Methodology for ADA ramp project prioritization using accessibility and betwenness-centrality

State Smart Transportation Initiative

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Accessibility metrics hold great promise as a means to inform transportation decision-making. Not only do these metrics address the purpose of the transportation system directly – linking travelers to destinations – but they are also infinitely scalable, so they can provide insights at a very granular level. As such, they may be especially useful in evaluating decisions around active transportation facilities, which can be difficult to address in conventional modeling. This white paper investigates a particular issue within active transportation: prioritizing pedestrian improvements to meet ADA standards.

Sidewalk networks that lack ADA ramps at intersections can pose major accessibility challenges to wheelchair users.[1] Federal ADA standards require such ramps, but existing intersections are grandfathered, so curb cuts are typically added in an ad hoc fashion, when sidewalks or streets are improved for other reasons. If sidewalks are improved in isolated locations, they can have some local benefit, but not contribute much to the overall connectivity of the network.

When agencies do seek to specifically improve ADA connectivity, they face the reality that their resources will not allow them to install ramps everywhere all at once; they must prioritize. Typically, agencies will use spatial analysis to identify areas that are in proximity to certain amenities such as transit stops, schools, libraries, shops, etc., and prioritize those locations for improvement. But this, again, could lead to isolated improvements. A more holistic approach considers the effect on accessibility from network improvements. To that end, the method described here employs accessibility analysis. We show that prioritizing improvements based on the “delta-accessibility” metric shown results in much greater gains in accessibility compared with random improvements.

Beyond accessibility, it may also be useful to take into account network continuity measures. We explore one called “betweenness centrality” here. The way we apply it does not, unfortunately, raise accessibility compared to simply applying delta-accessibility. But we mention it here as a potential topic of further research.

Data and methodology

In this exploration we use pedestrian network data that comes bundled with the Sugar Access accessibility tool – data that originates with the navigation firm HERE – for Dane County, Wisconsin. For most roadway links, this network is a centerline; that is, it assumes the network is continuous – that all streets are traversable by pedestrians.

[1] A note on nomenclature: We use “accessibility” in the senses of “access to destinations.” In the ADA context, “accessibility” sometimes has a narrower meaning, e.g. referring to facilities that are can be used by travelers in wheelchairs. Here we look at accessibility provided by the entire pedestrian network, assuming that lack of ADA facilities – curb ramps – makes a part of the network unusable, lowering accessibility.

To simulate a discontinuous network, where some links are inaccessible to wheelchair users, we create 54 breaks at intersections, which can be thought of as missing one or more ADA ramps, and remove one intersecting link at each. We calculate non-work accessibility (to shopping, schools, parks, and other destinations, on a 0-100 point scale) at the block level using Sugar Access for both the continuous and discontinuous networks. We then calculate the loss in accessibility from the network breaks, which we term "delta-accessibility" (Figure 1). The greater the delta-accessibility, the greater the loss from the missing ADA facilities. Conversely, the greater the delta-accessibility, the greater the benefit could be from fixing the ADA facilities.

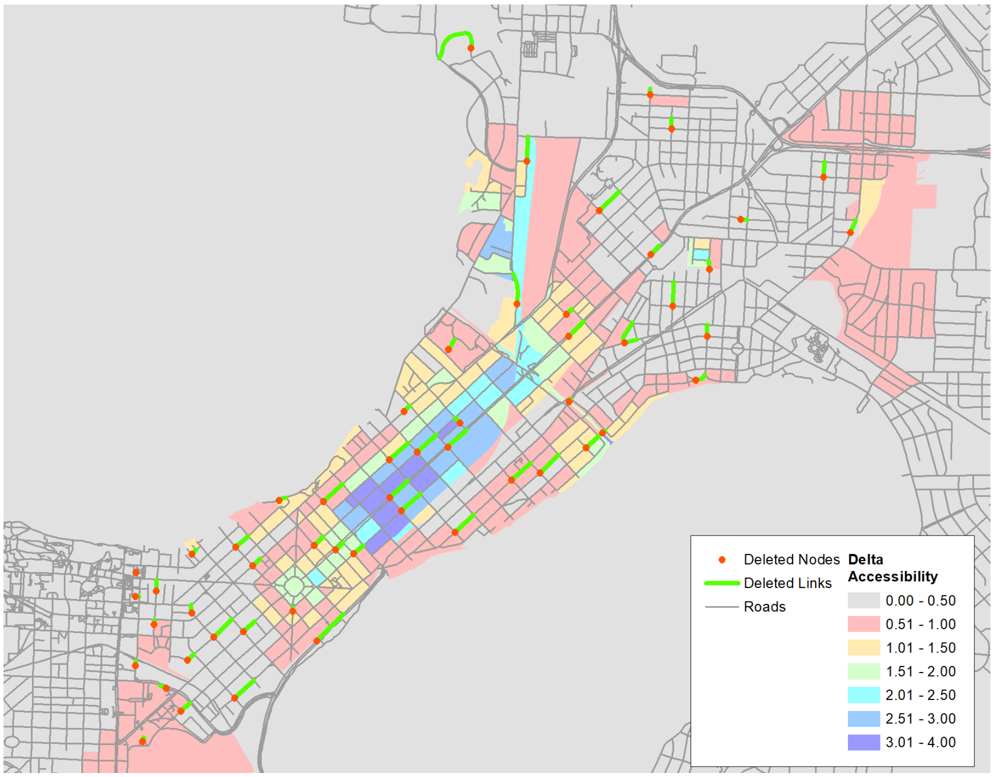

Figure 1. Links removed from continuous network to approximate missing ramps.

To apply the delta-accessibility metric, which relates to geographies, to missing ADA facilities, which are points in the pedestrian network, we use a spatial join to apply polygon-based delta-accessibility to the network nodes that intersect the polygons. In the cases where a node intersects more than one polygon, we apply the mean delta-accessibility of the intersected geographies. Visual inspection shows a good match between the weighted nodes and the polygon geographies (Fig. 2.)

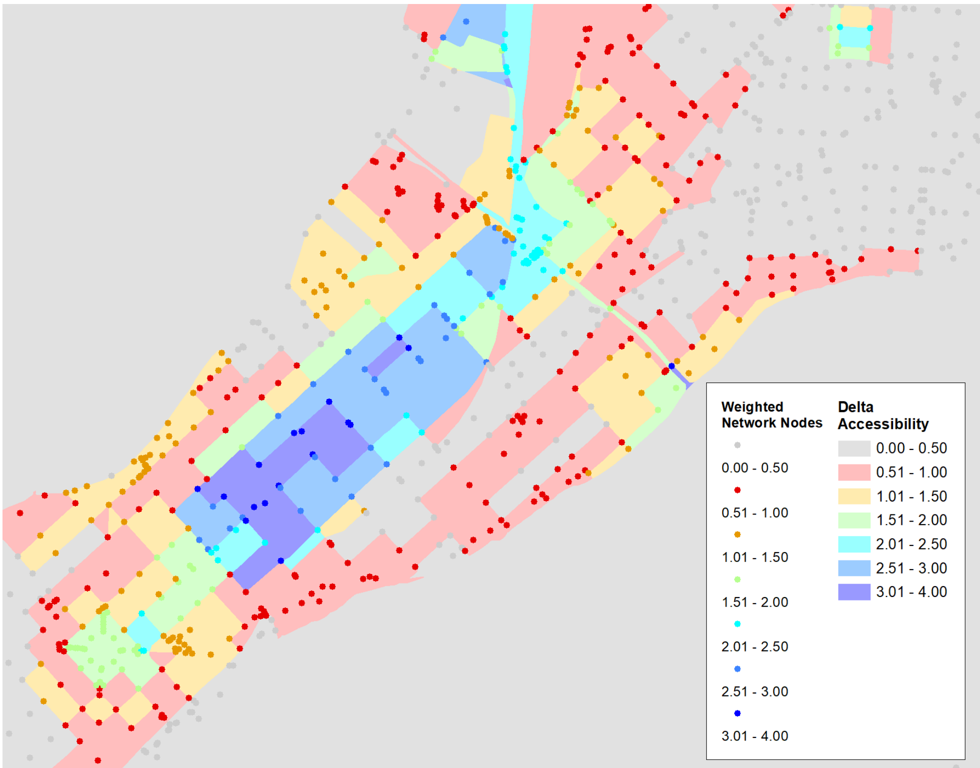

Figure 2. Network nodes weighted by delta accessibility.

The benefit from making ADA improvements in areas with high delta-accessibility seems clear, but it may not provide the absolute optimum solution. There may be too many broken ramps in this area to fix. Or there may be broken ramps that are further from the delta-accessibility geographies but that are key missing links. If only a few ramps are in question, we could calculate delta-accessibility for each combination of fixes. But this process would become unworkable with more than a handful of ramp locations from which to choose. So, we need a more efficient process.

"Betweenness-centrality" is a concept that can be used to estimate the importance of links in a network. For any node, it is defined as the probability that a shortest path between any two other nodes will go through that node. It may be possible to combine this concept with accessibility to improve prioritization. Indeed, at least one very recent paper, published as we were completing this project, uses the concept in such a way.[2] Prioritizing projects by their betweenness-centrality, along with delta-accessibilitiy, may identify nodes that are important both to the continuity of the network and to raising accessibility.

We calculate the betweenness-centrality of every node in the network, using the NetworkX package in Python. Figure 3 shows the betweenness-centrality of the network nodes.

[2] Sarlas, Georgios; et al., "Betweenness-accessibility: Estimating impacts of accessibility on networks." April 2020: Journal of Transport Geography, accessed March 30, 2020 from https://doi.org/10.1016/j.jtrangeo.2020.102680.

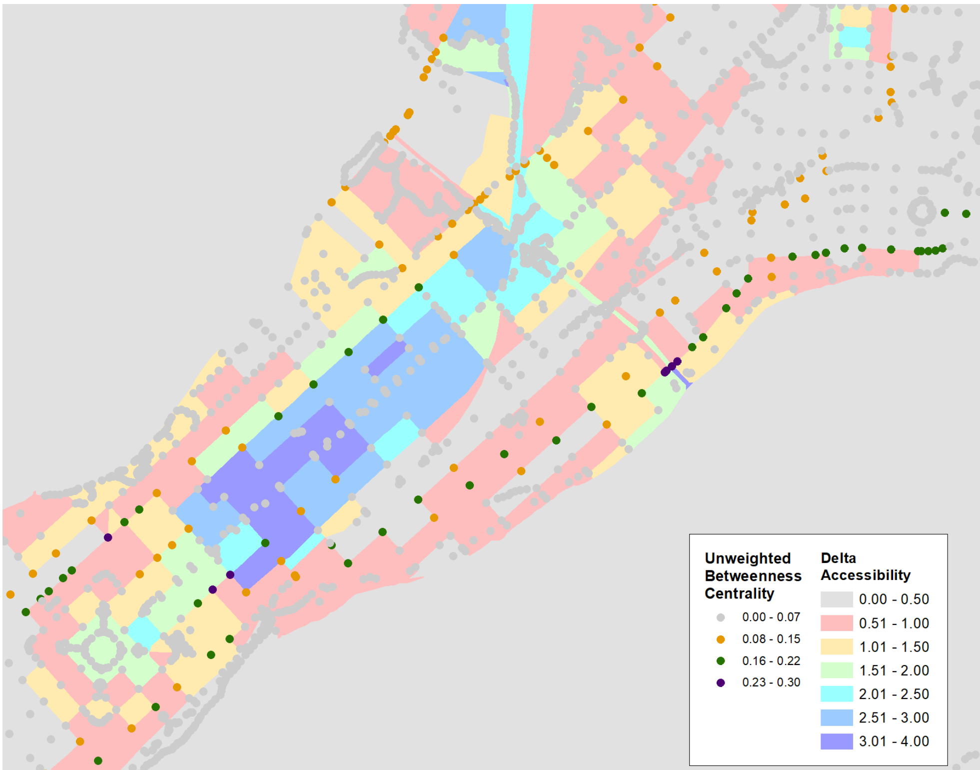

Figure 3. Betweenness centrality of each node in the network.

Prioritization comparisons

Here we look at three potential prioritization methods (Figure 4). We compare the nonwork accessibility provided in each scenario, as reported below:

<u>Ten missing ramps picked at random</u>

As a base case, we add ADA facilities at 10 randomly selected intersections.

<u>High delta-accessibility</u>

We add ADA facilities at 10 notes ranked by delta-accessibility.

<u>High delta-accessibility ranked by betweenness-centrality</u>

We take the top 20 nodes ranked by delta-accessibility and select the top 10 of those by their betweenness-centrality.

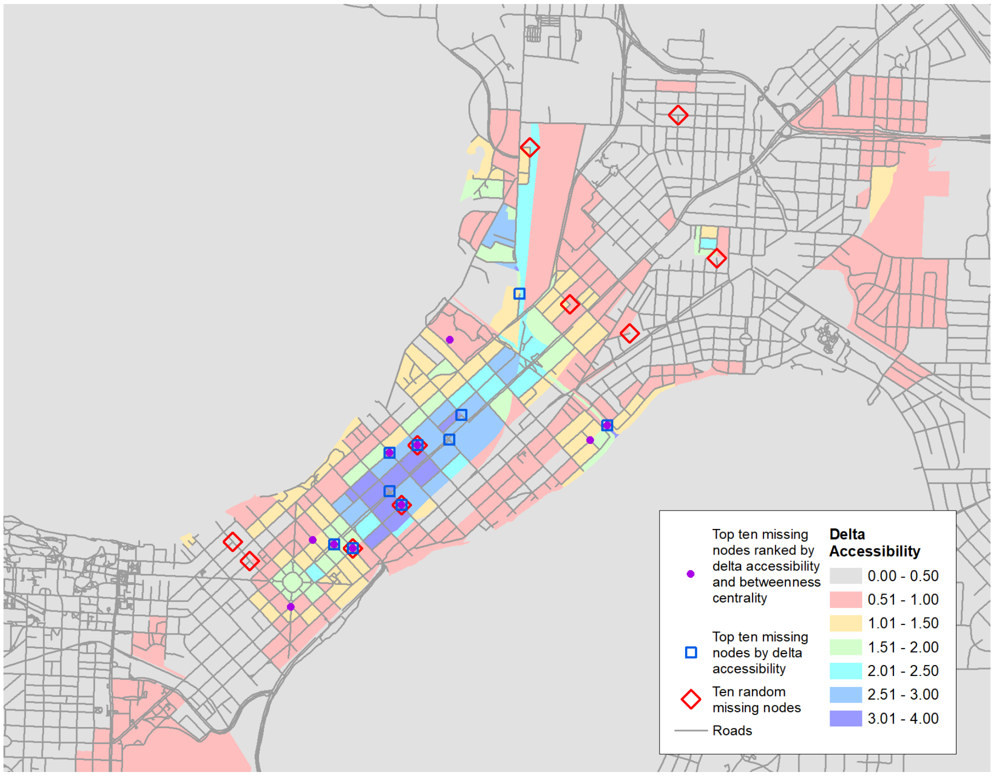

Figure 4. Missing ramp intersections selected by three methodologies.

Findings

In the most-affected Census blocks, the reduction in nonwork accessibility from missing ramps ranges between 3 and 4 on a 100-point scale. The study area includes all of Dane County, Wisconsin. It comprises 12,568 blocks, many of which are minimally affected by the ramps in question, lowering the apparent average effect of any ramp treatment. Overall, the missing ramps subtract an average of .063 accessibility points per block. We evaluate the three methods for adding ramps – a random-choice base case, a method using delta-accessibility, and a method using delta-accessibility with betweenness-centrality – based on how close each comes to providing the accessibility of the continuous network.

Table 1 summarizes the effects at the block level.

Scenarios	Average accessibility by Census block	Percentage accessibility gained (compared to 54 breaks)
Continuous network	27.02387	100
Discontinuous network (54 breaks)	26.96051	0
Network with ten restored intersections, selected randomly	26.97801	27.6
Network with 10 restored intersections, based on delta-accessibility	26.98989	46.4
Network with 10 restored intersections, based on delta-accessibility and betweenness-centrality	26.98962	45.9

Recommendations for practice

For practitioners with the ability to use Sugar Access or a similar tool, calculating delta-access appears to provide useful guidance in the prioritization of ramp improvements. In our test this method nearly half the possible accessibility improvement, compared to randomly selecting ramp installations, which achieved about a quarter. The SSTI team can provide a step-by-step process for this analysis if desired.

Adding a step for betweenness-centrality in the way we did does not appear to improve the prioritization analysis. However, the concept or other network-optimization methods probably deserve more consideration going forward.