure 12a). The ramp was located at an existing crossing and had no DWS. A moderate priority was a Grade D ramp located in a residential area that provided access to a trail and utilized a driveway as the curb ramp (Figure 12b). The lowest priority was a Grade B diagonal ramp located on a main roadway at an existing crossing; the crossing was served by a pedestrian signal (Figure 12c).

These results appear to align well with the priorities derived from the survey results. The top priority ramp was Grade C rather than Grade D, but it was located in a dense commercial area that would likely see high volumes of pedestrian traffic. As seen in the survey results, respondents often cited relative pedestrian demand as a justification for prioritizing one ramp over another.



(a) (b)

(c)

Figure 12. Results of ActiveTrans Priority Tool (a) Top Priority Ramp *(Image capture: March 2020 © 2021 Google),* **(b) Moderate Priority Ramp** *(Image capture: August 2019 © 2021 Google),* **(c) Lowest Priority Ramp** *(Image capture: September 2019 © 2021 Google)*

The moderate priority ramp was a Grade D ramp where access was provided by a residential driveway. The ramp provided access to a neighborhood sidewalk and a trail, likely seeing little pedestrian demand compared to other ramps in the sample. Despite its condition rating, survey respondents were less concerned with a Grade D ramp that utilized a residential driveway, probably because it provided some level of access compared to the obstacle that a curb presents. The nuance of a driveway serving as a ramp was not a consideration in the APT, where other factors such as low pedestrian demand would lower the ramp's priority ranking.

The lowest priority ramp was a Grade B diagonal ramp located near a train station and community center. The condition of the ramp and the relatively few destinations it served likely contributed to it being a low priority for improvement.

Discussion of Quantitative Approaches

The APT provides an efficient way to convert raw data into a priority ranking. The tool incorporates both quantitative and qualitative data and provides a step-by-step approach to reach the final ranking. The area used in the GIS analysis consisted of over 11,000 ramps. The programmed spreadsheet allows for the prioritization of only 500 features at time. It could be altered to accommodate larger datasets, or a new spreadsheet could be developed to meet the exact needs of the agency. The spreadsheet allows factors and variables to be set once and used repeatedly, and new datasets can be added as they become available.

Although both processes could be expanded statewide, it may be more efficient and practical to conduct prioritization activities where funding is allocated—at the district or residency level. An automated process would allow all VDOT offices to employ the same prioritization process with their own data, providing consistency across the state. These methods could also be used by localities to submit, or by VDOT to evaluate, ramp upgrade projects, as a starting point for determining an allocation of funds. Both the GIS analysis and the APT produced several duplicate priority scores in the sample analysis, indicating an equal priority level based on the criteria used. So although these tools provide an efficient method for screening high-priority ramps and corridors, further analysis would be required to finalize a prioritized project list.

The APT and the GIS analysis also resulted in clusters of high-priority and low-priority curb ramps, likely the result of VDOT's current approach of improving ramps along with repaving projects. This approach provides an efficient way to address large clusters of high-priority ramps. It could also provide an explanation for the clusters of lower priority ramps that may have been improved during a recent repaving project.

Future analyses could include more variables to capture additional pedestrian characteristics. A few data types were identified for use in the prioritization process for which datasets were not readily available. The state and local agencies whose prioritization processes were collected and reviewed commonly utilized citizen requests for curb ramp upgrades. A recent VTRC contract project developed an app, InfraHub, which allows residents to log problematic curb ramps (Zhu et al., 2020). Widespread use of InfraHub could allow, in future prioritization processes, for a centralized database of requests to be included.

Comprehensive pedestrian network data, including sidewalks and crosswalks, would allow decision-makers to include connectivity in the curb ramp prioritization process. Statewide sidewalk data currently exists; however, crosswalks are not included in the dataset. Crosswalks are an essential element of pedestrian infrastructure, and a data set of crosswalk locations is necessary for accurately calculating connectivity and network distances for use in the curb ramp prioritization processes. A recently completed VTRC study suggested that a crosswalk inventory could be developed through a manual review of aerial imagery (Zhu et al., 2020).

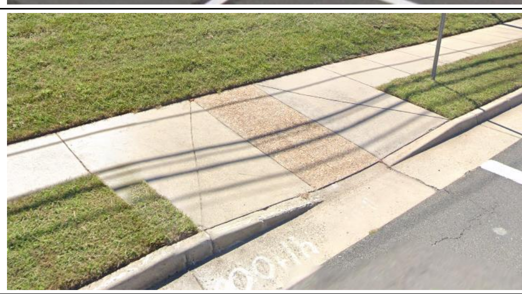
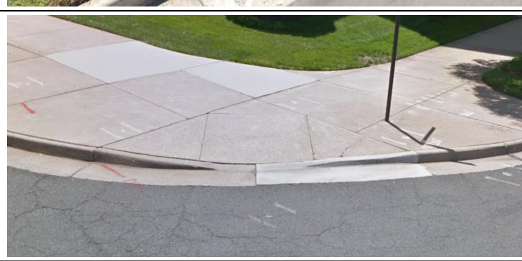
In addition to, or in place of, the current surrogate measures for pedestrian demand, officials could use StreetLight Multimode data. By doing so, officials would possess a numerical value for existing pedestrian volumes that would enable them to compare curb ramp sites. In using StreetLight, officials would have to manually enter segments or corridors for analysis, which, on a very large a scale, could become tedious and time-consuming. It would be more attainable if done at the local level. Or officials could use StreetLight as a secondary analysis to further prioritize ramps. As with any method of collecting existing volumes, StreetLight would not address latent demand such as pedestrians who do not use a given location for lack of a safe crossing or connected and accessible routes.

The prioritization processes could be developed with other methods, such as the decision tree method or the dominance approach. The decision tree method is a machine learning method and can be used as an alternative to regressions or other statistical approaches. Both quantitative and qualitative variables can be considered, resulting in a set of rules rather than a number or score. The dominance approach is a scoring system applying a non-linear combination of factors. The most important factor dominates the others; the remaining factors are considered afterwards, according to their level of importance. These methods, however, were outside the scope of this study.

Prioritization Processes

Information about the six curb ramps used in this task is presented in Table 16. The ramps in the survey (Table 10) and the ramps in this task have similar characteristics. For example, ramp 1 in the survey and ramp I in this task have similar characteristics, ramp 2 in the survey and ramp II in this task have similar characteristics, and so forth.

Table 16. Curb Ramp Information for Applying Prioritization Processes

Ramp No. (Condition Rating)	Photo[a]	Road Type	Destinations Served	Additional Information
Ramp I (Grade B)		4-lane divided roadway, 40 MPH speed limit	Single-family residential, commercial, 24 transit stops	Crosses to similar condition ramps, existing crosswalks in both directions, diagonal ramp[b]
Ramp II (Grade B)		4-lane undivided roadway, 35 MPH speed limit	Single-family residential, medical, school, 5 transit stops	Crosses to Grade C ramp, existing crosswalk, no pedestrian signal
Ramp III (Grade C)		5-lane divided roadway, 30 MPH speed limit	Commercial, library, multi-family residential, 27 transit stops	Crosses side street (2-lane undivided) to Grade B ramp; not aligned with crossing
Ramp IV (Grade C)		4-lane divided roadway, 45 MPH speed limit	Single-family residential, school, church, 1 transit stops	Not aligned with existing crosswalk, crosses to Grade A ramp, uneven surface (lip)

Ramp V (Grade D)		2-lane undivided roadway, 25 MPH speed limit	Single-family residential, school	Uses driveway as curb ramp, crosses to Grade B ramp, existing crosswalk, lip
Ramp VI (Grade D)		3-lane divided roadway, 25 MPH speed limit	Multi-family residential, school, commercial, recreational, 7 transit stops	Crosswalks lead to median with no curb ramps, connects Grade A ramps with Grade C ramps, intersection has another crossing

[a] *Image captures © 2021 Google: June 2018 (Ramp I), September 2019 (Ramp II), June 2018 (Ramp III), October 2016 (Ramp IV), August 2019 (Ramp V), and August 2019 (Ramp VI)*
[b] Diagonal ramps "force pedestrians descending the ramp to proceed into the intersection before turning to the left or right to cross the street" (VDOT, 2020b)

Prioritization Using VDOT Process

Curb ramp improvements in Virginia are prioritized based on condition. Top priority goes to Grade D ramps, followed by Grade C, and then Grade B (VDOT, 2017). Ramps can be further prioritized by pedestrian-demand factors. Additionally, projects with substantial constraints may be assigned a lower priority in favor of projects that are more feasible. Sean Becker of the Central Office TED prioritized the comparison set of curb ramps based on the following: the functional condition ratings, surrounding pedestrian attractors, and significant retrofit constraints of the comparison set of ramps. Ramp V was identified as the highest priority, followed by ramps III, IV, II, I, and VI. Ramp VI had a functional condition rating of Grade D, meaning it would typically be prioritized first. To install a curb ramp at that location, however, would require crews to relocate a structure and related utilities. These added expenses would likely result in the construction being deferred until a future project impacted the crossing, requiring the ramp's installation. It was noted that several factors influence the priorities, including "engineering judgment, available funding, site-specific conditions, and density of assets" (S. Becker, unpublished data).

Prioritization Using Survey Results

Survey respondents prioritized pairs of ramps and provided their reasoning, as well as their overall priorities. These responses were aggregated to determine what the most important characteristics were for survey respondents. The most frequently cited priorities were as follows:

- People served (overall demand, likelihood of use by pedestrians with disabilities)
- Condition (uneven surfaces, DWS, slope)

- Destinations (quantity, type)

Other prioritization factors included safety, connectivity, and road type (traffic speed, traffic volume, number of lanes). Researchers manually prioritized the comparison set of ramps (Table 15) by pairs based on what characteristics were most important to survey respondents for the similar set of ramps presented in the survey. Prioritization choices and rationale for each pair are presented in Table 17.

Table 17. Prioritization of Comparison Set of Ramps Based on Priorities from Survey Respondents

Pair	Choice	Rationale
I & II	I	Serves more destinations/transit, higher speeds, worse condition
I & III	I	Higher speeds, condition looks worse
I & IV	I	Higher demand, condition
I & V	I	Higher demand, driveway provides some access
I & VI	I	Destinations, ramp 6 has another crossing at intersection
II & III	III	Condition, people served, destinations
II & IV	IV	Condition (lip), higher speed
II & V	II	People served, higher speed, destinations
II & VI	II	Destinations, people served, no alternative crossing, not signalized
III & IV	IV	Condition (lip), higher speed
III & V	III	People served, destinations
III & VI	III	Ramp 6 has alternative crossing
IV & V	IV	Road type, people served, destinations
IV & VI	IV	Speed, ramp 6 has another crossing at intersection
V & VI	VI	Destinations, people served, condition

The prioritization process derived from the survey responses resulted in ramp I being selected as the top priority, followed by ramps IV, III, II, VI, and V.

Prioritization Using GIS Analysis

The GIS analysis process ranked ramp characteristics and weighted those values using the weights outlined in Table 12. The resulting priority scores were used to prioritize the comparison set of ramps. In addition to the factors derived from the survey, the GIS analysis also included demographics, safety, and planned paving projects. From the GIS analysis, ramp III was given the highest priority, followed by ramps VI, V, IV, I, and II.

Prioritization Using ActiveTrans Priority Tool

To prioritize the comparison set of ramps, researchers applied the APT, which converted ramp characteristics to a common scale and weighted them to determine a final score. Researchers used the same datasets as those used in the GIS analysis, and the resulting rankings were similar. The APT ranked ramp III as the highest priority, followed by ramps VI, IV, V, I, and II.

Comparison of Prioritization Methods

The four methods resulted in different prioritization rankings of the six ramps (Table 18). The method that varied most from the others was the manual application of survey results; resulting in the most similar rankings were the GIS analysis and the APT.

Table 18. Priority Rankings from Four Different Methods

Method	Priority 1	Priority 2	Priority 3	Priority 4	Priority 5	Priority 6
VDOT	V	III	IV	II	I	VI
Survey	I	IV	III	II	VI	V
GIS Analysis	III	VI	V	IV	I	II
ActiveTrans	III	VI	IV	V	I	II

The VDOT process currently favors, with some exceptions, condition over other characteristics. Additional data sources, such as destinations and demand, were used only to further prioritize ramps. The VDOT condition rating considers only three elements of the curb ramp—ramp width, type of DWS, and material condition (visual assessment). More than half of the survey respondents indicated that running slope, level landings, and visual contrast were important for accessibility, criteria not explicitly addressed by the current condition assessment. Meanwhile, ramp width was selected by just over one-third of respondents as being important for accessibility.

The priorities derived from the survey resulted in the most distinctive rankings of the four methods. The survey results represent a small sample size of respondents and therefore may not reflect the beliefs of the whole community. Given the limited information that was presented in the survey and in Table 10, ranking decisions were largely qualitative, somewhat subjective, and informed not by quantitative data but by images and descriptions. Some of the ramps used in the prioritization exercise were visually in poor condition, regardless of their VDOT condition rating. The ramp's appearance may have influenced some survey respondents more than the condition rating itself. The ramps used in applying the four prioritization processes had the same VDOT ratings as those in the survey, but the ramps in that set of images appeared to be in better condition overall than those in the survey. Additionally, the ramps used in applying the prioritization processes that were rated B or C were located in high-activity areas, which when the survey results were applied increased their priority relative to grade D ramps.

The analyses using GIS and the APT included several more factors than the current VDOT process. By utilizing a scoring system, researchers were able to establish, at the beginning of the process, the relative importance of each factor; this provided consistency and transparency. The APT provided many different scaling methods to best accommodate each dataset, allowing for a more sophisticated analysis than using GIS alone. These two methods considered condition as one of the most important features, but the rankings indicate that there were instances where other factors carried more weight than condition alone.

Several themes emerged out of all four prioritization rankings. Ramp 3, a poor-condition ramp in a high-traffic area, was consistently ranked as one of the top three priorities. Medium- to low-demand ramps located in low-speed areas were more frequently placed in the bottom three rankings relative to ramps in high-demand or high-speed areas. Ramps in fair condition were consistently ranked as one of the bottom three priorities, indicating that a partially accessible ramp is considered a lower priority than an inaccessible or nonexistent ramp. These rankings indicated that one important component in determining improvement priorities is condition, although additional factors are useful.

It is also important to note the different viewpoints of VDOT and the public. VDOT's maintenance program must operate within budgetary constraints and take into consideration such factors as condition, cost, and the proximity to planned paving projects. Survey respondents, on the other hand, were often focused on the accessibility of destinations and connectivity of pedestrian routes. Finding an approach that links the two viewpoints will be vital to achieving a prioritization process that meets the needs of all users.

Guidelines and Potential Program Performance Metrics

Suggested Guidelines

By developing ranked lists of curb ramps for upgrade using the APT, the following guidelines provide VDOT with a process for prioritizing curb ramp improvements. These guidelines follow the process outlined in the APT Guidebook (Lagerwey et al., 2015). The following instructions should be used with the APT programmed spreadsheet, located on the APT website (Pedestrian & Bicycle Information Center, n.d.):

1. *Define Purpose (APT Step 1)*: For prioritizing curb ramps, the Mode should be set to "Pedestrian," and the Location Type should be set to "Intersection or Crossing."

2. *Select Factors (APT Step 2)*: Using data currently available, a user should select the following factors: "Opportunities," "Safety," "Demand," "Equity," and "Compliance."

3. *Weight Factors (APT Step 3)*: Factors are weighted on a scale from 0 to 10, with 10 indicating that the factor is extremely important. The priorities identified throughout this study suggest assigning initial factor weights as shown in Table 19. District staff should adjust weights if different priorities have been identified.

Table 19. Recommended Factor Weights for Use in APT

Factor	Weight
Opportunities	2
Safety	6
Demand	10
Equity	10
Compliance	9

4. *Select Variables (APT Step 4)*: Within each APT factor, several variables may be chosen to reflect available data. Table 20 outlines which variables should be selected. As data availability increases, researchers could add more variables. For example, if a district has data on citizen requests, a user should select the "Stakeholder Input" factor and "Number of Requests/Comments" variable. "Stakeholder Input" should be assigned a weight of 10

to reflect the importance of addressing citizen requests.

Table 20. Variables for Use in APT

Factor	Variable
Opportunities	Implement w/ Future Construction
Safety	Total Ped Crash
Demand	Proximity to Activity Centers (0.5 miles)
	Number of Transit Stops within 0.25 miles
	Number of Jobs
Equity	% with Disabilities
	% older than Age 64
Compliance	Non-State Design Compliance

5. *Assess Data (APT Step 5)*: For use in the prioritization process, researchers identified the data sources shown in Table 21. The most recent release of each data source should be utilized when feasible.

Table 21. Data Sources for Curb Ramp Prioritization

Name	Type	Source	Details
Number of Jobs	Polygon	Census Longitudinal Employer-Household Dynamics[a]	Total number of jobs by census block
% older than Age 64	Polygon	American Community Survey Statistics[b]	% of census tract population older than age 64
% with Disabilities			% of census tract population with a disability
Proximity to Activity Centers	Point	VTrans[c]	Locations of designated Activity Centers
Number of Transit Stops	Point	Virginia Department of Rail and Public Transportation	Locations of transit stops in Virginia
Total Ped Crash	Point	VDOT[d]	Locations of pedestrian-involved crashes
Implement w/ Future Construction	Line	VDOT	Locations of planned paving projects in Virginia
Non-State Design Compliance	Point	VDOT	Functional condition rating of curb ramps

[a] (U.S. Census Bureau, 2018)
[b] (U.S. Census Bureau, 2020a; U.S. Census Bureau, 2020b)
[c] (VTRANS, 2019)
[d] (VDOT, 2020c)

6. *Data Preparation.* Prior to using the programmed spreadsheet, a user must associate the data with individual curb ramps. Curb ramp location and condition data is provided in the Inventory of Barriers. This data layer serves as the starting point for the analysis. GIS should be used to perform proximity analyses for the remaining data sets using the search radii specified in Table 22. For variables measured by census tract or block, including "Number of Jobs," "% older than Age 64," and "% with Disabilities," ramps should be joined to the tracts and blocks in which they are located, rather than by search radii. Both of these tasks can be accomplished using the "Spatial Join" tool in GIS.

Table 22. Recommended Search Radii for Use in APT

Variable	Search Radius
Proximity to Activity Centers	0.5 miles
Total Ped Crash	250 feet
Implement w/ Future Construction	0.25 miles
Non-State Design Compliance	0.25 miles

7. *Input Data (APT Step 8)*: The resulting attribute table from the task above should be exported for use in the APT (using the "Table to Excel" tool). Each data column should be transcribed to the appropriate column in the programmed spreadsheet. Each curb ramp has a unique Ramp ID in the Inventory of Barriers; these IDs should be transcribed to the column labeled "ID." Additional identifying information may be added to the "Location" column, though this is unnecessary for the analysis.

8. *Scale Variables (APT Step 9)*: The APT provides several scaling options to convert raw data to scores from 0 to 10. Rank order scaling calculates the rank for each value and scales the rank values proportionally from 0 to 10. This method should be used for variables that are likely to have both outliers and many duplicate values. For the recommended data, this method should be used for the "Implement w/ Future Construction," "Total Ped Crash," "Number of Transit Stops with 0.25 miles," and "Proximity to Activity Centers" variables.

   Quantile scaling divides the data into equal groups and assigns scores proportionally, from 0 to 10. This method should be used for data that may include outliers but few duplicate values. Too many duplicate values could result in the same value being placed in two different quantiles. For the recommended variables, this method should be used for the "Number of Jobs," "% with Disabilities," and "% older than Age 64" variables.

   Proportional scaling assigns scores between 0 and 10, proportionate to the raw data. The lowest data value is assigned a score of 0, and the highest data value is assigned a score of 10. This method should be used to scale the "Non-State Design Compliance" variable.

9. *Calculate Priority Scores and Priority Rank (APT Step 10)*: Using the inputs above, the programmed spreadsheet calculates the priority scores for each ramp and generates a prioritized list. These priority rankings, rather than dictating exactly which ramps to improve first, should be used to identify high-priority ramps and high-need areas. Staff may use engineering judgment to determine how best to apply the priority rankings with available funding.

10. *Visualize Results in GIS (Optional)*: The resulting priority rankings spreadsheet may be exported back to GIS to visualize high-need areas or corridors (using the "Excel to Table" tool). This new table should be associated with the curb ramp layer such that the priority scores are assigned to a ramp's specific location. Using the "Graduated colors" symbology, ramps should be divided into classes based on their priority score. Staff may use engineering judgement to determine how many classes best meet their needs. Each

class should be assigned a different color to visualize the high- and low-priority locations.

Potential Program Performance Metrics

To aid in tracking the progress of VDOT's ADA curb ramp improvement program, researchers identified three potential program performance metrics. Each performance metric assesses a different aspect of accessibility or equity. The potential performance metrics are as follows:

1. *Percent of total ramps that are Grade A.* This metric would assess the overall progress of curb ramp improvements throughout the state in terms of physical condition. Ramp condition ratings would be collected through the inventory of barriers; retrofits would be reported to the Chief Engineer by the Civil Rights division on a quarterly basis. These two inventories could be compared to assess the progress of the curb ramp improvement program.

2. *Percent of improved ramps located in census tracts with high percentages of people with disabilities or older adults.* This metric would assess equity and the equitable distribution of curb ramps in areas of particular need. American Community Survey data estimates the percent of people older than 64 and the percent of people with a disability in each census tract. This can be compared with the locations of improved ramps, as reported to the Chief Engineer. One limitation of this metric is that it would favor residential locations and does not consider where these individuals might need to travel outside of their neighborhoods.

3. *Percent of improved ramps in areas of high pedestrian activity*. This metric would assess the distribution of ramp improvements in areas of increased demand. Pedestrian demand can be estimated using surrogate measures, such as National Accessibility Evaluation job-access data (see Appendix B). This could be compared with the locations of improved ramps, as reported to the Chief Engineer.

Researchers identified two additional metrics, though both would require additional data not currently available.

1. *Percent of improved ramps that fill a gap in a pedestrian accessible route or extend an accessible route.* This metric would assess improvements to connectivity. This metric would require statewide sidewalk and crosswalk data to best calculate pedestrian routes.

2. *Percent of citizen requests resolved within one year of request.* This metric would assess both the number of requests received, as well as the success of the ADA program in providing requested upgrades. This metric would require a database of requests at the district or state level. The one-year timeframe could be shortened or lengthened as appropriate.

CONCLUSIONS

- *VDOT's current condition-based ramp classification system does not consider the same factors as other states' classification systems*. VDOT's system considers some of the required elements under ADAAG that are easily assessed and may be key indicators of a ramp's overall condition. However, many additional elements identified through the survey results and literature are important to users for accessibility. These include running slope, level landings, visual contrast, and flush transitions.

- *Based on the prioritization methods examined and the survey responses received, condition is rarely the only consideration in determining which curb ramps to upgrade or retrofit.* As justification for prioritizing one ramp over another, survey respondents most frequently cited the number and type of users, as well as the number and type of destinations, served by the ramps. Similarly, nearly all prioritization processes reviewed in the literature used pedestrian demand. Prioritization tools, such as GIS and APT, can account for these additional factors.

- *There is no consensus on what elements are most important for prioritizing curb ramps.* Even within disability groups, survey responses varied regarding what features were most important for prioritization, although there was general interest in connectivity being taken into consideration.

- *Transit is a commonly utilized prioritization criterion at the local level.* Although not practical for a statewide program, transit may be applied to prioritization processes conducted at the district or local level.

- *When it comes to prioritizing curb ramps, there is no "one-size-fits-all" approach.* A prioritization process developed at the state level would need flexibility for districts to apply engineering judgment in developing factor weights to meet the needs of the communities they serve.

- *The curb ramp prioritization process would be enhanced by comprehensive sidewalk and crosswalk data.* Concerning the prioritization process, survey respondents overwhelmingly favored having decision-makers take connectivity into consideration, but data limitations preclude doing so at present.

RECOMMENDATIONS

1. *VDOT's Central Office TED should, with VTRC assistance, use the suggested guidelines of this report to generate a prioritized set of curb ramps within a curb ramp tracker tool and distribute it to district partners.* The tracker tool would be a dynamic map allowing district staff to visualize and easily identify high-priority locations for curb ramp upgrades.

2. *VDOT's TED should communicate with district partners and develop training materials to help improve the curb ramp prioritization process.* Sharing the main conclusions and recommendations of this report could assist district partners in making use of the curb ramp

tracker tool and incorporating user feedback into their curb ramp prioritization processes.

3. *VDOT's TED should monitor technological advancements that might allow for creation of a statewide inventory of crosswalks to supplement the existing sidewalk and curb ramp inventories.* A crosswalk dataset is necessary to perform connectivity analyses and calculate accurate network distances for proximity analyses.

IMPLEMENTATION AND BENEFITS

Implementation

With regard to Recommendation 1, by summer 2021, VTRC will work with TED's Traffic Asset Program Manager to establish a work plan for implementing this recommendation. TED, with assistance from VTRC, will utilize the guidelines from this report to produce a dynamic curb ramp tracking map that visualizes the curb ramp priority rankings (similar to an existing guardrail assessment tool developed by TED). VTRC will work through decisions with TED as needed, such as whether to prioritize curb ramps statewide or reflect potential differences across districts. Ideally, the curb ramp tracking tool would be updated as assessments were completed ahead of paving projects and as ramps were improved and added. Depending on the outcome of this implementation activity, a follow-up action could be for TED to consider revisions to I&IM 376.1 to reflect the use of the curb ramp tracking tool, including the revision of the Curb Ramp Improvement Prioritization Methodology and the addition of one or more program performance metrics.

With regard to Recommendation 2, by fall 2021, TED's Traffic Asset Program Manager will engage with district stakeholders, sharing this VTRC report and high-level recommendations as well as discussing the need to incorporate user feedback into the curb ramp improvement program as feasible. TED will pursue related implementation actions as needed, such as developing and delivering training materials on ADA prioritization to district stakeholders—advising districts of the ability to overlay additional data onto the condition-based ramp inventory, which allows flexibility in how districts prioritize ramp delivery for improvements impacted by the paving schedule; evaluating ramp improvement options under enhanced funding scenarios; and maintaining prioritization plans to support decision-makers in identifying appropriate program funding levels.

With regard to Recommendation 3, in January 2021, the Google Maps interface began displaying marked crosswalks in some cities (El Khoury, 2021) suggesting that in time similar data may become available for Virginia. Marked crosswalks are likely also inventoried by self-driving car companies. However, the availability and cost of this data are unknown. By summer 2021, TED's Traffic Asset Program Manager will determine whether VDOT could obtain such data at a reasonable cost from this or similar tools.

Benefits

The benefits of implementing Recommendation 1 will stem from improved decision-making using data-driven guidelines for prioritizing ADA curb ramp retrofits. Considering additional prioritization factors could increase pedestrian mobility and accessibility if ramp improvements are targeted based on the factors that users think are important. Although current funding only allows for curb ramp upgrades as part of the paving program, the curb ramp tracker tool would improve understanding of where additional improvements can be delivered if ADA funding is enhanced.

The benefits of implementing Recommendation 2 will be improved programmatic outcomes and consistency among districts. Creating and distributing training resources outlining the prioritization process would improve consistency between districts. As new staff are added or stakeholders change roles, training materials would ensure the continuity of the prioritization process.

The primary benefit of implementing Recommendation 3 will be cost savings over conducting a manual crosswalk inventory. Given the potential for data to become available via other methods, the benefits of conducting a manual inventory immediately may not outweigh the costs (i.e., funding a crosswalk inventory would require diverting funds otherwise available for improvements).

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APPENDIX A – SURVEY QUESTIONS

1. Name: ___ Email: ______

2. Do you work for an agency or organization that works with people with disabilities? (Yes / No)

3. Mobility Impairment: Do you have difficulty walking? (Yes / No / Prefer Not to Answer)

4. Vision Impairment: Do you have difficulty seeing, even if wearing glasses? (Yes / No / Prefer Not to Answer)

5. Agency: ____Position: _____

6. What population group(s) does your agency work with? Select all that apply. [People with visual impairments / People with mobility impairments / People with other disabilities / Older adults / Other (please specify)]

7. Which, if any, of the following assistive mobility devices do you use to get around? Select all that apply. [Canes or walking sticks / Crutches / Walker or rollator / Manual Wheelchair / Power Wheelchair / Other (please specify) / None]

8. Which, if any, of the following assistive devices do you use to get around? Select all that apply. [Handheld Electronic Mobility Aid / White Cane / Guide Dog / Personal Care Assistant / Other (please specify) / None]

9. How familiar are you with the federal Americans with Disabilities Act Accessibility Guidelines (ADAAG)? (1 – I have never heard of it / 2 – I have heard of it, but not read it / 3 – I have read at least one section and/or reference it frequently)

10. How familiar are you with the federal Public Rights-of-Way Accessibility Guidelines (PROWAG)? (1 – I have never heard of it / 2 – I have heard of it, but not read it / 3 – I have read at least one section and/or reference it frequently)

11. What elements of the built environment do you think are most important for accessibility? Select all that apply. [Sidewalks / Crosswalks / Curb Ramps / Accessible Pedestrian Signals / Other (please specify)]

12. Which physical features of curb ramps are most important for accessibility? Select all that apply. [Running Slope – parallel with direction of travel / Cross Slope – perpendicular to direction of travel / Detectable Warning Surface / Level Landings / Visual Contrast / Width / Flush Transitions / Other (please specify)]

13. When there is limited funding for curb ramp improvements, should connectivity be considered when prioritizing curb ramp upgrades? For example, should a ramp that fills a gap in a sidewalk network be prioritized over a ramp that only provides access to a

specific destination?

14. Which destinations should be assigned higher priority for curb ramp upgrades? Select all that apply. [Commercial sites / Residential sites / Recreational sites / Schools / Government Facilities / Disability Services Agencies / Other (please specify)]

15. Which road type should be assigned higher priority for curb ramp upgrades? (Roads with speed limits of 35 MPH and below, low traffic volumes, and direct access to buildings and other destinations adjacent to the road / Roads that offer a balance between access and mobility, with moderate speeds / Major roads with speeds of 35 MPH – 55 MPH, high traffic volumes, traffic lights, and sometimes transit routes)

16. In Virginia, curb ramps are rated on a scale from A to D, with A being ADA compliant and D being non-existent (no ramp present at all). B and C are varying levels of non-compliance that may be accessible to some users but less so for others. If you had limited funding for curb ramp improvements, would you first improve existing non-compliant ramps rated B or C, or build ramps where none exist (condition D)?

17. Please choose which ramp in each of the following pairs you would upgrade first. In the text box corresponding to your answer choice, indicate why you chose that ramp. Which factors were most influential?

- Ramp 1 or ramp 2?
- Ramp 1 or ramp 3?
- Ramp 1 or ramp 4?
- Ramp 1 or ramp 5?
- Ramp 1 or ramp 6?
- Ramp 2 or ramp 3?
- Ramp 2 or ramp 4?
- Ramp 2 or ramp 5?
- Ramp 2 or ramp 6?
- Ramp 3 or ramp 4?
- Ramp 3 or ramp 5?
- Ramp 3 or ramp 6?
- Ramp 4 or ramp 5?
- Ramp 4 or ramp 6?
- Ramp 5 or ramp 6?

18. Why did you choose to prioritize the ramps that way? Which factors were most influential?

APPENDIX B – USING NATIONAL ACCESSIBILITY EVALUATION DATA TO TRACK THE PROGRESS OF THE ADA CURB RAMP IMPROVEMENT PROGRAM

The National Accessibility Evaluation (NAE) is a pool-funded study to measure destination access for jobs across the United States (Owen 2020). Using employment, transit, driving, and pedestrian network data, the NAE assesses how many jobs are reachable from each census block within a given travel time threshold via a given travel mode. Job destination access is measured for 5-minute to 60-minute travel time thresholds at 5-minute intervals. The NAE transit dataset provides a single metric that encompasses transit frequency and connectivity, the pedestrian network, and employment locations, which can be used as a surrogate measure for pedestrian demand. This dataset can be used to measure the percent of improved ramps in areas of high pedestrian activity; this measure can be calculated at the state or district level.

The following steps should be taken to use NAE transit data for tracking the progress of the ADA program:

1. Download NAE transit data for Virginia from https://hdl.handle.net/11299/200592. Data is released annually in geopackages; the most recent release at the time of analysis should be used.
2. Spatially associate curb ramps with the census block they are located in using the "Spatial Join" tool in GIS. The VDOT Barrier Inventory curb ramp layer should be used; census block shapefiles are widely available. (Skip this step if the suggested Guidelines in this report have already been implemented, because the task of associating ramps with the appropriate census block was included therein.)
3. From the geopackage, add the NAE data to the curb ramp file in GIS; the 30-minute threshold data should be used for consistency.
4. Use the "Join" tool for tables to associate the NAE data with the curb ramp data based on census block id.
5. Determine if progress will be assessed at the state or district level. By using a pre-determined threshold (such as the top 20% of NAE values across the state or district), identify ramps in areas of high pedestrian activity (high numbers of jobs accessible by a 30-minute transit trip).
6. Compare the number of improved ramps above the threshold from Step 5 to the total number of improved ramps in the state or district to determine the percent of improved ramps located in areas of high pedestrian activity.