Chapter 21
Mobility and Sustainability

Aaron Golub

Abstract Urban practices such as automobile dependence result from webs of institutions, from citizens and neighborhoods to city and state governments to federal policies. Effective action for achieving sustainability begins with understanding these institutions and how they respond to and resist change. In this chapter, we review those institutions involved with creating and preserving automobile use. This investigation illustrates that it is not enough to have a "right answer" be it a certain technology or a certain urban design proposal. The importance is in how these answers are implemented by citizens and governments – how visions are translated into interventions by real communities in various experiments and pilot projects which can help to illustrate pieces of those future states – today. In this chapter we review several cases of such proactive planning and policy which have been successful in enacting long-term visions for sustainable transportation. These include new urban planning paradigms based on transit-oriented design and accessibility, systems to facilitate sharing cars and to encourage cycling, and innovations in technology to improve the management of existing infrastructure.

Keywords Transportation • Mobility • Accessibility • Urban • Planning

1 Introduction

Some of the world's most pressing problems result from the manner in which urban systems operate. These systems consume huge amounts of energy and materials and create intense local "hotspots" for pollution, solid waste, congestion, safety problems, and other challenges to livability and sustainability. Urban mobility systems are often a leading cause of these challenges, and focusing on urban mobility is an effective approach to solving several key sustainability challenges (Black 2005; Golub 2012).

A. Golub (✉)
Toulan School of Urban Studies and Planning, Portland State University,
Portland, OR, USA
e-mail: agolub@pdx.edu

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Urban *mobility*, in a broad sense, refers to the moving of people and goods between different destinations within the city, including residences, workplaces, shopping areas, warehouses, ports, and factories. Mobility is expensive, requiring resources and imposing various kinds of costs on society, including not only fees (e.g., tolls or parking) and fixed costs (e.g., costs of automobile ownership or infrastructures), but also time costs, and other costs, such as health or environmental damages. These costs of mobility, however, are often difficult for the average traveler to understand. As certain modes of travel are supported by investments in infrastructure (e.g., roads, trains) and institutional support (e.g., traffic engineering, zoning policies requiring minimum car parking supply), their costs to the average user may seem lower. Therefore, travel by a certain mode of transportation is not convenient in the absolute but is made convenient by a coordination of investments by a variety of social actors, from households to city governments, the national government, and private industries. For example, without significant public investments in traffic engineering, road construction, parking systems, and emergency systems, travel by automobile would be very expensive and inconvenient.

Related to mobility is the idea of *accessibility*, which considers more explicitly the objective of movement. Ultimately, the value of movement results from the value derived from the completed trip (unless the trip was made purely for leisure purposes). Accessibility is the attainment of that value from the trip – irrespective of how much travel that entails. Ultimately, accessibility is the aim of any mobility system. Thus, in urban areas where origins (say, residences) and destinations (say, workplaces) are far apart, accessibility results from being mobile. On the other hand, locating destinations close to origins, or placing them close to a coordinated public transit network, can improve access while reducing the need to travel.

Many urban mobility systems attempt to create ubiquitous, inexpensive mobility, typically based on the automobile (Cervero 1996). This mobility-focused approach creates significant external costs and unintended consequences. Furthermore, the size and extent of the roads and parking needed to support such an approach become a hindrance to the use of modes of transportation other than the automobile. From this excess need for travel stem many adverse effects, to be discussed below.

Efforts to enhance accessibility and transform urban mobility systems in order to control their detrimental effects focus on four core approaches: price signals, land-use changes, technology development, and communication. Pricing, which can include various types of taxes and fees, is used in mobility systems to manage demand, internalize externalities (e.g., environmental damages), fund infrastructure and operation of the systems, or subsidize other needs in society through general budgets (e.g., education, health). Changes to land uses generally transform urban places to include more activities in a given land area (increasing density) and allow for a greater "mixing" of uses (commercial, residential, light industrial) within a given area or even within a single development project (i.e., a "mixed use" project). Technological changes to mobility systems, such as pollution-control technology in automobiles, can reduce some environmental externalities per unit of travel (though total externalities may increase or decrease depending on the amount of total travel). Finally, an important but less commonly used approach to transformation includes attempts to affect the knowledge and attitudes of users or managers of mobility systems.

The state of the art is the understanding that these four approaches must be applied in combination to create net effects – no single approach will create significant transformations of existing mobility patterns. Also, because existing mobility systems are so resource intensive, there is significant inertia in continuing the existing socio-technological systems (Wachs 1995). Thus, even seemingly significant interventions may have little measurable effect on system-wide characteristics. A shift in practice toward more comprehensive "accessibility planning," to be introduced below, will require all four of these approaches at a variety of spatial and temporal scales to make long-term impacts on mobility systems.

- ***Task***: *Describe the different challenges to planning based on an accessibility paradigm compared to the mobility paradigm.*

2 Sustainability Problems Caused by Urban Mobility

2.1 Adverse Effects

Urban mobility is a significant direct and indirect cause of several detrimental effects in the city (Golub 2012).

Traffic Fatalities and Injuries In the United States, around 3000 people – roughly the same number that perished during the September 11, 2001 terrorist attacks – die every month on the nation's roadways from traffic accidents and have been dying at that rate for the past 700 months (ca. 60 years). For those that survive crashes, there are pain, suffering, and thousands of hours of lost work time and cost for physical rehabilitation, etc. Together, traffic fatalities and injuries impose costs on the US society, estimated to be between $46 and $161 billion per year (Delucchi and McCubbin 2010).

Social Inequality, Exclusion, and Isolation Planning a mobility system around the need to own and operate a personal vehicle means that, for those who are unable to do so, the system will be poorly configured. In most metropolitan areas in the United States, for example, around 25 % of the population is too old, too young, or not able to afford an automobile, and therefore, they can become isolated and excluded from the mainstream of society (Taylor and Ong 1995; Lucas 2012). For example, in many central cities where low-income populations lack access to automobiles, a lack of access to healthy food and grocery options results in what is known as a "food desert" (USDA 2009). Furthermore, transportation systems have been used to segregate or reinforce existing segregation in some cities (Golub et al. 2013).

Detrimental Health Impacts Studies have shown that mobility systems significantly impact peoples' activity levels, and in turn, their health. The lack of safe, walkable neighborhoods, or barriers in neighborhoods created by transportation infrastructure (such as busy streets or freeways), leads to low rates of cycling and walking. This lack of activity is linked to higher body–mass indexes (e.g., obesity), poorer health indicators (Frank et al. 2006; Keegan and O'Mahony 2003), and consequently, additional health costs for the society (Frumkin 2002).

Reduced Social Time Budgets and Productivity While in good traffic conditions, driving is normally the fastest way to travel in US cities; during rush hour, the average traveler can suffer from long delays which negatively affect personal life and social relations. At a value of $10 per hour, these delays are estimated to cost between $63 and $246 billion per year (Delucchi and McCubbin 2010).

Local Air Pollution In the United States, environmental legislation like the Clean Air Act, enacted in 1970, has reduced tailpipe pollution emissions by around 99 % for most pollutants. However, large increases in driving mean local air pollution remains a national problem. More than 120 million Americans live in counties which fail at least one of the National Ambient Air Quality Standards, imposing a health cost burden of around $60 billion per year (EPA 2010; Parry et al. 2007).

Greenhouse Gas Emissions Greenhouse gasses in the atmosphere manage the planet's greenhouse process, whereby the global climate is regulated. Most transportation systems other than bicycles burn fuel which creates greenhouse gas emissions such as carbon dioxide and methane. In the United States, transportation is responsible for about one-third of the national greenhouse gas emissions, imposing a total cost of around $9 billion per year (EPA 2011; Parry et al. 2007).

Over-Exploitation of Nonrenewable Resources Cars and lights trucks use a large amount of nonrenewable steel, glass, rubber, and other materials. Data from 2001 showed that automobile production in the United States consumed 14 % of the national consumption of steel, 32 % of its aluminum, 31 % of its iron, and 68 % of its rubber (McAlinden et al. 2003, pp. 21–23). Around ten million automobiles are retired and junked every year, with the majority of the built-in resources lost, worth around $3 billion.

Contamination of Habitats Negative environmental impacts occur throughout the petroleum supply chain – from spills and flares at the local sites of extraction to spills and toxic pollution emissions at ports and refineries to local service stations where fuels can cause groundwater contamination. Roughly ten million gallons are spilled into US waters every year (Etkin 2001). This does not include the large spills such as the Gulf (aka Deepwater Horizon) spill in 2010 of around 170 million gallons or the Exxon Valdez spill in 1989 of 11 million gallons. Worldwide, more than three billion gallons have been spilled into waters since 1970, with typical annual environmental damages costing around $3 billion (Parry et al. 2007).

Costs of Petroleum Dependence In the United States, around half of the country's petroleum needs are imported from other countries, resulting in significant costs, estimated to be between $7 and $30 billion per year (Delucchi and McCubbin 2010), from a lack of flexibility in the economy to respond to changes in price. The noncompetitive structure of the oil industry has resulted in artificially high prices, with costs estimated to exceed $8 trillion since 1970 (Davis et al. 2010). US military presence in locations of strategic importance to the oil industry amount to between $6 and $60 billion per year (Davis et al. 2010).

2.2 *Underlying Causes and Actors*

Urban mobility is driven by a complex set of practices, habits, norms and so forth driven by the transportation industry, planners, government, and consumers or some combinations of these, all of which give current planning paradigms great inertia (Geels et al. 2012). Here, we describe some of these processes in preparation for the next and final sections outlining the wide ranging decisions and behaviors of these key actor groups.

2.2.1 The Individual and the Household

The individual and households sit at the most micro level of activity yielding daily decisions about how to travel and less regular decisions about home location or vehicle purchases. Daily decisions are made, mostly on the rational maximization of perceived travel convenience. There are large constraints on these decisions, however, as significant costs sunk into automobile ownership compel people to drive, since they are paying for the vehicle (through depreciation, insurance, etc.) whether they use it or not. Home location decisions are rarely made to minimize travel, as many choose to locate themselves in particular school districts or in communities with particular demographics. Additionally, car ownership is a powerful tool of identity formation in the US society, where it's seen as a symbol of status and patriotism (Paterson 2007).

2.2.2 Planners and Developers

Early last century, most urban planners in the US felt that suburban-type development based on automobile transportation offered a better quality of life compared to the crowded and dirty industrial urban centers of the time (Foster 1981). Even today, most urban planning practices merely reproduce the suburban, automobile-oriented models. After all, planners are simply agents of the governments for which they work and rarely serve as forces for change.

Developers reproduce the suburban model, not out of a particular preference but mostly because it seems to be the least-risky investment (e.g., Levine 2005). Banks are more likely to lend construction loans to build traditional suburban developments, and developers find it easier to develop fresh "greenfield" sites on the edge of cities where they can avoid potential neighborhood rejection of their project and higher or unpredictable construction costs in urban infill sites. Furthermore, many developers feel local land-use zoning often prevents them from building more dense and walkable developments (Levine and Inam 2004).

2.2.3 The State and Federal Governments

The state governments have a special role in urban transportation systems in the United States, as they were tasked with overseeing the construction of the interstate highway system. Most states also collect their own gasoline taxes, mostly used for investment in roads, freeways, and bridges.

The federal government has an important role in supporting automobile use, as well as regulating it and supporting alternatives to the automobile. Together, the 1956 Interstate Highway Act, federal support for home mortgages, and a relative lack of investment in urban revitalization during the postwar era solidified Federal support for suburbanization and automobile-based mobility. Furthermore, the U S foreign and military policy is heavily tied to the stability of the oil supply, a key ingredient in mobility. Federal policies are also important for managing automobile use. These include regulations to control pollution from automobiles, fuel economy standards, and safety regulations. Federal funds also support public transportation systems and bicycle transportation, though in small amounts compared to the monies spent for roads.

2.2.4 Oil and Automobiles Industries

The oil and automobile industries are some of the most heavily concentrated in the entire US economy – a relatively small number of companies account for nearly all of their industry's production. This means that they can easily join together to coordinate their concerns, influence public policy, and shape consumer demands through organized action. Thus, we must see urban transportation systems' use and dependence on petroleum and automobiles as being tied directly into the needs of the oil- and automobile-related industrial pillars. In the United States, automobile manufacturers became the focus of the emerging mass-consumption economy during the interwar period (1920s-1930s), riding the wave of public investments in freeways and suburbia and overcoming competition from transportation alternatives such as streetcars in most cities in the country (Golub 2012).

- ***Task**: Describe the main factors that contribute most to the perpetuation of unsustainable mobility patterns. Provide an example from a specific city for each factor.*

3 Sustainable Solution Options for Urban Mobility from Around the World

Understanding the system driving urban mobility challenges is only a first step toward transforming urban mobility. A key next step is to create *visions* of sustainable mobility, highlighting the goals of safety, convenience for all travelers using all modes, acceptable external environmental and social costs (at many temporal and spatial scales), and efficiency in the use of public resources, among other things. The vision would also address the fairness of the manner in which mobility systems are planned and governed. Besides these broader issues, community-specific visions reflect the needs of specific urban neighborhoods while still complying with principles of sustainability (e.g., Machler et al. 2012), a process requiring deliberation and negotiation (Wiek and Iwaniec 2014).

A sound understanding of urban mobility challenges and a sustainable vision of urban mobility are critical ingredients, but they do not suffice. A third element is critical for transforming today's mobility system into one which can achieve the visions of sustainable mobility (Wiek et al. 2012; also see Chap. 3 in this book). Changes in trajectory result from *interventions*, which detail step by step how the current mobility system needs to be transformed. From our understanding of the status quo, we can determine effective intervention points and strategies at the multitude of scales at play in the system. For example, traffic engineering practice and norms are strong drivers of current mobility systems. Thus, experiments and pilot projects in traffic engineering may help transform the system.

As was mentioned at the start of this chapter, most solution options focus on a combination of four core areas: price signals, land-use changes, technology development, and communication. These domains of intervention are invoked at a variety of scales and by different actors in the urban development process. Experiments and pilot projects of various types create glimpses of future possibilities and allow the system to "learn" and transform (Geels et al. 2012). We have compiled some of the more promising solution options here.

3.1 Proactive Urban Planning Paradigms (Planners, Developers, and Governments)

Research shows that urban planning and its control of land-use and transportation systems can have profound effects on automobile dependence. Urban travel modes are more or less convenient, depending on the arrangement of land uses and the prices of using those modes, such as gasoline, parking, bus fares, tolls, etc. For example, one strategy is to join public transportation with land uses such as job and housing centers, often called transit-oriented development (TOD). TODs combine higher densities with the convenience of being colocated at a public transportation facility, such as a light-rail or bus rapid transit (BRT) station (GAO 2003). It has been shown that compact development approaches such as TOD reduce the need for driving by around 20–35 % in the United States (ULI 2010, p. 7). In fact, residents in one TOD area in Atlanta drive only one-third as much as the average Atlanta resident (ULI 2010, p. 7).

Implementing TOD while improving public transportation, reducing the rate of highway construction, and increasing fuel prices (whether by raising taxes or through the natural increase in petroleum prices) have been estimated to reduce total driving by about 38 % (ULI 2010, p. 12). Regions recognized worldwide for taking this combined approach include: Mexico City; Curitiba, Brazil; Bogotá, Colombia; Stockholm, Sweden; and Singapore (Cervero 1998). Government policies are often important for the success of these combined approaches by, for example, creating transit-oriented land-use zoning, funding public transportation investments, or regulating the use of streets.

Because of their role in regulating and funding transportation systems and regulating land uses, governments are in a particularly strategic position to affect advancements toward accessibility planning. City governments are increasingly attempting to leverage investments in public transit facilities such as light-rail by rezoning to encourage more intense urban development. They have also been leading the wave in investments in bike-sharing systems and often support for-profit and nonprofit car-sharing services.

3.2 Sharing Cars (For-profit and Nonprofit Businesses, Governments and Individuals, and Households)

At first glance, trading the convenience of one's private car for the occasional use of a shared car, located somewhere out in the public realm, seems countercultural in many places, especially the United States (Golub and Henderson 2011). It appears, however, that there are places all over the world where this idea makes sense and has increased in popularity. Car sharing is a system which allows members to use cars on a short-term rental basis – as short as 15 min in some systems. The cars are placed in public areas in cities, rather than in car rental agencies, and members can use them at any time of the day.

Car sharing dates back to the 1940s in Northern Europe (Shaheen et al. 2009). Though few car-sharing programs existed in North America before 1994, by mid-2009, following a decade of improvements in satellite communications technology, there were roughly 280,000 car-share members sharing about 5,800 vehicles in the United States (Shaheen et al. 2009), with these numbers growing roughly 20 % per year (Martin et al. 2010). Studies show that car sharing can reduce household car-ownership, user, and parking demand and increase demand for public transportation, cycling, and walking (Cervero et al. 2007). Even more vehicles were reduced because car-sharing households avoided the planned purchase of vehicles.

3.3 Fostering Bicycling (Government and Individuals and Households)

Representing only about 1 % of all trips, bicycling makes up a very small share of daily travel in the United States. But with increased gasoline prices and traffic congestion, and growing concern about climate change and health, bicycling has experienced a boom in many US cities (Golub and Henderson 2011). Chicago, New York, Portland, Seattle, and many smaller university cities have experienced significant increases in utilitarian bicycling. In San Francisco, it is estimated that 5 % of adults use bicycles as their main mode of transportation (up from 2 % in 2001) and 16 % ride a bike at least twice a week (SFMTA 2009, 22).

Bicycling is poised to be a substitute for many short-range automobile trips and has enormous potential to reduce automobile use. Nationally, roughly 72 % of all trips less than three miles in length are by car, a distance that an average cyclist can cover easily (USDOT 2010, 22). "Bicycle space," or an interconnected, coordinated, and multifaceted set of safe bicycle lanes, paths, and parking racks, and accompanying laws and regulations to protect and promote cycling, has been extremely difficult to implement in the United States (Henderson 2013). The lack of political will has been a major barrier; there are no nationally dedicated funding programs for bicycles, and advocacy for bicycling has been a largely local, grassroots, and fragmented effort.

Many cities in the United States, including Washington DC and New York City, are making large investments in bike lanes and bike-sharing systems. Places like Bogotá, Colombia, and Mexico City have implemented even more ambitious region-wide improvements in bike and pedestrian infrastructure with profound results in short timescales (ITDP 2013a, b).

3.4 Technology Innovations (For-profit and Nonprofit Businesses and Governments)

Governments and businesses have been pivotal in funding and deploying the research and development of technology, which have important effects on transportation sustainability. Technological improvements are already responsible for cutting the levels of local air pollution emissions per vehicle to a small fraction. They also show promise for reducing fuel use and thus carbon emissions. Prominent ongoing examples of technological developments include intelligent transportation systems (ITS), which use increased data processing capabilities from satellites, and wireless technologies to improve roadway and parking management and public transit services (ITSA 2013). ITS applications are now being applied to vehicles to make them communicate with the roadway and other vehicles, making traffic safer and smoother. Satellite communications were also pivotal in facilitating advancements such as London's congestion pricing scheme and most modern car-sharing systems.

Questions

1. What are the barriers to sustainable mobility solutions based on sharing (car sharing and bike sharing)? What kind of actions can be taken to overcome those barriers?
2. How might accessibility solutions vary from place to place? How do culture and history influence how accessibility planning needs to happen in a certain place?

4 Open Issues

Innovations and transformations away from automobile-based mobility systems face great challenges in making broad impacts. Still, important innovations are meeting with significant and rapid success in places like Bogotá, Colombia, and Mexico City, encouraging other cities to try similarly broad changes. Even in the United States, there is evidence that growth in automobile travel is finally stagnating and declining in some places (Millard-Ball and Schipper 2011). There are still open research questions, including: What policies have the largest effects on behavior?, For how long do changes endure?, How can policies balance social equity while altering travel behaviors?, and, Are there rebound effects or other unintended consequences? For example, TOD planning may lead to more congestion because of less road capacity and higher density, and a recent review of research about planning for bicyclists and pedestrians shows mixed results from approaches thought previously to be important (Forsyth and Krizek 2010). Furthermore, significant demographic changes are on the horizon in much of the developed world which may cause even greater changes in travel patterns, for better or worse (e.g., Nelson 2009).

5 Conclusions

There are several important lessons here for sustainability science and sustainable development. The larger lesson is that urban practices such as automobile dependence, water or energy use, pollution, etc., result from webs of institutions, from citizens and neighborhoods to city and state governments to federal policies. Effective action for achieving sustainability begins with understanding these institutions and how they respond to and resist change (Geels et al. 2012). Inertia in the maintenance of the status quo in the dependence on the automobile for urban mobility illustrates that it is not enough to have a "right answer," be it a certain technology or a certain urban density. The importance is in how these answers are implemented by citizens and governments – how visions are translated into interventions by real communities in various experiments and pilot projects which can help to illustrate pieces of those future states today. A turn toward sustainable mobility will be achieved when we join with others with similar visions and create the social change needed to challenge the dominant urban planning and practice of automobile dependence.

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