Propportion of jobs/housing within X miles of transit & Proximity to amenities

Prepared for the Georgetown Climate Center and the Transportation and Climate Initiative

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Introduction

Accessibility – which is at the heart of indicators focused on the proportion of jobs/housing within a certain distance of transit, as well as proximity to amenities – is a measure of the “ease with which people can reach their opportunities or services.” This concept involves three factors, namely: people, activities, and linkages (Lei, et al, 2010). Measures of accessibility typically focus on determining the ease with which people can reach desired destinations using the linkages available to them.

Why is accessibility of interest in the context of the Transportation and Climate Initiative (TCI)? In addition to reducing the carbon content of fuel and improving vehicle efficiency, reductions in vehicle miles traveled (VMT) are critical to realizing necessary reductions in CO₂ emissions from the transportation sector. Cervero and Duncan (2006) concluded jobs-housing balance reduced travel more than housing-retail-service mixing based on data from the San Francisco Bay area. However, both strategies appeared to have beneficial effects on the reduction of VMT and Cervero and Duncan (2006) postulated that pursuing both strategies could yield combined benefits, such as inducement of trip chaining for more efficient travel. Close spatial proximity to a variety of amenities and transit accessibility (both important tenants of smart growth) are instrumental in forming this “third leg” of the emissions reductions “stool,” as they serve to decrease the distances traveled in the course of everyday life, and offer a viable alternative to, or more efficient use of, the personal vehicle when travel is necessary (Ewing et al, 2007; Pearce et al, 2006).

There are also “social equity” considerations related to accessibility, in that lower income households are at a distinct disadvantage in sprawling suburban environments where personal
vehicles are a must. Instead, areas in which amenities—such as jobs, healthcare, and groceries—are reachable on foot or by taking public transit, are better able to sustain the livelihood of these populations (Minocha, et al, 2008). However, Ross and Svajlenka (2011) found that in the Washington, DC region, housing costs are out of reach for low- and mid-skill workers in areas identified in this report as offering strong transit access to employment.

**Analytical Approaches**

There are a number of techniques that can be applied to gauge study area residents’ access to transit and other amenities; and many of these are dependent on Geographic Information Systems (GIS) for their calculation.¹ Six categories of analytical approaches to measure proximity/access have been identified in the literature. Specifically, those focused on: system accessibility, integral accessibility, system facilitated accessibility, space-time geography, utility theory, and relative accessibility (Lei, et al, 2010).

Measures of “system accessibility” are the most straightforward to carry out, and focus on users’ physical access to a system as a function of time, distance, or the effort needed to reach it. Appealing for the ease with which they can be calculated, and because they make no assumptions about mode selection and availability; these measures really speak to proximity, rather than accessibility. In fact, calculations of system accessibility may overestimate actual accessibility, as they fail to consider the ease with which the system allows travel to specific destinations.

¹ The scale of the study area at which proximity/accessibility of amenities can be gauged is quite malleable, and will likely be determined by the study’s intent as well as the availability, and comparability of data.
System accessibility is one of only two measures of proximity/accessibility that can be approximated without the aid of GIS\(^2\), and at its simplest is calculated using a straightforward set of analytical steps. First, the amenities of interest (be they transit stops, grocery stores, hospitals, or anything else), as well as the population whose ability to access those amenities is under study\(^3\), must be identified. The boundaries within which a destination can be deemed “accessible” must then be determined. When using GIS, these boundaries are typically delineated using a buffering function, with a distance of between ¼ mile and ½ mile. If GIS is not available, Census-determined spatial extents, such as block groups or blocks, may be used. In GIS, the buffers are used like “cookie cutters” to slice through the other data layers, revealing the total study population(s) within the desired distance of the point of interest. In non-GIS assisted analyses, population counts for the areas of interest can be summed to determine the total population that enjoys easy access to the amenities under study.

**Example Analyses**

- Transit accessibility in Seattle’s Queen Anne Community was measured by creating quarter mile buffers around transit stops. Any street that intersected the buffer was considered to have good transit access (Nyerges, 1995).
- A 1994 study found that employees living within a quarter mile buffer of Boston’s transit stops had good access to the city’s medical facilities (Azar et al, 1994).
- In an attempt to measure neighborhood accessibility, Aultman-Hall looked at the average and maximum distances between a collection of neighborhoods and destinations including schools and transit access points (Aultman-Hall et al, 1997).

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\(^2\) The other being integral accessibility, discussed below.

\(^3\) The population of interest may be total population, daytime population, number of households, streets, or another, study-specific measure.
Hillman and Pool (1997) created a software system for transit operators to measure the accessibility of transit stops in London.

The Florida Transit Geographic Information System was designed by Gan et al. (2005) to identify transit accessible areas in the state, calculate the proportion of the service area actually served by transit, as well as to identify areas into which transit service could be expanded according to levels of housing density and employment.

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“Integral accessibility” seeks to quantify the total accessibility associated with a collection of destinations. In their most simplistic form, measures of this type count opportunities to engage in a particular activity within a predetermined distance or time of a given start point (Lei, et al, 2010).

They are quite similar to approaches focused on system accessibility, in that they rely on the drawing of buffers around points (in GIS), or the identification of spatial extents of interest (in non-GIS assisted approaches). The two are essentially mirror opposites, however, because where system accessibility focuses on destinations and seeks to identify the population to which they are accessible, integral accessibility works by focusing on origins, and identifying the number of amenities of a particular type (or types) that can be accessed from them.

Like the previous variety of metrics, integral accessibility fails to capture some determinants of actual accessibility, such as time and cost constraints.
Example Analyses

- Both Wachs and Kumagai (1973) and Talen and Anselin (1998) carried out simplistic analyses of integral accessibility, by simply counting the activities of a certain type that occurred within a predetermined “reasonable” travel distance from a particular starting location.

- A more complicated approach involves creating “location profiles,” which represent aggregate accessibility for various activity types at certain cutoff distances from a starting point. Approaches of this kind were used by both German and Ritsema van Eck (1995) and de Jong and Ritsema van Eck (1996).

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“System facilitated accessibility” considers a user’s ability to get to their desired destination, by taking into account the cost or travel time associated with doing so using a particular mode. Central to these efforts is the calculation of trips between specific origins and destinations using network analyses; hence, in addition to data on populations and destination locations, the analyst must have access to reliable network data, such as a layer depicting roadways within the study area.

What’s more, with calculations of system facilitated accessibility (and all of the other GIS-based approaches discussed throughout the remainder of this paper), a point (or points) of origin from which accessibility is to be determined must be defined. In cases where address data
for populations of interest are available, these can serve this purpose, otherwise, specific public locales, such as transit hubs, shopping or employment centers, or medical facilities, can be used.

Example Analyses

- A very simplistic approach to measuring system facilitated accessibility was carried out by Liu and Zhu (2004), when they determined transit time by dividing distances by average travel speeds.

- More complicated approaches take into consideration system characteristics such as transfer and wait times, as well as schedule information. Hillman and Pool (1997), for instance, determined travel times between origins and destinations by accounting for walk time to a transit stop from an origin point, time spent waiting for the chosen travel mode, any wait time at intermediate change points, and total time traveling aboard a transit vehicle.

- A shortest path model was developed by O’Sullivan et al. (2000) that analyzed a multimodal network of bus and rail, using published service schedules, to create a shortest path model to a central business district.

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<td>Data requirements and GIS expertise are more intensive than less sophisticated analytical techniques</td>
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The fourth category, “**space-time geography**,” recognizes that movement is a function of mobility and a person’s available time budget. Calculations of this sort often rely on GIS network data to derive space-time accessibility measures (Lei, et al, 2010).

**Example Analyses**

- Kim and Kwan (2003) created a model to account for facility operating schedules and transport network properties by calculating the sum of available opportunities, weighted by service time availability.

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**Disadvantages**

- Cannot be estimated without GIS

“**Utility theory**” positions travelers as consumers, with various modes constituting their choice set. Users are assumed to be logical, in that they will select the mode of maximum utility; a determination made by taking into account user characteristics and destination, as well as attributes of the available travel options, such as time, cost, and comfort level (Lei, et al, 2010).

**Example Analyses**

- Rastogi and Rao (2002, 2003) created a utility theory model related to transit access in India, which incorporated socioeconomic variables, such as income, transit-specific factors, including distance to stations, modal split, and modal preference data, to estimate an accessibility index.

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**Advantages**

- May render more accurate estimates of accessibility than measures of system accessibility and integral accessibility

**Disadvantages**

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Finally, comparisons of access between users and modes are at the heart of measures that focus on “relative accessibility.” For example, the choice between taking transit or a personal vehicle (assuming one is available) depends on a variety of considerations, including cost, time, safety, and convenience. Transit’s value, according to methods of this type, is determined relative to other available options; hence, its appeal can be impacted by parking costs, route locations and schedules, etc.

Because it involves building networks for each available mode, running scenarios, and determining which are the optimal travel scenarios, models of the utility theory type are unique from, and more complicated than, their system facilitated accessibility and space time geography counterparts.

**Example Analyses**

- Sheppard (1995) analyzed relative accessibility by constructing a travel time ratio to construct diversion curves for modal split.

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The techniques described above can be expanded and repeated according to the study needs. For example, a change index can be created by repeating the analysis for different time periods and comparing the results. A comparison can also be made between the study area and a
control location (such as the surrounding region, a similar town in another state, or other place of interest) by computing output for both and examining the differences.

**Data Sources**

**Population**

Population data can be accessed from the US Census Bureau’s American Community Survey (ACS) at a variety of scales. Information about amenities, however, must be collected from disparate sources, each of which is discussed below.

**Transit**

The first step in gathering data on transit is to decide what types of services are of interest. Are only high flow stations worth considering, or do all stops merit inclusion? Is rail the primary target, or are other modes of equal or greater interest? The answers to these and related questions will help inform the data collection approach. As a general rule, the most reliable data can be obtained from local sources. In the case of transit, this would be from the agencies themselves, or from a state DOT.

If, for some reason, local data are not available, the Bureau of Transportation Statistic’s (BTS) National Transportation Atlas Database (NTAD) is a good source of for information on bus rapid transit and rail (fixed guideway modes). The NTAD is a collection of GIS layers, and is updated annually and can be accessed for free in the form of downloadable zip files and DVDs.

The database is known to have some gaps, however. For example, data on New York City is incomplete. Before incorporating NTAD data into an analysis, it is important to verify that it provides an accurate representation of the location of interest.

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\footnote{For an in-depth discussion of the ACS, its uses, and limitations, see the “Travel Mode Share” paper of this same series.}
The database also fails to differentiate between stops based on use levels, representing those with limited service schedules in the same manner as even the busiest urban stations. If the desired analysis is intended to focus on “high flow” locations, a local or regional agency should be able to help in their identification.

Another, even more complete source of data on transit stops is the Center for Transit Oriented Development’s (CTOD) National TOD Database (NTD). The NTD, which was created in 2009, contains information about all existing and proposed fixed guideway stations in the country, including ferry stops. Although not directly accessible through a web-based interface, since the data were gathered using federal funding, they must be made available to the public upon request. Bus route information may also be available from the Federal Transit Administration (FTA). These data were first collected by Bridgewater State College in 1995, and have been converted into GIS layers, easing their incorporation into an analysis of this kind.

**Streets**

Data layers representing local streets and roadways may be accessible from MPOs or local planning agencies, or they can be obtained from the US Census in a downloadable format from among their Topologically Integrated Geographical Encoding and Referencing (TIGER) products.5

**Businesses and Healthcare Facilities**

Accurate, free, downloadable data on the locations of business and healthcare facilities are not publically available for all areas; however, they can be purchased from a number of

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5 TIGER line and shapefiles are available at: http://www.census.gov/geo/maps-data/data/tiger.html
privately-maintained data sources. Among the best known of these are ReferenceUSA\textsuperscript{6} and Dunn and Bradstreet\textsuperscript{7}, which have information about private and public businesses of all kinds (grocery stores, pharmacies, daycares, etc.) and healthcare facilities. Information on new home buyers and movers is also available, which could be useful in analyses to determine the impacts of new initiatives, policies, and investments. Data of this kind can also be obtained by purchasing the ESRI Business analyst and Community Analyst for ArcGIS or Placeways’ CommunityViz.

Although not as comprehensive and reliable as purchased sources, some information may also be available for free download online. Websites of interest include ArcGIS.com, the GIS data depot\textsuperscript{8} and geoonestop.org.\textsuperscript{9}

**Parks and Open Space**

As with other data, local sources are best, meaning that if state-maintained land use/land cover information are available, they should be utilized. If, however, local data are not available, the National Land Cover Database (NLCD)\textsuperscript{10} can provide information on open spaces and undeveloped lands for use in GIS analyses (Vogelmann et al, 1998).\textsuperscript{11}

\begin{footnotes}
\footnote{Available at: http://www.referenceusa.com/Home/Home}
\footnote{Available at: http://www.dnb.com/}
\footnote{Available at: http://data.geocomm.com/}
\footnote{Available at: http://xps.geoonestop.org/}
\footnote{The NLCD can be accessed at: http://www.mrlc.gov/nlcd2001.php}
\footnote{For a comprehensive discussion of the National Land Cover Database (NLCD), see the paper on “Growth in Previously Developed/Designated Areas” paper of this series.}
\end{footnotes}
Conclusions and Recommendations

There are a number of analytical approaches to gauge the proximity and accessibility of transit and other amenities. Of these, the more simplistic offer the advantage of being readily computable, either using GIS or through simple mathematical manipulations, but may over estimate accessibility because they fail to account for real world travel costs, such as monetary and time constraints. More sophisticated approaches, in contrast, require the use of GIS by someone well-versed in its construction and operation, but the accuracy of the results can far surpass those of less complex methodologies.

Given this, the following recommendations have been formulated for TCI’s use:

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<td>Use a system accessibility or integral accessibility measure to determine proximity/accessibility for the study area using data from before and after the intervention; compare results.</td>
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<td><strong>If in-house GIS resources are robust and a single mode of travel is of interest and a “snapshot” of proximity/accessibility is desired:</strong></td>
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