

# Access for Performance

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## Abstract

This paper urges that policy decisions be based on important and reliable performance measures. Robust measures that assess the performance of the transportation *and land use* dimensions of cities, however, are typically missing from such discussions—they typically focus on congestion and mobility. The heart of approach suggested herein lies concept of accessibility: the ability of people to reach the destinations that they need to visit in order to meet their needs. By focusing on accessibility—rather than congestion or mobility—this approach produces a more complete and meaningful picture of metropolitan transport and land use. We place accessibility in a position of prominence as a performance measure by (a) describing the use and measurement of accessibility for metropolitan areas, (b) identifying robust, concrete and practical issues about measurement of the concept, (c) and offering prescriptions for resolving measurement issues.

# 1 Access for Performance

## 2 Introduction

3 Annually, traffic weary residents across the U.S. eagerly wait by their radio or for their  
4 newspaper to learn about the latest congestion report card from the Texas Transportation  
5 Institute. This urban mobility report makes headlines, especially in places with worsening  
6 congestion. Even smaller areas, possibly not yet victims of high levels of congestion, lament  
7 their annual increase in levels of congestion, but secretly enjoy their emerging big city status.  
8 Traffic engineers, planners, and politicians take more than feigned interest because to date, such  
9 ratings are the only available measure to assess progress toward an issue central to livability that  
10 is front and center on the front of the minds of many residents.

11  
12 Congestion is a serious issue, undoubtedly. But is congestion the problem or the solution? Taylor  
13 [1] argues that traffic congestion is a solution to the problem of how to allocate scarce road  
14 space. Even if we agree that congestion wastes time, is minimizing congestion the most  
15 appropriate public policy goal [1]? Do measures of congestion provide the basis for policy  
16 prescriptions? We argue elsewhere [2] that mobility (or lack thereof because of inadequate  
17 networks or congestion) is an element of the larger goal—ensuring accessibility.

18  
19 Recent years have witnessed more than a handful of conferences or workshops whose central  
20 themes focused on the concept of accessibility. For example, the University of Minnesota  
21 sponsored two conferences, producing an array of recent scholarly publications on the topic in  
22 2004 [3] and 2007 [4-9]; the European Science Foundation hosted a workshop, How to Define  
23 and Measure Access and Need Satisfaction in Transport, in 2007 [10]. The Network on European  
24 Communications and Transport Activities Research (NECTAR) continues to sponsor activities  
25 focusing on accessibility. Accessibility has also become a civil rights issue [11].

26  
27 As judged by the level of discussion, mention, and focus in specialized workshops, interest in the  
28 topic is high. Previous writings have focused on defining the concept of accessibility generally,  
29 starting from Hansen [12], but also involving other extensions [13-16], measuring the concept  
30 using different approaches [17], various data needs [18] or its use in explaining behavior [3, 19].

31  
32 This paper urges that policy decisions be based on important and reliable performance measures.  
33 Robust measures that assess the performance of the transportation *and land use* dimensions of  
34 cities, however, are typically missing from such discussions [20]. The heart of approach  
35 suggested herein lies concept of accessibility: the ability of people to reach the destinations that  
36 they need to visit in order to meet their needs. By focusing on accessibility—rather than  
37 congestion or mobility—this approach produces a more complete and meaningful picture of  
38 metropolitan transport and land use.

39  
40 Our intent in this paper is less about reviewing and commenting on the wealth of past research  
41 and more about adapting such research into means useful for informing and influencing policy.  
42 We aim to place accessibility in a position of prominence as a performance measure. This paper  
43 has three functions, to:

- 44 • Describe the use and measurement of accessibility for metropolitan areas,

- 1 • Identify robust, concrete and practical issues about measurement, and
- 2 • Offer prescriptions for resolving those issues.

### 3 **Definitions**

4 Accessibility has been a familiar concept in the transportation planning field since the 1950s  
 5 when it was defined as the ease of reaching desirable destinations [12]. This represented one of  
 6 the first efforts by planners to develop measures that linked land use and activity systems with  
 7 the transportation networks that serve them. Hansen presented a hypothetical model showing  
 8 how differences in accessibility—constructing an express highway—could be used as the basis  
 9 for a residential land use model. In this context and others [21], highways (and other  
 10 transportation infrastructure) provide accessibility that affect location decisions.

11  
 12 In these applications, accessibility weights opportunities (e.g., the quantity of an activity as  
 13 measured by employment) by impedance (e.g., a function of travel time or cost). Under this  
 14 framework, accessibility is typically described by the following equation:

15 
$$A_i = \sum_{j=1}^n O_j f(C_{ij})$$

- 16 where  $A_i$  = accessibility from a zone ( $i$ ) to the considered type of opportunities ( $j$ )  
 17  $O_j$  = opportunities of the considered type in zone  $j$  (e.g., employment, shopping, etc.)  
 18  $C_{ij}$  = generalized (or real) time or cost from  $i$  to  $j$   
 19  $f(C_{ij})$  = Impedance function (exponential or power functions are most often used)  
 20

21 Accessibility applies within cities and between cities. The matrix depicted in Table 1 suggests  
 22 one organizational schema. Most focus in the planning community has been on access for  
 23 passengers to various daily activities. But access from a city to other cities is important in  
 24 explaining the growth of areas as a whole; furthermore, industry depends on easy access for  
 25 goods both within the metropolitan area (to distribute to customers and suppliers) and to other  
 26 cities.  
 27

	Intra-metropolitan						Inter-metropolitan
Passenger		Car	Bus	Bike	...	Walk	
	Jobs						
	Stores						
	...						
	Workers						
Freight							

28 Table 1. Matrix of Accessibility

29  
 30 New modes of transportation change each city’s relative (and absolute) positioning for each type  
 31 of accessibility, and this in turn helps drive the rise and fall of cities. Cities built in earlier times  
 32 that could not, or did not, adapt to new modes fall by the wayside, cities that were well-located in  
 33 one era may be redundant in another, faster era when primary cities need not be so close. The  
 34 same applies within cities, and as intra-metropolitan transportation modes change,  
 35 neighborhoods that were once exclusive or attractive lose their relative advantage, and new

1 development rise in their wake.

2

3 The concept of accessibility was initially developed for automobile travel. To the extent that  
4 accessibility has been employed in past mainstream transportation planning circles, such  
5 measures have also typically been auto-based [22, 23]. In addition, many studies limit their focus  
6 to access to employment. The emphasis on employment accessibility is understandable, given its  
7 link to other important aspects of urban structure, such as choice of residential location, and also  
8 to outcomes hypothesized to be related to urban structure, such as social exclusion [24].

9 However, access to other types of destinations, such as retail, are also important because they  
10 strongly influence various dimensions of travel behavior such as trip frequency [25], destination  
11 choice [26], mode choice, and trip or tour complexity [27]. They also affect the price people will  
12 pay for land; areas with higher accessibility to desirable activities will be more expensive. The  
13 market (the collection of individual buyers and sellers) has an opinion on what is desirable,  
14 which can be ascertained through tools such as hedonic models for the price of real estate.  
15 Higher access levels to activities such as shopping and recreation are also thought to improve the  
16 general quality of life.

17

18 Different types of activities and services are associated with different sets of restrictions. Being  
19 located in a particular jurisdiction determines which government services one can legally access.  
20 Access to police, fire, and schools, e.g., depend on jurisdictional residence. Other types of  
21 activities (jobs, shops) are open to the free market, and while still subject to the capability (how  
22 far one can reach) and coupling (who one wants to reach it with) constraints of time geography  
23 [28], are not as limited by authority constraints.

24

25 As with sprawl and smart growth, the language of accessibility can be confusing and pliable as  
26 not everyone employs the same dictionary. That said, there is growing agreement among  
27 transportation scholars that accessibility refers specifically to the value of reaching destinations,  
28 while mobility simply represents the ease of moving on the network [3]. In that view,  
29 accessibility is about getting places and doing things, while mobility is just about that cost.

30

31 This identifying characteristic, the *ease* of reaching *destinations*, is often considered a suitable  
32 definition of accessibility and contains *two* important tenets. There is the land use side of the  
33 coin; the desirability of what can be reached. And, there is the transportation side; by what mode  
34 and how fast. The term accessibility is often countered with the term mobility, often defined as  
35 the “ease of movement.”

36

37 Such benefits are perhaps best illustrated through examples. Imagine traveling to (or through) the  
38 prairie province of Manitoba in Canada. The traveler meets with the basic services required for  
39 daily living (i.e., food stores, shelter, employment opportunities); these services are mostly  
40 distributed across the landscape in a manner befitting relatively low density development. The  
41 result is an environment with relatively limited services but also (usually) free flowing traffic.  
42 Traffic congestion fails to exist and, when the roads are free of snow and mud, levels of mobility  
43 are quite high. People can get what they need, assuming auto-based travel, but the array of  
44 choices of things to get is relatively limited, so they are less likely to get what they want.

45

1 Contrast the above situation with the island of Manhattan in New York City. Often thought of as  
2 the most congested city in the U.S., its overall attraction, both culturally and economically,  
3 suffers little nonetheless. The reason is relatively simple. An endless array of services and  
4 opportunities exist for consumption accompanied by several options as available transportation  
5 modes. Despite its high levels of congestion, New York City thrives because of the extreme ease  
6 with which it enables residents and visitors to reach varied and valuable destinations.

7  
8 The above exemplifies how nearby destinations produce high accessibility even with low  
9 mobility. Conversely, where origins and destinations are spread broadly, even great mobility  
10 does not ensure high accessibility. The two concepts can be readily distinguished through an  
11 understanding of the meaning of a change in each: an improvement in mobility reduces the time-  
12 plus-money cost of travel per mile, while an improvement in accessibility reduces the time-plus-  
13 money cost per (value of) destination. Land is more expensive in Manhattan than Manitoba,  
14 suggesting the market values accessibility more than mobility.

## 15 **Implementation**

16 While the concept of accessibility has received support among the academic community, its  
17 application as a planning concept has been less widespread, with just a few concrete examples to  
18 point to [29]. The reasons for limited use are myriad and not limited to the lack of: (a) consensus  
19 on a preferred and comprehensive measure (by purpose or by mode), (b) detailed, reliable and  
20 widely available travel or land use data [18], (c) consensus in understanding the different  
21 purposes for which the measures will be employed, and (d) relatively straightforward strategies  
22 for putting it all together. Below, we describe some of the difficulties associated with such  
23 reasons and strategies and, based on experience developing robust and metropolitan-scale  
24 measures [30] in the Minneapolis-St. Paul metropolitan area, prescribe strategies to address such  
25 issues.

### 26 *To where?*

27  
28 As mentioned, most measures of accessibility center on the ease of reaching employment. This is  
29 understandable given the prominent role economic activity plays in the health of cities. But in the  
30 spirit of quality of life, diversity of goods and services, and health, it is becoming increasingly  
31 important to consider, for example, access to food, low-cost goods, parks and recreation, and  
32 medical care. Many measurement efforts may aim to be cumulative in nature, aiming to capture  
33 all aspects of the built environment in single measures. The claim is that the “whole package of  
34 accessibility” is how most residents perceive their cities, so why not measure accordingly. Other  
35 efforts claim that most policies aim to prescribe specific modifications (e.g., more housing, less  
36 commercial, more food stores) and knowing how various places fare in the disaggregate is  
37 useful. Even nominally similar destinations may not be perceived equally, see Box 1 on Taste.

### 38 *By what mode?*

39  
40 Broadening the scope of accessibility to include additional types of destinations and non-auto  
41 modes such as walking and cycling has been proposed as an objective worthy of further study in  
42 the land use-transportation field [22, 26]. Other than Iacono et al. [23], to date, there have been  
43 few examples executing non-motorized accessibility measures for entire metropolitan areas (as  
44 opposed to smaller neighborhoods). Issues including, but certainly not limited to lack of reliable

1 data, computational power or knowledge of non-motorized travel behavior have prevented  
 2 widespread application of such measures.

3

4 *Using which function?*

5 At least three general functions have been extensively employed in past efforts. These include  
 6 the cumulative opportunities function, the traditional Hansen function, and the logsum function.

7

8 Despite their historic popularity, attraction-accessibility measures have some significant  
 9 weaknesses. These measures assume that the ordering of alternatives is irrelevant to the  
 10 individual; this is clearly not the case when individuals have less than complete knowledge and  
 11 must acquire information through a search process. Attraction-accessibility measures also deny  
 12 the possibility of a hierarchical decision process where individuals mentally cluster individual  
 13 choices into aggregates (e.g., making a choice between downtown versus suburban shopping  
 14 malls prior to choosing individual stores). Finally, attraction-accessibility measures can be  
 15 difficult to interpret. For example, researchers often interpret the Hansen measure as a gauge of  
 16 “potential interaction”; however, it is unclear exactly what this means beyond simple ordinal  
 17 relationships (e.g., “A has more potential interaction than B.”)[31].

## 18 **Box 1 Taste**

19 Imagine a hypothetical residential neighborhood that has the following services all within 800  
 20 meters: deli, movie theatre, grocery store, veterinary, coffee shop, and a restaurant. According to  
 21 most metrics of accessibility, such an environment would score exceptionally high; residents  
 22 have a full array of opportunities all within convenient walking distance. Consistent with  
 23 conventional theory, more places in the metropolitan area along the line of the above would be  
 24 preferred over fewer places. (Too much choice may increase search and mental transaction costs  
 25 however, and not be as desirable as a simple “more is better” rule would suggest, see Schwartz  
 26 *Paradox of Choice*). Overall the market is likely to score a place with more access higher, (with  
 27 concomitant higher rents), though for any individual, their preference structure values proximity  
 28 to some different mix of destinations.

29

30 Sometimes these individual-level constraints require accounting for consumer tastes. For  
 31 example, most people seek access to a grocery store, but for some people that means finding the  
 32 closest location for milk, while for others only a gourmet food store will suffice.

## 33 **Policy**

34 Having discussed some important theoretical underpinnings and outstanding intellectual issues in  
 35 measuring accessibility, we turn to describing how accessibility measures can best inform and  
 36 influence policy in metropolitan areas. In community planning initiatives, the goal of enhanced  
 37 accessibility has generally garnered a welcome seat at the table [29], alongside a laundry list of  
 38 aspirations and platitudes such as increased mobility, decreased congestion, and reduced  
 39 greenhouse gas emissions.

40

41 However, despite a seeming consensus among land use-transportation scholars and practitioners  
 42 about the merits and concepts of accessibility as a performance measurement tool, the concept  
 43 has not yet been widely adopted. A fundamental issue is that accessibility measures come in all

1 different shapes and sizes. Some are more theoretical and robust in their complexity. Others are  
2 more practical and applicable with readily available data. The advantages of each depend on the  
3 intent and purpose. Furthermore, data requirements have been relatively burdensome, thereby  
4 rendering the concept too difficult to effectively measure. Faster computational speeds and  
5 increasingly available land use data that are both detailed and reliable, however, help relax these  
6 constraints. The current outstanding challenge when approaching such a goal in metropolitan and  
7 policy confines now centers around the type—and value—of measures that would be used.

8  
9 We suggest that accessibility measures have enormous potential to provide an appropriate  
10 performance measurement tool to guide *both* future land use decisions and transportation  
11 investments. But for such a measure to gain the currency it deserves in the policy process, it  
12 needs to be straightforward and appealing to users and politicians.

13  
14 These stipulations require several criteria to be filled—criteria not unlike those described for  
15 measures of effectiveness in analyzing the goals or success of different policy initiatives [2],  
16 Levinson (2003). Key to the particular pursuit of measuring and furthering accessibility is that  
17 the measures be clearly understood by both residents and policy decision-makers. Towards this  
18 end, we suggest that five criteria need to be satisfied. We label these the “5 C’s” of effective  
19 accessibility measures and each are briefly discussed as follows.

20 *Cumulative* – Accessibility measures need to scale well. They need to apply to a  
21 particular address, a neighborhoods or an entire region.

22 *Comparable* – Accessibility measures need to inform multiple modes on the same  
23 continuum and the same scale. In other words, it is ideal to have the associated varying  
24 networks, varying travel speeds, and varying impedance functions be as consistent as  
25 possible. Comparing an accessibility measure for walking that focuses particular  
26 attention on experiential elements (e.g., urban design amenities) with an accessibility  
27 measure for auto based solely on travel time presents outstanding challenges.

28 *Clear* – For the measures to have appeal to various constituents, they need to be  
29 understood by them. They need to be transparent in terms of where the data came  
30 from, how they were calculated, and what they mean. Politicians and citizens have a  
31 hard time relating to phenomena such as log-sum measures or negative exponential  
32 distance decay curves.

33 *Comprehensive* – Accessibility measures need to be able to clearly capture just certain  
34 domains of interest—restaurants, for example—or be able to aggregate different types  
35 of land uses.

36 *Calculable* – Finally, it is best for measures to employ data that is readily accessible,  
37 available for an entire metropolitan area, and specific enough to capture the fine-grain  
38 calculations required for pedestrian travel.

39  
40 The above criteria and discussion ultimately limit the utility of some of the more theoretical,  
41 nuanced, or even robust and extended measures that have appeared throughout the literature over  
42 the past decades. As much as researchers support continued exploration of how more complex  
43 measures could and should be applied to policy environments, there are competing demands—  
44 demands which often cannot be realized. Satisfying the above five C’s of effective accessibility  
45 measures, we claim, ultimately leads to a suggested and specific type of measure to be employed,  
46 the “6<sup>th</sup> C,” *cumulative opportunity* measures of accessibility.

1  
2 Several advantages of this measure for this purpose stand out. It is a straightforward measure for  
3 people to understand; the number of destinations within a set amount of travel time is a concept  
4 most can relate to. It scales well; it can be used in a straightforward manner for a single point or  
5 an entire metropolitan area. It compares well; it can be used in the same manner to compare  
6 different modes, different neighborhoods, and even different metropolitan areas.

7  
8 Of course, a number of definitional considerations still need to be fully ironed out. Even the most  
9 straightforward of measures can be made complicated by attending to all sorts of details. For  
10 example, how should destinations be measured (e.g., by establishment, employees, or something  
11 else)? How detailed should transit schedules be consulted (e.g., what time of day, how many  
12 transfers)? What time cut-off should be imposed (20 minutes, longer or shorter)? Should more  
13 than one time band be used?

14  
15 A prescribed measure we endorse would be computed using a cumulative opportunity measure  
16 that: (a) uses 20 minutes as a baseline measure for comparative purposes, (b) is performed for  
17 specific subunits for a region (e.g., transportation analysis zones to measure auto accessibility,  
18 census blocks for other modes), (c) measures various types of destinations (e.g., retail, food,  
19 health care) independently or in an aggregated manner, and (d) does so using actual measures of  
20 the phenomena rather than modeled estimates.

21  
22 Accessibility measures are typically thought of in terms of locational (x-y) attributes. Their value  
23 from a policy perspective, however, is when the measures are detailed in nature, but can be  
24 scaled up to represent broader areas using a weighted average for the area under inquiry. One  
25 could present a weighted accessibility score for a particular latitude and longitude location or a  
26 sub-area (e.g., a transportation analysis zone, or block) or an accessibility measure for an entire  
27 neighborhood, community or even metropolitan area using the following equation:

$$28$$

$$29 A_{\text{area}} = (\sum A_{\text{sub-area}} * P_{\text{sub-area}}) / P_{\text{area}}$$

30  
31 A = Accessibility Measure (for a particular area such as a neighborhood, district or even  
32 metropolitan area)

33 P = Weight (e.g., population of the disaggregate unit area)

34  
35 Figures 1, 2, and 3 illustrate the accessibility to jobs by walking, biking, and transit for 1995,  
36 2000, and 2005 respectively in the Twin Cities Metropolitan Area (Minnesota). The bar charts,  
37 compiled using the above equation, parsimoniously depict the number of jobs that can be  
38 reached in 20 minutes of travel time by each mode. As can be seen, walking is slower than  
39 biking or transit, and thus has overall a lower level of accessibility. Over time accessibility is  
40 increasing, primarily because of the redistribution and growth of land use, and in part because of  
41 changes to the transportation network. The visual map depiction combined with the bar chart—  
42 which could be computed for any geographic area—provide a clear, useful, and robust story for  
43 accessibility in the region that planners, high level policy analysts and decision makers can easily  
44 relate to.

## 1 Directions

2 For many years, normative work looking at cities and transportation has focused on strategies to  
3 modify transportation phenomena or behavior: how to encourage residents to drive less, use  
4 transit more, or spur walking. (In contrast with 20<sup>th</sup> century policy, which favored more driving  
5 and less transit, and spurned walking). These normative strategies are often pursued outside of an  
6 appreciation of the policy-related forces that have shaped these behaviors. Furthermore, the ways  
7 of thinking about policy prescriptions are bereft of appropriate measurement methods or  
8 standards.

9  
10 For example, considerable research seeks improved models of travel behavior. Furthermore, it  
11 tries to draw close associations to environmental outcomes; alternatively, research might seek to  
12 put more accurate dollar figures on various intangibles, etc. The intent is that such research will  
13 enhance policy making. Implicit in this line of reasoning is that shortcoming in transportation  
14 policies in the past were primarily attributable to lack of accuracy in this kind of knowledge. By  
15 reducing uncertainty in these areas, it is thought, more effective policies could be uncovered.

16  
17 But what if weaknesses in the policies are derived from sources other than gaps in predicted  
18 outcomes? What if they come from inferior definitions of the problems (e.g., mobility vs.  
19 accessibility)? This paper suggests that problem definitions can be reformed to bring them in line  
20 with current transportation goals and also identifies several important issues. As issues of mobile  
21 source pollutants, consumption of non-renewable resources, and global climate change rise in  
22 prominence, increasing attention focuses on urban development strategies to alleviate these  
23 concerns. Indicators to comprehensively measure the performance of the combined transport *and*  
24 land use system are valuable in such an endeavor.

25  
26 The concept of accessibility operationalized using cumulative opportunities measures offers a  
27 compelling alternative basis for policy regarding the built environment. In this application we  
28 view the process of developing accessibility consistent measures for both motorized and non-  
29 motorized modes as both an accomplishment and an invitation for future work for both  
30 practitioners and academics.

31  
32 Accessibility is rarely presented in units that are easily interpreted. The measures rarely have any  
33 absolute meaning in terms of costs or benefits or other values such as convenience. Thus, they  
34 are often normalized over a certain range and interpreted in purely relative terms [32]. Relativity  
35 helps users grasp differences between various places or neighborhoods but many are yearning for  
36 a concrete unit of measurement. Such is certainly one distinct advantage of the cumulative  
37 opportunities measure.

38  
39 The bottom line is that accessibility measures help planners and others better differentiate  
40 between policy variables they can control—such as trip cost or development approvals—and  
41 how individual travelers weigh and select among destinations (which planners can do little to  
42 control). Implementation of this framework would, at a minimum, permit a more straightforward  
43 comparison of access in different communities, in a given community over time, or across  
44 alternative future scenarios. A more standardized definition of what to measure is thus valuable.

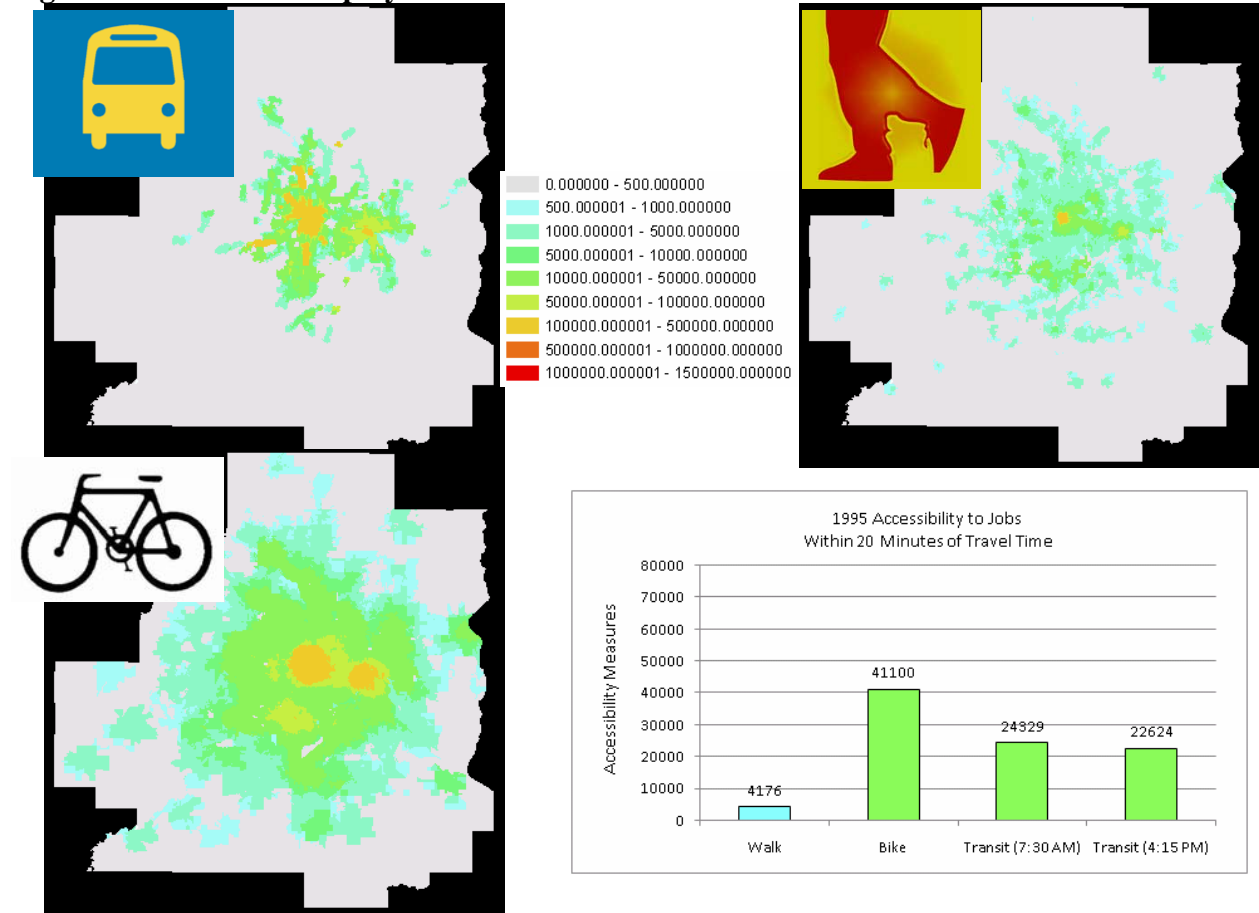
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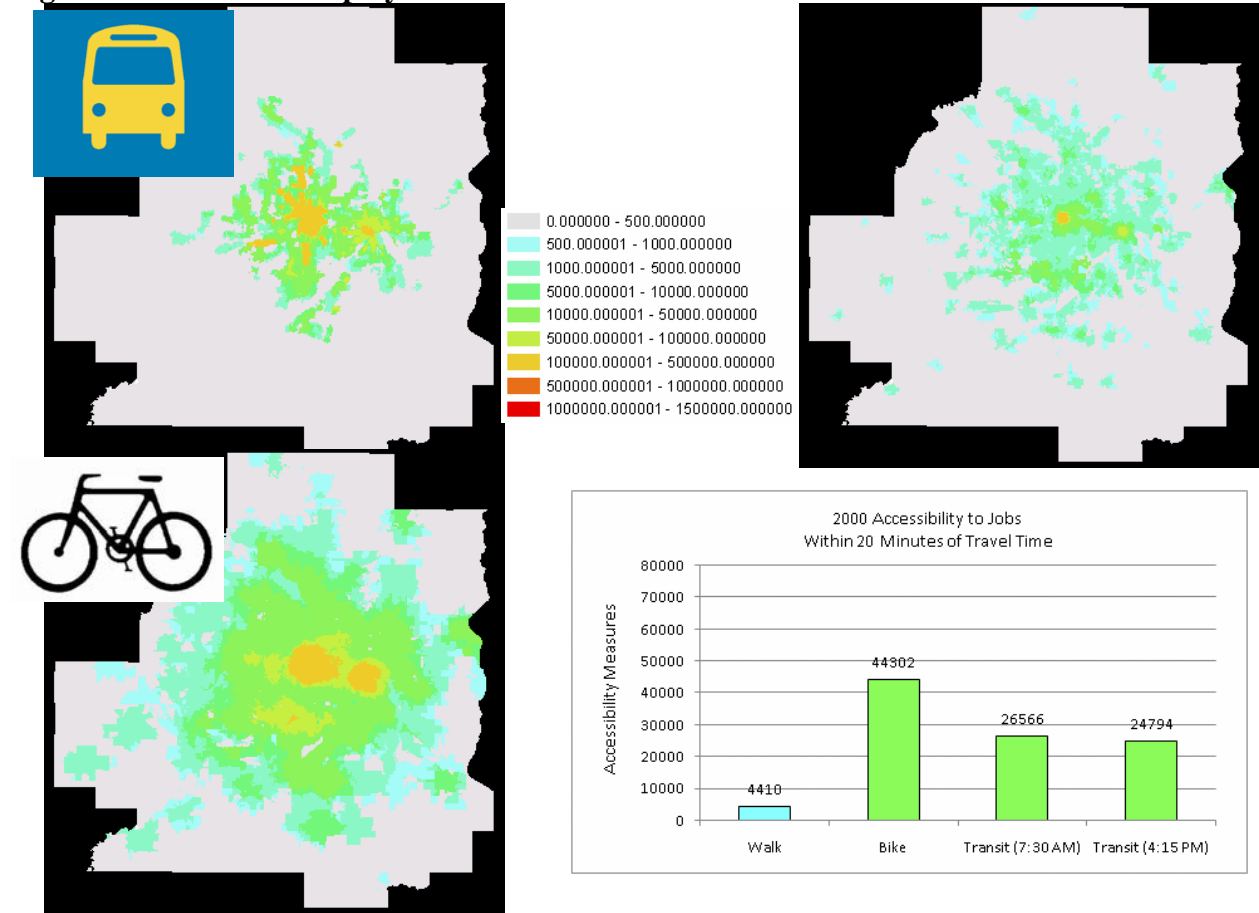
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1 **Figure 1. 1995 Total Employment**



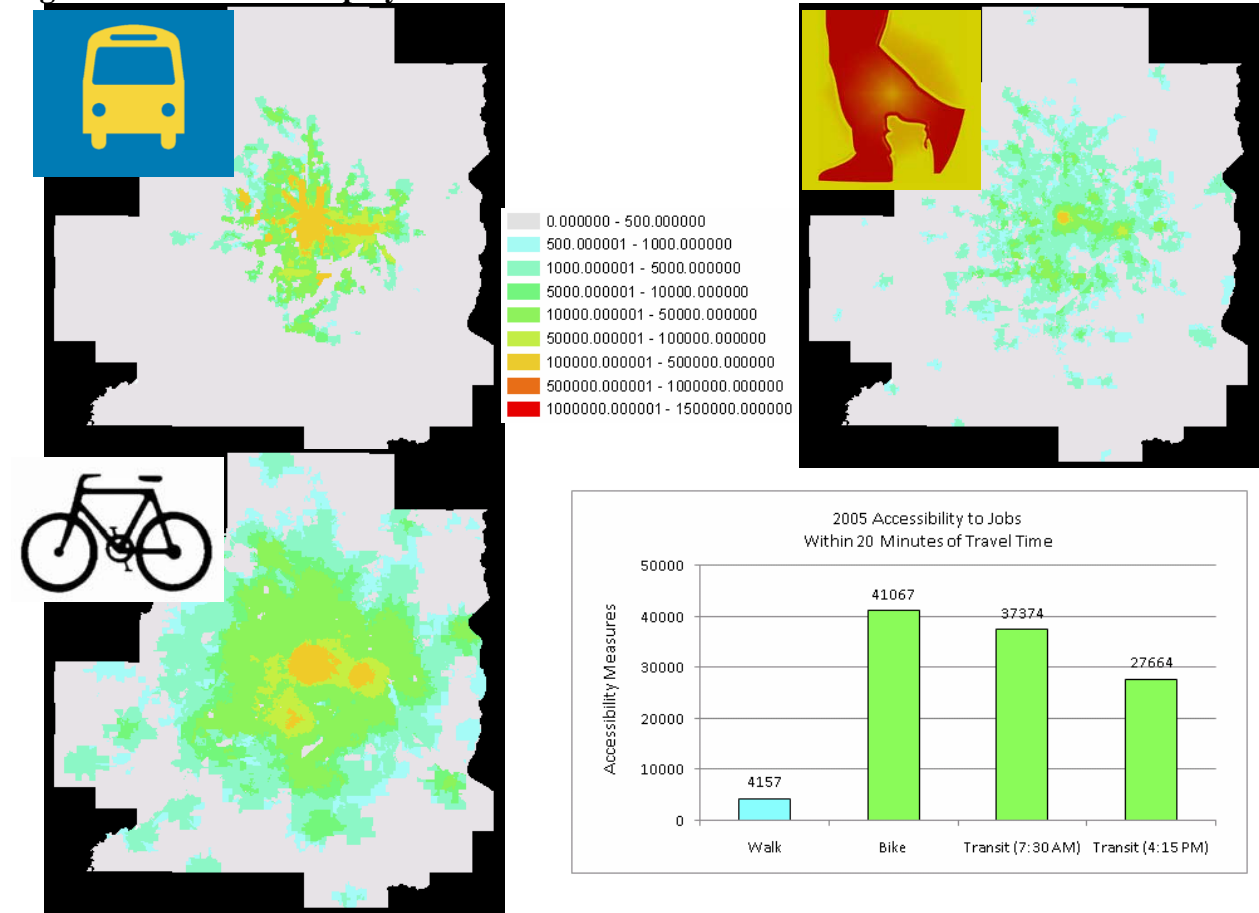
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1 **Figure 2. 2000 Total Employment**



2

1 **Figure 3. 2005 Total Employment**



2