Trip-making and accessibility:
New tools, better decisions

Transportation and land-use decision makers need tools and standards to guide their thinking and to assess success. For decades, major tools and standards have revolved around two methods: 1) speed of motor vehicles, also known as "mobility," measured directly or by level-of-service calculations, and 2) anticipated travel demand—always for motor vehicles, and sometimes for transit, but only rarely for active modes—as predicted by models. Practice around these methods has incrementally improved, e.g., by focusing less on absolute vehicle speed and more on variation to gauge reliability, and by improving models to account for trip-chaining. Fundamentally, however, these methods still have significant flaws and generally answer the same question they were designed to give when they first came into currency: Which highways should we widen first to speed up vehicles traveling the region?

The field has long sought other tools to complement or perhaps replace conventional methods—tools that would better analyze trips rather than speed at points in the system, speak to non-auto modes of travel, address land use solutions as well as highway infrastructure, and so on. Barriers to such tools have included lack of data and analytic methods, as well as considerable inertia in practice.

Fortunately, new sources of data and emerging methods, as well as newfound interest in performance and scenario planning, are yielding the types of tools that the field needs. These fall into two related but distinct categories: 1) **trip-making,** which looks at complete trips rather than vehicle speeds on system segments, as observed empirically rather than through models, and 2) **accessibility,** which describes the ease or difficulty involved in reaching destinations on the existing or planned network. Sections below describe each of these in more detail, focusing on personal travel, which accounts for the bulk of system use in metro areas. The tools share the ability to inform decisions in these ways:

- By providing area scans to assess behavior and performance
- By tracking behavior and performance over time
- By diagnosing problems
- By assessing solutions
- By engaging stakeholders with meaningful, intuitive information

In contrast to the conventional practice of looking at where vehicle speeds are reduced due to congestion—either now or in the future—and assuming those are the places to add capacity, newer tools provide a wealth of insights that may point in different directions and suggest better solutions. We should stress that these are not the only new methods available. For example, calculations of induced demand, such as those being developed under California's SB 743, would provide new information on capacity expansions using either conventional or new tools.

But we believe trip-making and accessibility will become fundamental to a practice that is oriented toward performance and scenario planning.

Trip-making

Trip-making analysis looks at where people and/or goods are going: origins, destinations, routes, times of day, and other attributes. This contrasts with the conventional practice of looking at the speed and number of vehicles or transit passengers at points in the system, or taking infrequent samples and modeling travel flows across the region without much validation. Neither method addresses active transportation, and both are designed to look at regional flows, mostly ignoring shorter trips. These short trip and active transportation options are often made more difficult by the presence of high-speed regional facilities.

Empirical trip-making analysis at a moderate cost is made possible by the availability of "big data" in two forms: GPS and cellphone traces. These data are passively collected, meaning they exist without transportation agencies having to actively collect them, and therefore cost much less than conventional surveys while covering much larger segments of the population. They are not free, however, as they require contracts with phone companies, connected vehicle systems, and methods for anonymity, quality control, and storage. GPS traces are collected from vehicles with GPS systems as well as smartphones, and are available through vendors such as INRIX and StreetLight Data. Cellphone traces are collected from smartphones and voice-only cellphones as they communicate with cell towers, and are available from vendors such as AirSage and Teralytics.

Table 1. Trip-making technologies compared.

	GPS	Cell
Spatial precision	5 meters	125 meters or more
Sample size	Large compared to surveys, growing	Up to 50 percent of population per vendor, stable
Modal tracking	Motor vehicles, bike-ped[1]	Motor vehicles, transit, bike-ped
Motor vehicle types	Personal, commercial	No distinction
Long-distance rail, plane	No	Yes
Route tracking	Very precise	Less precise
Linked trips	Single trips only[2]	Trip chains
Trip purpose	Imputed for home and work, medium confidence	Imputed for home and work, high confidence
Trip-maker demographics	Imputed	Imputed or direct

The two technologies have contrasting strengths and weaknesses (though both promise to improve over time). Table 1 lists some of the most important aspects. Note that we have worked

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[1] Bike-ped tracking is under development as part of an ongoing project SSTI is running.
[2] Trip chains may be traceable with GPS in coming months.

extensively with GPS and can vouch for the attributes listed here, while some of the attributes for cell traces are based on vendor claims, which we have not yet tested. Note also that applications are improving (partly as a result of SSTI work), so that the utility of big data should improve over time.

Using these technologies it is possible to determine zone-to-zone travel flows, with zones as small as individual parking lots or parcels. It is also possible to determine routes, speed, distance, time of day, circuity, and modal connections, and to impute trip purpose and demographic information about travelers.

Figure 1 shows the results of a scan of origins and destinations in the Northern Virginia suburbs of Washington. A surprising result was that nearly 40 percent of morning trips to George Mason University, a commuter campus, came from nearby or adjoining neighborhoods. This suggested that the GMU bike and pedestrian plan, which calls for much better connections within the car-oriented campus, be extended outward to allow those who would like to make a 1- or 2-mile commute by active transportation to do so. It also suggested that many GMU students and employees were choosing to live near campus, and additional campus-oriented housing might draw more campus users, reducing the need to drive or to drive as far as they currently do.
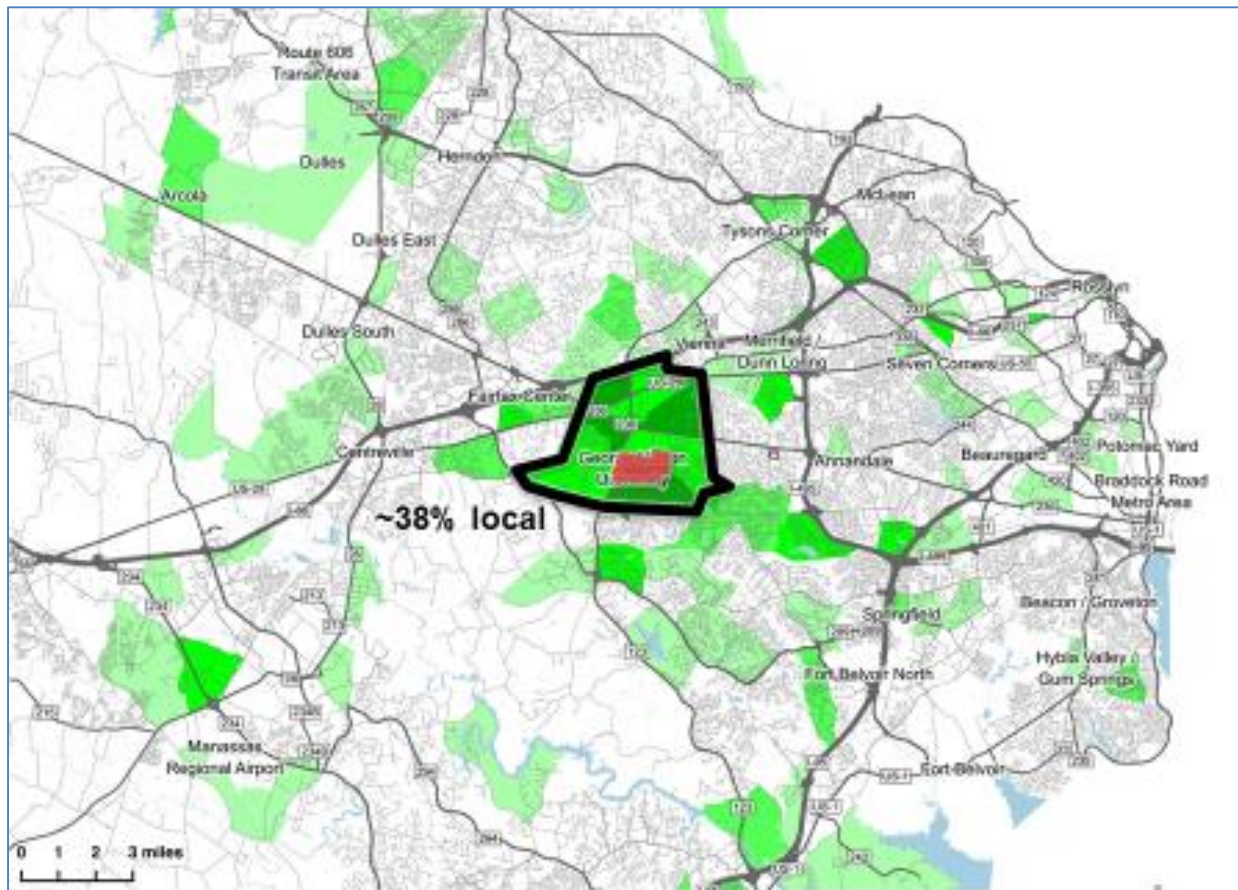

Figure 1. Morning vehicle trips to George Mason University (red). Nearly 40 percent of trips originate in nearby neighborhoods (black border).

In another case involving the suburban Tyson's Corner business district in Northern Virginia, results showed that there were more than 32,000 internal motor vehicle trips a day, congesting the arterials that go through Tyson's Corner (Figure 2). This suggests that better internal connectivity between land uses and across busy roads would present the opportunity for visitors to park once and walk between destinations, or to use the newly opened Silver Line of the Washington area's Metro system (or conversely, that the failure to provide such opportunities will keep ridership on the Silver Line down).
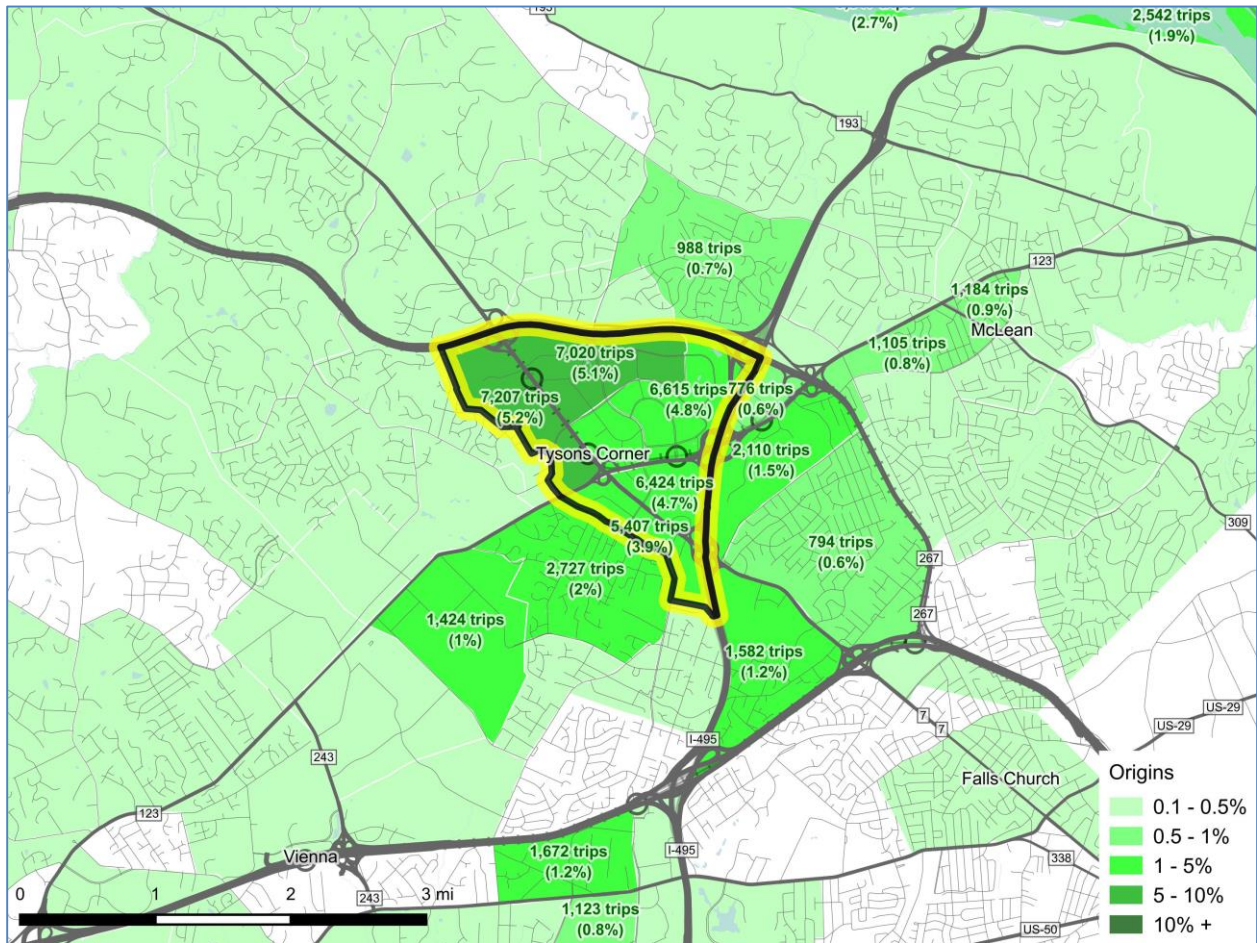

Figure 2. Tyson's Corner, Virginia. Figures indicate the number of daily trips ending in analysis zones within Tyson's Corner (black and yellow border). Internal trips, those that begin and end in Tyson's Corner, total 32,673 a day.

Accessibility

Accessibility measures the ease by which travelers can reach destinations on the network by car, by transit, by bike, or on foot. Destinations include jobs as well as non-work destinations, such as shopping, schools, and parks. Non-work destinations are important because they attract more trips and miles traveled than do jobs.

To operationalize accessibility, the ease of reaching destinations is usually measured in time. This allows analysis to get beyond traffic speed—although that is a factor in accessibility for the automobile mode—to also include distance and non-auto modes, providing a better representation of conditions than speed alone. And because accessibility looks at both networks and land uses, it can bring transportation and land use decision-making together, providing practitioners in both areas with a common metric and analytic tool.

To compute accessibility three things are needed: 1) locations of households, jobs, and other destinations; 2) networks for all modes being evaluated; and 3) a method of computing travel times. With the advent of big data and modern computing, all these elements exist. SSTI has been using a tool called Sugar Access from Citilabs, which works on the ArcGIS platform commonly used in transportation and land use planning practice.

A critical element of measuring accessibility is the notion that shorter trips are more valuable—or less costly—than longer ones. The decay rates vary by mode and can be derived from observed travel behaviors. We see, for example, that willingness to walk drops off more quickly with time than for auto and transit modes. Sugar Access provides default decay rates that can be adjusted to account for local conditions or populations.

Conventions around this metric are developing, and it seems likely that work and non-work accessibility will be scored separately. In our work we have measured work accessibility in terms of decay-weighted jobs or, where particular analyses demand it, absolute numbers of jobs. We have measured non-work accessibility—encompassing a basket of destinations such as groceries, banks, restaurants, and schools—on a scale from 0 to 100, which is similar to the well-known Walk Score (www.walkscore.com) application. Again, Sugar has a default non-work destination basket, which can be adjusted as needed. As with jobs, we sometimes measure accessibility to particular destinations. For example, decision makers might look at walking access to groceries in low-income areas to assess food deserts.

Figure 3 depicts decay-weighted job access by transit in Madison, WI. Neighborhoods in green have the best access to jobs due to the proximity of jobs or robustness of transit or both. Neighborhoods in orange have limited job accessibility, and those with no shading have no job accessibility, usually because they have very limited or no transit.
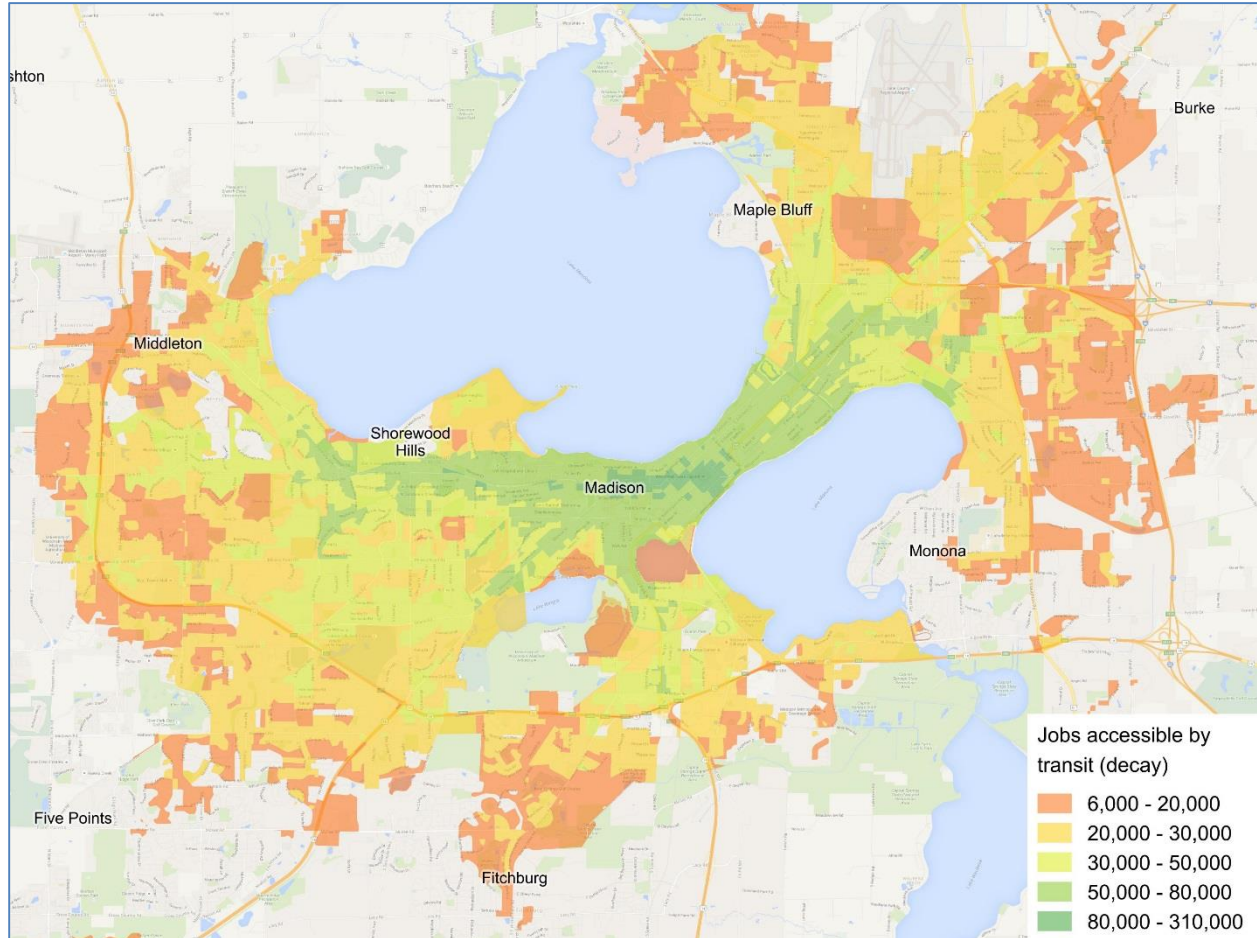
Figure 3. Decay-weighted job access by transit in Madison, WI.

Figure 4 shows walking access to non-work destinations in Madison, WI. Green areas have high destination density and well-connected walking networks. Lower-scoring areas require longer walks because destinations are more spread out, or because networks are less connected, or both.
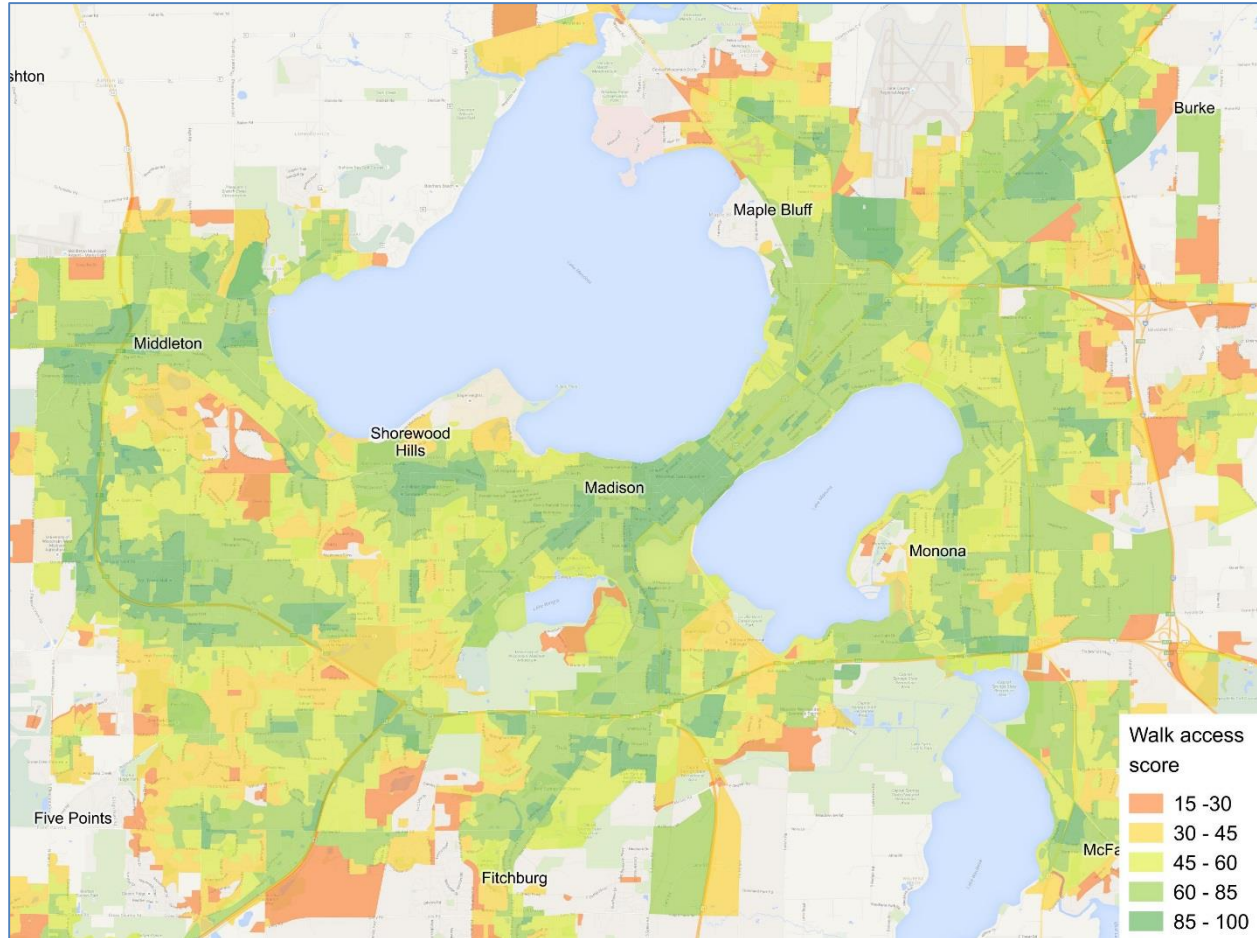
Figure 4. Accessibility to non-work destinations in Madison, WI.

With an accessibility tool that works in a GIS platform, we can perform a variety of other analyses, including those that make use of other attributes in GIS and those that involve possible changes in the network or in land uses. It is also possible to assess likely mode choice via relative modal accessibilities. Below are several examples:

- In Figure 5, we overlay poverty with transit access to jobs to identify disconnected areas with many low-income households.
- In Figure 6, we examine the impact to transit riders of a proposed community college relocation. The current building (No. 1 in the figure) has significantly higher accessibility than the proposed location (No. 2), where average travel times would be 22 percent higher.
- In Figure 7, we address a planned green-field subdivision that has been proposed with only residential and school uses. We add a handful of neighborhood-serving retail uses and display the increase in walking accessibility.
- In Figure 8, we assess the impact of a recently added transit route, showing the additional decay-weighted jobs accessible along the route and throughout the system.
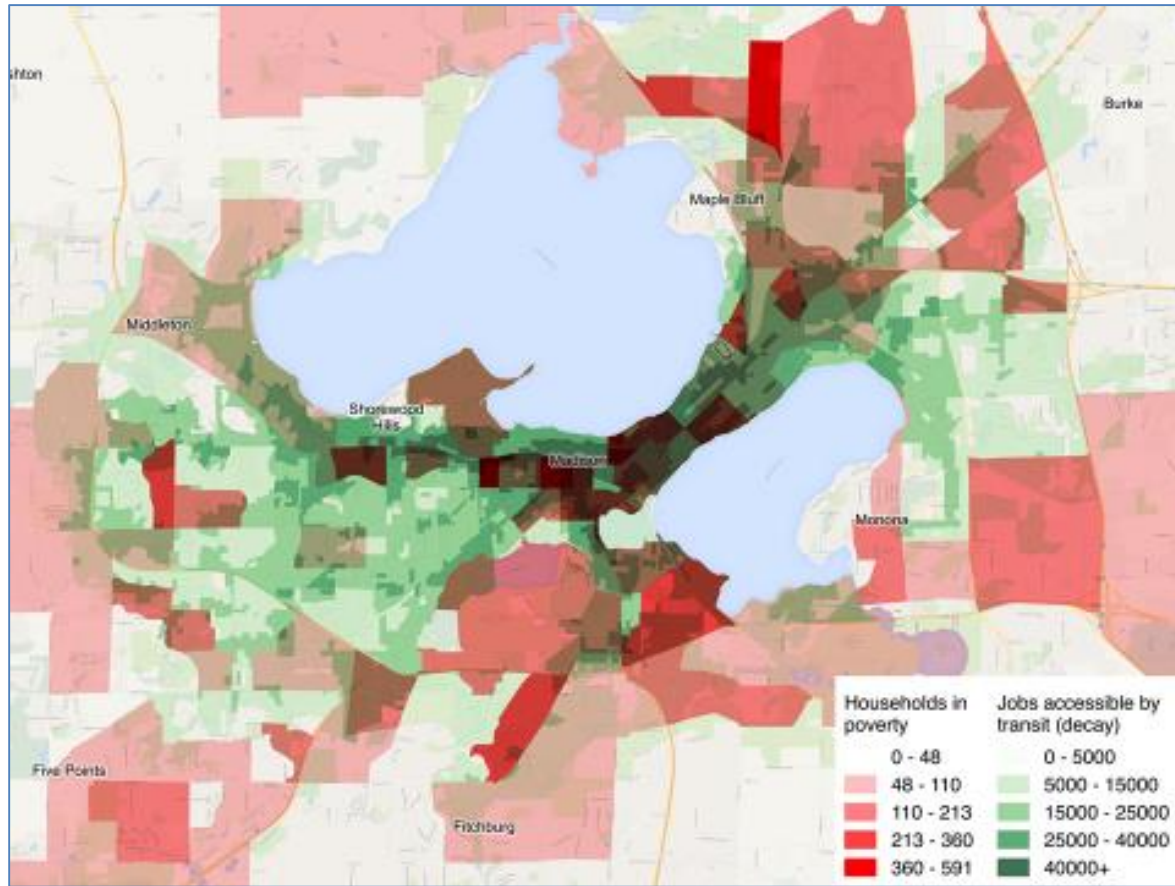
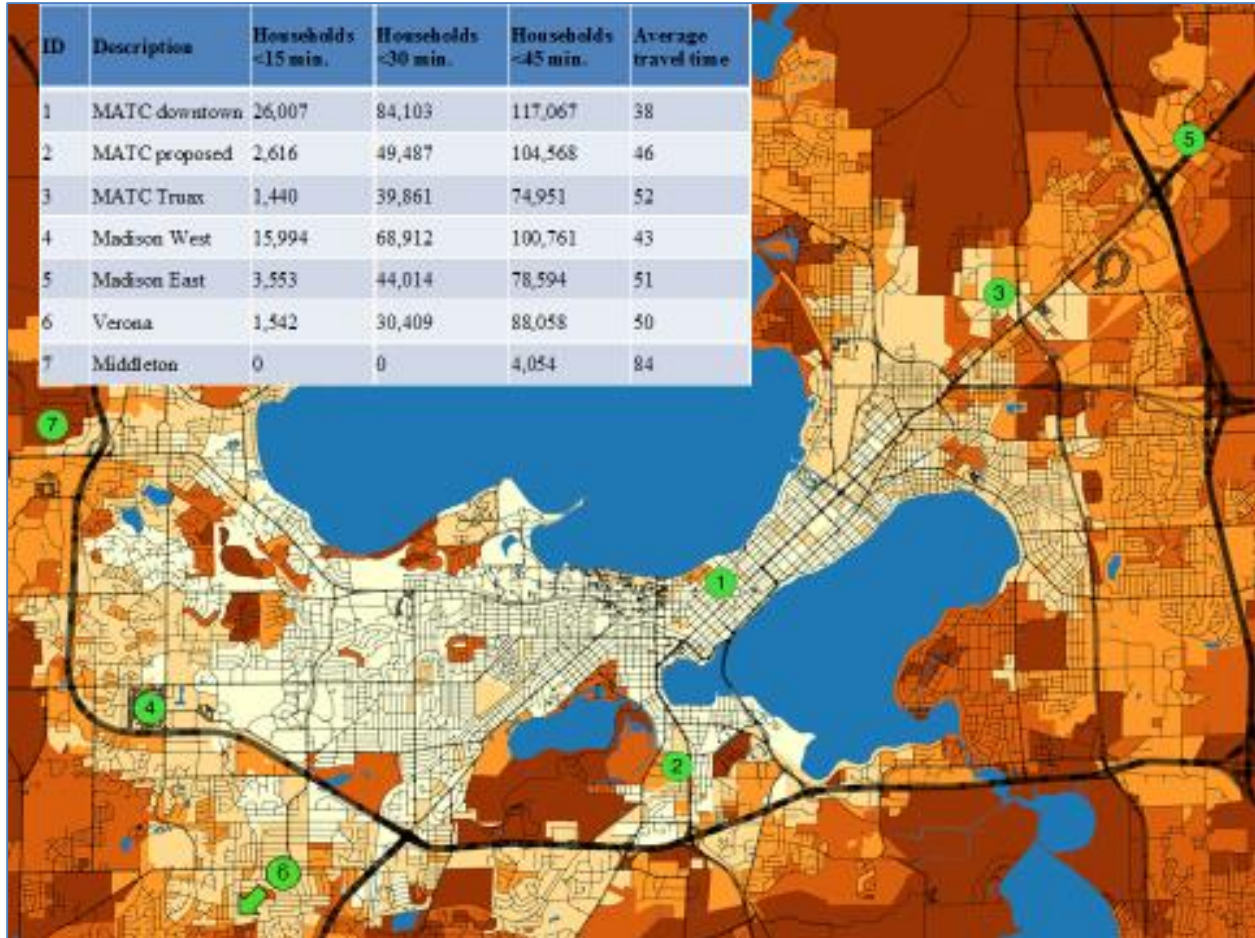*Figure 5. Poverty and transit access in Madison, WI.*

ID	Description	Households <15 min.	Households <30 min.	Households <45 min.	Average travel time
1	MATC downtown	26,007	84,103	117,067	38
2	MATC proposed	2,616	49,487	104,568	46
3	MATC Truax	1,440	39,861	74,951	52
4	Madison West	15,994	68,912	100,761	43
5	Madison East	3,553	44,014	78,594	51
6	Verona	1,542	30,409	88,058	50
7	Middleton	0	0	4,054	84

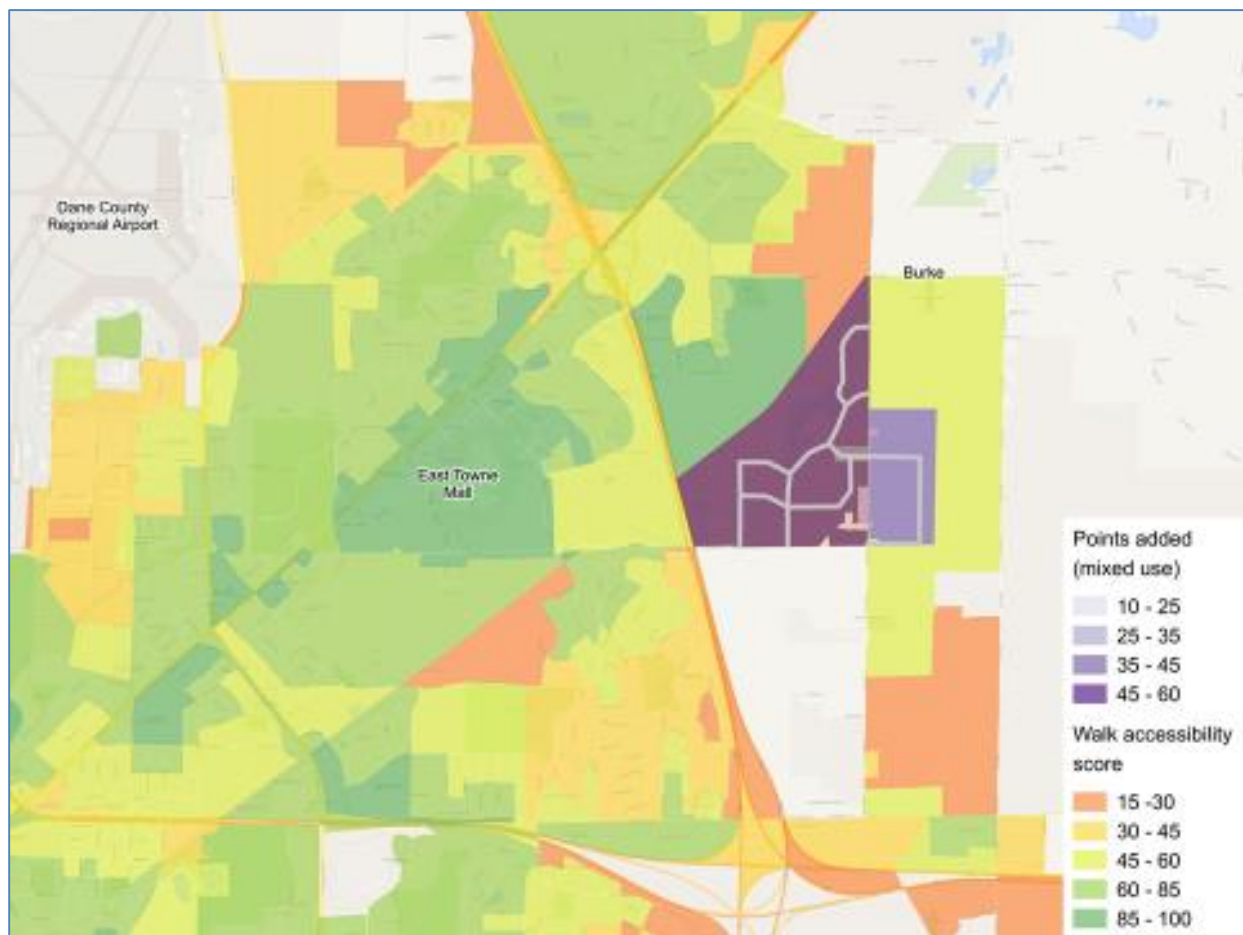*Figure 6. Transit accessibility to existing and planned community college campuses in Madison, WI.*

Figure 7. The walking accessibility effect of adding neighborhood retail in a planned residential subdivision in Madison, WI.
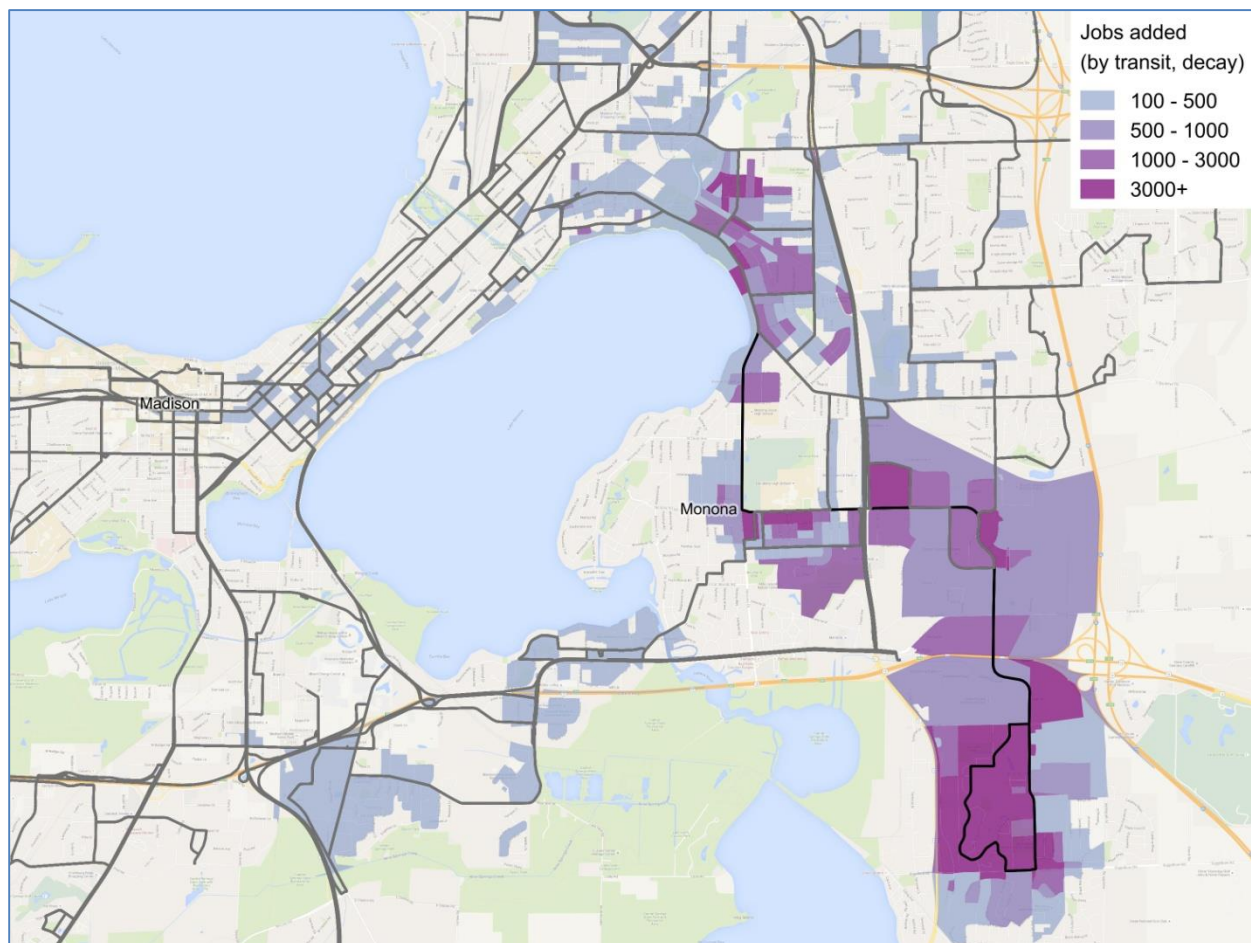
Figure 8. Decay-weighted job access improvement with a new Metro bus route, Madison, WI.

Conclusion

The previous examples give a sense of the power of trip-making and accessibility analysis. Both tools can be further developed—for example with standard nomenclature and thresholds—but both are available now and offer significant improvements to practice. Here are some examples of how these tools could be used in the five ways described above:

- Scanning. The tools can be used to determine where common flows of travelers are; where many short, circuitous car trips are taking place; and where accessibility to particular destinations is good or poor.

- Tracking progress. By determining targets and tracking travel flows or accessibility over time, the tools can be used to assess performance.

- Diagnosing problems. Travel-flow data and accessibility can show where connectivity is poor, or where land uses are not sufficient to serve communities.

- Assessing solutions. Sketch-planning tools can be applied to traveler flow data, and land-use and transportation changes can be assessed directly with accessibility tools.

- Engaging stakeholders. Maps and metrics of showing actual travel flows and the access to destinations can be intuitive prompts for scenario planning aimed at the public, elected officials, the development community and others.

For more information on applying these tools, please contact Eric Sundquist, SSTI managing director, at erics@ssti.us or 608-265-6155.