CHAPTER 11

Sustainable Transportation

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Introduction

Some of the world's most pressing problems result from how its urban systems operate. These systems consume huge amounts of energy and materials and create intense local "hotspots" for emissions, solid waste, water pollution, congestion, safety, and other challenges to livability. Of course, well-managed urban systems can be fairly efficient and effective at providing sustainable livelihoods for large numbers. Urban transportation systems, in this vein, can be both an asset and a liability to the development of sustainable cities. In the United States, a large share of energy consumption, carbon emissions, and preventable death and injury result from urban transportation systems. For example, because of enormous growth in urban travel, about half of Americans currently live in counties that fail the now four-decades-old National Ambient Air Quality standards, even after spending billions of dollars on technology to reduce emissions from automobiles.

In this chapter, we explore the sustainability challenges and solutions of urban transportation systems in three steps. First, we define the sustainability problem as a special class of urgent and harmful multi-scale and multi-sector problems. We can then clarify sustainability problems that United States urban transportation systems create.

Next, to move from defining a problem to solving it, we must understand the problem's drivers or causes.. Looking at cars' exhaust pipes is just not enough to understand urban air pollution; we need to investigate all of the connections between the different factors to uncover the forces behind the pollution and the impacts. If we could snap our fingers and eliminate the pollution, we would have solved the problem a long time ago. We need to recognize that some segments of society benefit from the air pollution, and that pollution is an outcome of a complex system of institutions with their own web of rewards and feedbacks.

Next, we can move toward solutions; understanding the causes allows us to uncover solutions. We can also develop intervention strategies, areas of policy and practice to focus efforts for change. We can uncover "low-hanging fruit," the easy changes in practice that yield large benefits, as well as the deeper underlying forces and values that may take decades to change.

This chapter will follow these steps, first introducing and defining the special class of problems that are sustainability problems, and then exploring the various problems that stem from urban transportation systems in the United States. Then, it will explore the various drivers of those problems, which form barriers to moving forward toward solutions. Finally, examples and cases from places within both the United States and internationally show some promise toward solving these urgent and messy problems.

Sustainability Problems and Solutions

Not all problems we face are sustainability problems. Sustainability problems are a special class of problems that pose a particularly urgent threat to **human-ecological systems**. Their urgency is compounded by their **complexity** and their involvement of **multiple sectors** and actors across multiple scales. This complexity means that they are best tackled by using interdisciplinary approaches as diverse as the many systems that affect the problem or by applying new methods to these problems.

Human-ecological systems - humans are dependent on natural systems, such as the water cycle or other nutrient cycles. On the other hand, humans alter these cycles by their effects on the natural environment. This combination of dependence and effects are characteristic of human-ecological systems.

Complexity - a characteristic of a system based on webs of interrelated and interdependent institutions and subcomponents. Complexity means that changes in certain inputs yield unforeseeable and unintended consequences.

Multiple sectors - urban systems are built on various sectors, such as housing, transportation, and the various systems that supply them with the resources they need, such as fuels, electricity, and other materials.

An example of a sustainability problem is urban air pollution. It poses significant harm to the health of many urban residents, and it causes billions of dollars in damage to infrastructure and crops, lost worker productivity, and additional burdens on the healthcare system. It is caused by a complex array of factors: emissions from electric power generation, exhaust from trucks and automobiles, and emissions from construction and industrial sites, among others. Obviously, to tackle such a problem would require understanding of such diverse issues as household energy use, freight logistics, the demand for automobile and air travel, and the technological and regulatory factors governing automobile, freight, industrial, and construction site emissions. It gets even more complex when governments must set air pollution standards, implement strategies to meet these standards, and monitor them. Something as simple as clean air, as we can see, is not a simple matter, but requires a team approach involving efforts from across many different disciplines, such as urban planning, engineering, business, and public policy. Cultural and psychological factors may underlie certain household practices that result in pollution, and these need exploration as well.

We can now move to the focus of this chapter—sustainable urban transportation. We will explore the underlying sustainability problems current transportation practice poses, uncover the sources of problems in urban transportation systems, and then explore sustainability solutions.

Urban Transportation and its Sustainability Problems

Following from such a definition of a sustainability problem, we can see that urban transportation is not a sustainability problem in and of itself, but it is a significant direct and indirect cause of several sustainability problems. This chain of causation means that focusing on urban transportation is an effective approach to solving those problems it causes. Here, we introduce some of these urgent problems that urban transportation systems cause, grouped into different realms; some, such as petroleum dependence, cause a set of other "indirect" problems.

Most urban travel in the United States is by automobile; thus, the urgent problems urban transportation systems create here derive from the particular issue of using automobiles for mass transportation. The problems from urban transportation in other countries may relate to different issues particular to systems there. In 2000, 88 percent of United States workers drove or were driven to work, and fewer than 5 percent took public transit.[1] For all trips, not just those to work, only about 6 percent are by human power (biking or walking). Compare this statistic with other industrialized countries like England, where 16 percent walk and bike, or Germany, where more than 34 percent bike or walk.[2] Thus, when we investigate the significant problems arising from our

transportation system, they largely result from using the private automobile for mass transportation. Here, we review briefly some of these problems, grouped along social, economic, and environmental realms.

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Car Crash.

Social Problems

Social disruption from traffic fatalities and injuries

Around 3,000 people—roughly the same number that perished during the September 11 attacks—die *every month* on the nation's roadways from traffic crashes. Americans have been dying on our roadways at that rate for the past 700 months. On top of these fatalities are about 200,000 injuries from traffic crashes monthly, resulting in thousands of permanent disabilities and days, weeks, or months of physical therapy and recovery and countless days lost from work or school.

Social inequality, exclusion, and isolation

Planning a transportation 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, around 25 percent of the population is too old to drive, too young to drive, or not able to afford an automobile. The dispersion and suburbanization of jobs and housing and the resulting automobile dependence means that those who cannot afford or cannot operate an automobile have greater difficulty finding work, and they can become isolated and excluded from the mainstream of society. In many central cities where low-income populations lack access to automobiles and decent transportation, a lack of access to healthy food and grocery options results in what is known as a "food desert." The reliance on cheaper but less healthy food options has been shown to create health problems, especially in inner-city neighborhoods. The "Food Desert" is discussed in Chapter 8.

Sedentary lifestyles and detrimental health impacts

Studies have shown that transportation has a significant impact on how active people are, and in turn, on their health. The lack of "walkability" in many metropolitan areas leads to low rates of cycling and walking, and this inactivity is linked to higher body mass indexes and poorer health. Obesity and diabetes are at alarming rates in many segments of the population, including children.

Ethical dilemmas of petroleum dependence

The strict reliance on petroleum for the operation of the economy is called "petroleum dependence." Today, U.S. demand for petroleum overwhelms the country's own domestic supply: more than half its petroleum needs are imported from other countries (See Box 1). Ethical problems arise because dependence on oil imports forces the United States to make political decisions that may often betray its own ethics. More fundamentally, however, dependence on oil means we are forced to use it, even if we do not want to. U.S. citizens in several cases were basically powerless to react by choosing

BOX 1: OIL AND UNITED STATES—A short history

Oil was initially used in the United States to produce kerosene for illumination. It was discovered in large quantities first in Pennsylvania in the 1850s, though it would not be until the 1890s when demand for it rose because internal combustion engines were becoming more commonplace in industry and transportation. Oil was discovered in California and Texas around 1900, during which time a single company dominated the system for distributing and refining it—Rockefeller's Standard Oil Company. After 1900, the demand for oil products exploded—and so did Standard's wealth, along with threats from new competitors and government displeasure with Rockefeller's ruthless anti-competitive behavior. In 1911, Standard was broken up into more than a dozen independent companies, many of which still exist today, such as Chevron, Exxon, Mobil, Amoco, ARCO, and Conoco, among others. The international system of oil production and distribution also began during the last years of the 1800s, with tight competition between Standard Oil and Royal Dutch Petroleum Company (now Shell) in Indonesia. Soon after, Mexico, Venezuela, Iraq, and Iran became locations of significant oil extraction.

While in 1900 only about 25 percent of the few thousand existing automobiles ran on gasoline—most were steam or electric—in a short time, gasoline would emerge as the dominant fueling technology. Significantly as well, military prowess became linked to petroleum as World War I (1914 to 1918) showed for the first time how important planes and tanks would become to the future of warfare. After 1920, the demand for gasoline in the United States would explode and the number of automobiles reached 27 million in 1939 (Philip 1994, 36). Thus, the die was set—our economy would become increasingly dependent on petroleum, and those firms who could supply it would become increasingly powerful. On the eve of World War II, the United States contained over 80 percent of the world's automobiles and consumed 65 percent of the world's oil produced (Philip 1994, 36–37).

Between the late 1930s and 1950, large oil deposits were discovered in the Gulf countries of Saudi Arabia, Iran, Iraq, and Kuwait, completely rearranging the world oil map. Initial dominance of the British in the Middle East followed from their colonial administration of it after the fall of the Turkish Empire during World War I. During and after World War II, diplomacy was increasingly used to support oil production by U.S.-based companies in the Middle East and to edge out British competition. By the 1950s, five U.S. oil companies, together with two European firms, controlled nearly all of the Middle Eastern oil resources. These "Seven Sisters" include British Petroleum, Royal Dutch–Shell, Gulf Oil, Chevron, Exxon, Mobil, and Texaco.

This close relationship between the U.S. government, private oil companies, and the governments in the Middle East would become problematic. Rapidly rising demand for oil in the United States following the full shift to Fordist consumption after World War II would put pressure on the U.S. government to preserve these special relationships in the name of oil supply stability. (The U.S. demand for oil would outstrip its own internal production in the 1960s.) The power struggle over oil, while complicated by the tension caused by the presence of the Soviet Union in the Middle East, forced the United States to support many anti-democratic regimes

over the years. The relationship between the United States and Saudi Arabia is particularly close—it provides the United States with access to some of the largest known oil reserves on the planet in exchange for guaranteed revenues and protection of the Saudi government against external or internal aggressors. In another example, the United States supported a coup against Iran's Mossadeq government after it nationalized (converted from private to public ownership) the Anglo-Iranian Oil Company in 1951 (ironically, the Anglo-Iranian Oil Company was itself a national company of the British government). This coup installed the pro-U.S. Shah as ruler. A similar coup was supported in Iraq when it too threatened to nationalize its oil system, leading eventually to the rise of Saddam Hussein. His desires to restrict oil production to raise prices were, in part, responsible for the 1991 U.S. invasion. While Hussein had always cooperated with the United States, his new activism did not follow U.S. plans. U.S. strategy in the region also forced the United States to overlook Iraq's attack on the Kurds in 1973 and forced it to arm groups such as the Mujahedeen in Afghanistan.

The United States and Europe became so dependent on Middle East oil that changes in oil production policies among Middle East oil producers had profound effects on their economies. In late 1973, responding to U.S. and European support for Israel during its war with Egypt and Syria, several countries in the region restricted or completely halted oil production. This quickly quadrupled the world price and caused shortages throughout the United States. World prices would soon stabilize, but spike again during the 1979 Iranian revolution over the U.S.-backed Shah. To this day, oil prices continue to rise and fall with changes in production and policy in the few oil producing countries. The United States has reduced some of its dependence on Middle East oil by improving its energy efficiency and moving to alternative sources for oil, such as Mexico, Venezuela, and Nigeria. Still, it remains in a highly vulnerable position in the world system: in 2008, it imported 57 percent of its petroleum needs, about one-third of that from the Persian Gulf.

For more information on the history of oil and the development of U.S. policy, see *The Political Economy of International Oil* by George Philip (1994) and *The Prize* by Daniel Yergin (2008).

alternatives, which were simply not available at any reasonable scale. Examples include the 2010 BP oil spill in the Gulf of Mexico, when the Exxon-Valdez oil tanker ran aground in 1989 off the coast of Alaska, and when the government of Nigeria executed indigenous activists in 1995 who were questioning its oil export practices. What is worse is that even these significant spills are dwarfed by the total amount of routine spills that result from the normal operation of the oil distribution system. Petroleum dependence poses a significant ethical dilemma for those urban residents hoping to choose freely how their lives affect the larger world.

Bird killed in Gulf of Mexico oil.

Economic Problems

Costs of traffic fatalities and injuries, traffic congestion, and petroleum dependence

Traffic fatalities and injuries impose large financial costs on our society. Some of these costs are borne by car insurance holders, and others fall on society at large. These "externalized" costs are estimated to be between $46 and $161 billion per year.[3] In good traffic conditions, driving is normally the fastest way to travel in U.S. cities, however, during rush-hour, the average traveler can suffer from long delays. At a value of $10 per hour, these delays are estimated to cost between $63 and $246 billion per year.[4] Petroleum dependence imposes several kinds of financial costs on the U.S. economy. Significant costs, estimated to total between $7 and $30 billion per year,[5] result from lack of flexibility in the economy to respond to changes in price. Additional costs result from the non-competitive structure of the oil industry, resulting in prices that are higher than what a competitive market would charge. The sum of these costs since 1970 is estimated to be over $8 trillion. Finally, the United States military incurs costs for its presence in locations of strategic importance to the oil industry, amounting to estimates of between $6 and $60 billion.[6]

Local air pollution

The Clean Air Act, enacted in 1970 and enforced by the U.S. Environmental Protection Agency, has had a major impact on regulating and reducing pollution emissions from automobiles for more than 40 years. Most pollution is reduced to just a small percent of what it was before regulation. But, large increases in driving and worsening congestion in metropolitan areas means that although each vehicle is cleaner, local air pollution remains a national problem. More than 120 million Americans live in counties that fail at least one of the National Ambient Air Quality Standards that define what levels of pollution in the air are safe to breathe.[7]

Infrastructure barrier effects

Infrastructure for automobiles, such as freeways and arterial roads, are large, intrusive, and can separate neighborhoods from each other and cause barriers to mobility. Studies show that these "barrier effects" exacerbate automobile dependence because they can deter residents from walking or cycling for even short trips.

Greenhouse gas emissions

Greenhouse gasses in the atmosphere manage the planet's greenhouse process, whereby temperatures are regulated. Most greenhouse gases are created from the burning of fuels to create energy either in electric power plants, factories, or in vehicles which burn fuels for energy. Overwhelming evidence suggests that the significant greenhouse gas emissions created by human activity, rivaling the amount of gases produced by natural ecological systems, are influencing the planet's normal climate. Reducing greenhouse gas emissions is essential to avoid the worst effects of climate change. Unfortunately, because human-induced climate change has already begun, we are already too late in avoiding some significant climate change effects.

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A lot of used cars in the junkyard.

Transportation systems burn fossil fuels, which create greenhouse gas emissions such as carbon dioxide and methane, either in the vehicle's own engine or in power plants that make electricity for electric vehicles' batteries. Transportation is responsible for about one-third of our country's greenhouse gas emissions. About 70 percent of that is for cars, light trucks, and SUVs.[8] The net effects of high automobile use are evident when we compare cities' energy use, which is related to their greenhouse gas emissions. U.S. cities consume an average of 2.4 MJ of transportation energy for every dollar of regional product, ranging from a high of 3.1MJ/$ in Phoenix to lows of 1.7 MJ/$ and 1.8 MJ/$ in Washington, D.C., and New York, respectively. In contrast, European cities consume around 0.8 MJ of transportation energy per dollar of product, contributing to their much lower greenhouse gas emissions rates.[9]

Production and disposal of vehicles

Cars and lights trucks use a large amount of non-renewable steel, glass, rubber, and other materials. Data from 1990 showed that automobile production consumed 13 percent of the total national consumption of steel, 16 percent of its aluminum, 69 percent of its lead, 36 percent of its iron, 36 percent of its platinum, and 58 percent of its rubber. Around 10 million automobiles are disposed of every year.[10]

Environmental impacts of petroleum extraction, transport, and refining

Negative environmental effects occur throughout the supply chain—from spills and flares at the local sites of oil extraction, to spills and toxic pollution emissions at ports and refineries, to local service stations where fuels can cause groundwater contamination. Oil spills, large and small, are part of our transportation system, which is so reliant on international extraction, transportation, and refining of oil. Roughly 10 million gallons are spilled into U.S. waters every year.[11] This does not include the large spills such as the 2010 BP oil spill of around 170 million gallons, or the 1989 Exxon Valdez spill of 11 million gallons. Worldwide, more than 3 billion gallons have been spilled into waters since 1970.

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Gulf shores Alabama.

Agents of Automobile Dependence

Urban transportation systems in the United States are driven by a complex set of historical and institutional factors giving current practices great momentum and resistance to change. Its complexity results from the combination of numerous histories, cultural norms, expectations, and practices. Urban transportation is shaped and reshaped, produced, and consumed across several groups of actors. Entering into a discussion about fundamentally changing urban transportation systems in the United States means one must consider the needs of these various actors, how they interact with each other, and how they respond to demands for change. We must understand that a web of actors *benefits* from the current system. In this section, we briefly consider these different actors and how they interact. This discussion will then lead us into our final section, where we discuss strategies for change.

The Individual and the Household

The individual and household sit at the most micro level of activity, making daily decisions about how to travel and less regular decisions about home location or vehicle ownership. These decisions are made mostly on rationally minimizing travel times and maximizing convenience. As work and home became more decentralized in most cities, the automobile was a clear choice for travel: the automobile system delivers significantly higher performance than public transit systems. This is due entirely to the government's much greater attention and resources placed on guaranteeing the performance of driving. It is not a result of any technical or "natural" advantage that cars have over public transit.

What is more, however, is that individuals and households engage with larger cultural forces. For instance, car ownership in general and specific vehicles in particular are often powerful tools of an individual's identity formation in our society. Automobile ownership is seen as a symbol of status, patriotism, and of belonging to and supporting mainstream (referred to as Fordism) society (see Box 2). These cultural contexts can become significant shapers of decisions regarding automobiles.

BOX 2. FORDISM: The Marriage of Mass Production and Mass Consumption

Throughout human history, a dynamic interaction has existed between social organization and its technologies and techniques. New ideas about the organization of work and production lead to technological innovations, which in turn reveal even new ways of organizing work and production. A complex series of changes to the U.S. economy during the late 1800s led to a shift from small-scale to industrial production and to a corporate form of private investment management. Large companies' capacities for investment and further innovations in mass production during the early 1900s led to incredible improvements in industrial productivity. The limited capacity for the society to absorb all of the outputs of mass production, along with other factors, led to the crash of the U.S. economy and the Great Depression of the 1930s.

The response to the Depression was a new way of thinking about the interaction between the economy and society and between production and consumption.

Through the theories of British economist Keynes and the political negotiations between industry, organized labor, and the government through the New Deal, a plan to stabilize the economy was developed. This plan, sometimes called Keynesianism, would emphasize government intervention in the economy to stimulate consumption to solve the crisis of the Great Depression. The government would borrow and tax to play a more significant role in building infrastructure, regulating business and finance, subsidizing and insuring credit, and stabilizing the overall size of the economy. Together with wartime spending and an employment boom during World War II, the plan succeeded, causing relatively stable and sustained growth for the 30 years following the end of the war.

This new form of society is known as Fordism—named after one of the originators of the assembly line, Henry Ford. Government intervention in infrastructure and credit meant that highly productive and well-paid workers could afford to purchase much more of the goods they produced, such as automobiles and houses, and even become investors themselves. The suburb and the single-family home, the freeway and the automobile, along with the oil and other resources needed to power them all, became the centerpieces of the Fordist society. Indeed, many of these processes remain alive today, though conditions have changed. Fordism was linked to the incredible manufacturing capacity of the U.S. economy, along with the existence of inexpensive oil, conditions which have changed drastically over the past 40 years.

Today, the Fordist links between worker productivity, production, and consumption are weakening. An increasingly global production system supplies ever cheaper goods for the U.S. economy, while the role of domestic workers has changed from production to service for this new "Post-Fordist" arrangement. The implications for urban development, automobile ownership, and suburban growth are only weakly understood.

For more information on the history and inner workings of Fordism, see *The Public and Its Possibilities* by John Fairfield (2010), *A Consumers' Republic* by Lizabeth Cohen (2003), and *The Condition of Postmodernity* by David Harvey (1991).

Planners and Developers

Urban planning emerged as an important force in the process of urban development in the United States. Early last century, planners felt that suburban areas offered a better quality of life compared to the crowded and dirty industrial cities of the time. To this day, much professionalized urban planning practice merely reproduces the suburban, automobile-oriented models. Since this is often what the public and governments request, this is what planners deliver.

Modern suburban neighborhood.

Developers reproduce the suburban model, not out of a particular preference, but mostly because

that is what seems to be the least risky endeavor. Banks are more likely to lend construction loans to build traditional suburban developments, and developers will find it easier to develop fresh **"greenfield"** sites on the edge of cities, compared to dealing with potential neighborhood conflict and higher or unpredictable construction costs in urban infill sites.

Greenfield - urban growth that happens on previously undeveloped "green" land, such as agricultural or forested areas. This is in contrast with urban growth, which happens by reusing previously developed land within the city's areas.

The State and Federal Government

State governments have a special role in urban transportation systems because they are tasked with overseeing the design and construction of the interstate highway system. Most states also collect their own gasoline taxes, mostly used for investment in roads and freeways. The federal government has an important role for supporting automobile use and urban development around automobile dependence, as well as regulating it and supporting alternatives to the automobile. Federal funds have long been used to support automobile use. Federal funds were first used to build roads in significant amounts during the 1920s and the 1930s New Deal stimulus package. The 1956 Interstate Highway Act solidified support into a set of financing systems, based on the national gasoline tax and federal planning support, to build the national network of interstate highways we have today. Furthermore, U.S. foreign policy is heavily tied to the stability of oil supply in order to keep gasoline prices low and predictable (see Box 2). Urban historians point to two federal policies that spurred suburban development after World War II—the Interstate Highway Act and federal support for home mortgages.

Federal policies have also been important in managing automobile use. These include regulations to control safety, pollution from automobiles, and fuel economy standards that all automobile companies must follow. Federal funds also support public transportation systems, though in small amounts compared to the monies spent for roads.

Industrial Structures: Oil and Automobiles

The oil and automobile sectors are some of most heavily concentrated in the entire United States economy—relatively few companies account for nearly all of their industry's production. (Fordist society is built around large companies that can direct the mass production and consumption process more efficiently – see the Box 2 on Fordism.) This concentration means that they can together easily 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.

Automobile manufacturers became the focus of the emerging Fordist economy, riding the wave of public investments in freeways and suburbia, and overcoming competition from transportation alternatives, such as streetcars, in most cities. The 1956 Interstate Highway Act, passed by a federal commission with ample automobile-related representatives, solidified the course toward automobile dependence, guaranteeing financing and planning support for freeways. Though homebuilding in the suburbs predated the Highway Act, the pace of suburbanization exploded after its passage.

Surrounding larger pillar industrial sectors sit countless small companies—automobile parts suppliers, independently owned car dealers, service stations, repair shops, along with other related sectors such as automobile insurance companies, drive-through restaurants, and suburban homebuilders. In the 1970s, one study found that all together, the automobile-related industries contributed one-seventh of the total U.S. economy.

Sustainability Solutions: Toward Sustainable Transportation in the United States

Thus far, the chapter has explored the particular sustainability problems urban transportation systems produce and then discussed some of the most powerful drivers of the current transportation system. Now, we can envision sustainability solutions to particular problems by appreciating the drivers of those problems. Understanding the drivers will help us formulate specific strategies. Because we have emphasized the social nature of these problems, we will emphasize a social approach to their solution by looking at examples of social change and social movements that work toward advancing sustainable transportation. This approach generally involves challenging and reducing automobile dependence, which, in turn, would reduce driving, which would reduce fatalities, emissions, costs, among other things. Challenging the broader role of driving in society would yield compounding benefits across different problem areas.

As we saw earlier, the social production and maintenance of automobile dependence occurs at various scales and institutions. In this section, we explore several solutions that build on the social context of transportation systems across those various scales and institutions. The first is an urban planning approach that reorients the city away from traditional automobile planning. We look at the cases of Curitiba, Brazil, and Portland, Oregon, as inspiring examples where social change and social movements led to the rejection of the automobile-dependence model. Then, we look at the international movement in **car-sharing**, and how technology has been used to facilitate automobile sharing. Rather than redesigning the automobile, these systems redesign how people use the automobile, replacing ownership with short-term usage. Finally, we consider the social movement around bicycling in the United States, looking at the specific example of San Francisco. Here, we can see glimpses of challenges to Fordist society by challenging dominant paradigms about urban efficiency and the use of road space.

Car-sharing - a system that allows members to use cars on a short-term rental basis. The car-sharing system owns and maintains the cars, and allows members to access and use them at any time of the day, for as little as 30 minutes, removing the hassle of going to a rental car facility. The cars are placed in public parking facilities or on streets to facilitate easy access. As of 2012, there are an estimated 500,000 car-sharing members in North America.

Proactive Urban Planning Paradigms

Research shows that urban planning, and reflecting variations in the mix of land use and transportation systems in a region, can have profound effects on automobile dependence and the accompanying problems that automobile use produces. Travelers in urban areas are always faced with the choice of different modes of travel—between walking, bicycling, public transportation, and driving. The relative convenience and costs of the different options affect how travelers decide to travel. Some modes become more or less convenient depending on the arrangement of land uses and the prices of using those modes, such as gasoline, parking, and bus fares. Strategies to reduce automobile use then rely on a range of land use and price changes.

The transportation systems in many cities in the United States were designed to facilitate **mobility**. This paradigm of mobility planning refers to the dedication of urban resources and space to moving people and goods between different destinations including residences, workplaces, and shopping areas. Mobility is expensive, however, requiring substantial resources, including fees (e.g. tolls or parking), fixed costs (e.g. costs of automobile ownership or infrastructures), but also time costs, and other costs such as health or environmental damages, as were described earlier. Mobility is only made to seem convenient and inexpensive by a coordination of investments by the institutions described above – from the government to each household.[12] Without significant public investments in traffic engineering, road construction, parking systems, and emergency systems, mobility by automobile would be very inconvenient and few people chose it for their travel.

Accessibility - The measure of ease with which something can be reached in an environment.

Related to mobility is the idea of **accessibility**, which considers more explicitly the objective of travel. Ultimately, the value of mobility results from the value derived from the completed trip. Accessibility is the attainment of that value from the trip. 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. But, accessibility doesn't have to be provided by mobility.[13] Locating destinations close to origins or placing them close to a coordinated public transit network can improve access. This can be referred to as accessibility planning. For instance, the density of jobs or houses in an area dictates how proximate origins and destinations are in space. When jobs, houses, and other uses are close together, it makes walking or bicycling relatively more convenient and a more likely option for a greater number of travelers. If land uses are spread out, then the average distances between places is much farther, making travelers rely on faster modes such as driving or public transportation. Making land uses closer together is a key strategy to reduce the reliance on automobiles. It can also help to improve the walkability of a place.

Transit oriented development (TOD) - the practice of mixing land uses, such as retail and housing, and increasing the density of urban development near public transit stations. This enables more residents and workers to use public transit for their travel.

Bus Rapid Transit (BRT) - using buses to offer rail-like public transit services. BRT systems are based on using normal buses in exclusive, dedicated lanes that allow them to avoid traffic. BRT also relies on passengers prepaying their fares at kiosks or stations like rail systems to speed up passenger boarding.

More specifically, there is a strategy of integrating the location of public transportation and land uses such as job and housing centers; the strategy is called **transit oriented development (TOD)**. TODs combine the idea of density, with the convenience of being located at a public transportation facility such as a light rail or **Bus Rapid Transit (BRT)** station. Evidence shows that compact development approaches such as TODs reduce the need for driving by around 20 to 35 percent, depending on the specific design.[14] In fact, residents in one TOD area in Atlanta drive only one-third as much as the average Atlanta resident.[15] Combining land use strategies such as TOD with measures such as increasing the supply of 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 percent.[16]

It is clear that the arrangement of land use and transportation in a region dictate how people travel. Knowing this fact, however, does not get us any closer to solutions—implementing alternative land use and transportation systems is not easy, considering the array of institutions listed earlier in this chapter. We proceed with three cases showing how citizens and elected officials worked to change their land use and transportation planning in an effort to reduce automobile dependence.

Curitiba, Brazil

Curitiba is generally considered an example of best practices in terms of urban transport planning in the world. The city's history shows the importance of the relationship between investment in public transport improvements and urban development. An important element of its success was a master plan adopted in 1966 to direct the city's growth and development.[17] It was decided at this early stage that the city's growth would be directed along certain corridors and that these corridors would be focused around public transit, not automobiles. This was, in effect, a rejection of the U.S.-originated model of automobile-based urban development being exported around the world, especially in Brazil, during the post-war period. In fact, at around the same time Curitiba was growing, Brazilian planners had just completed Brasilia, the capital city, based on a decentralized, automobile-oriented model. It has since needed retrofitting with heavy and light rail systems to improve its functioning.

The relationship between land use planning and public transport was solidified when higher densities were enforced along the bus corridors through a strict zoning code. This makes public transit very attractive to most residents of the city, since most live close to the various bus routes and most destinations are also close to the bus system. In addition, these plans were made before there were residents—the proactive planning channeled development with explicit goals rather than having to respond to ad hoc development after problems arose.

Jaime Lerner, mayor of Curitiba during this period, favored a bus-based system over the often-proposed rail systems because of its relative lower cost and ability for flexible and fast deployment. In 1974, a hierarchical bus system was developed with the introduction of express and local buses and the single ticket. A "trinary road system" was developed wherein an exclusive bus way (lanes only for buses) and slower travel lanes make up the main axis of the system. Buses in the bus way, sometimes called Bus Rapid Transit, act like light rail—they use mini-stations with platforms that help speed boarding. The exclusive bus lane speeds the buses up ahead of crowded local streets. The rail-like boarding system makes boarding much faster since passengers have already paid to get into the bus stop, thus eliminating the need to pay the driver.

Lerner's proposals were not always accepted by the car-owning public in Curitiba. He engaged in several political battles with proponents of the automobile model, and was forced at times to use drastic measures to protect the public spaces he was trying to remove from the automobile network. In one instance, car drivers threatened to drive through a pedestrian plaza he had created by closing several downtown streets; in response, Lerner brought hundreds of schoolchildren to play in the plaza.[18] Curitiba's comprehensive and proactive planning, in contrast to more typical piecemeal and reactive planning in U.S. cities, makes it an inspiring example. Curitiba's thinking has gone on to influence urban planning and sustainability thinking around the world. Bogota, Colombia, recently implemented a city-wide BRT system to inexpensively add significant capacity to its public transit systems.

A recent national study showed that these new planning approaches linking land use and public transportation will be essential for the United States to reach carbon dioxide targets (60–80 percent below 1990 levels) required for climate stabilization.[19] Though nothing as sweeping as Curitiba's approach can be found in the United States,

there is an increasing awareness of the interaction between transportation, land use, energy, and emissions. Dozens of new transit-oriented developments are appearing in public transit station areas across the country. New-Urbanist principles are being increasingly used in what would have been more conventional suburban master planned communities. Moreover, Curitiba's BRT innovations are now being built in dozens of cities across the country with funding and planning support from the Federal Transit Administration.

Portland, Oregon

During the 1950s and 1960s, when many U.S. cities were being retrofitted for automobile use, communities in Portland, Oregon rejected a significant part of freeway plans developed for it by the State of Oregon's Department of Transportation. The Mt. Hood freeway was slated to connect downtown Portland to the southeast, running through established neighborhoods as it made its way to connect to an outer interstate running north-south. The Mt. Hood, as a designated interstate, was to be funded by the federal gas tax—only 8 percent of the funds would need to come from local sources. Regardless, neighborhoods in the area organized themselves to challenge the freeway using new regulations in the National Environmental Protection Act of 1969 and the Clean Air Act of 1970. These acts required environmental impact analyses for infrastructure projects—tests never required before for freeways. Using these procedures and growing support from local political bodies, the community and city government got the freeway cancelled in 1974. New rules in the 1973 renewal of the 1956 Interstate Highway Act allowed the use of federal highway funds for mass transit, and the $180 million planned for the Mt. Hood freeway was redirected to build light rail in Portland.

Dozens of other communities across the United States successfully fought freeway plans in their communities. The most famous cases include San Francisco's cancelling of the planned Embarcadero Freeway connection to the Golden Gate Bridge, and Boston-area residents' stoppage of the "inner beltway" around Boston. For more on the history of freeway revolts, see "Stop the Road: Freeway Revolts in American Cities," written by Raymond Mohl in 2004.[20]

Phoenix, Arizona

While Phoenix, Arizona may not initially conjure up images of urban living, the city has been making great strides towards accessibility planning over the past decade. In fact, streetcars played an important role in the development of the city and by the late 1800s streetcars provided a significant part of the city's transportation needs.[21] From the 1950s, however, the Phoenix metro area experienced rapid exurban and suburban growth based around the mobility planning paradigm. In 1999, however, several cities in Maricopa County created a proposal for the Central Phoenix / East Valley Light Rail project and the 20-mile, 28-station line opened in December of 2008 and passes through central and east Phoenix and connects with neighboring cities of Tempe and Mesa to the east. Current weekday ridership averages around 43,600 per day, up substantially from 34,800 per day in 2009, its first year of operation.[22]

Supporters argued that it would stimulate and re-center growth and revitalize downtown Phoenix and the surrounding neighborhoods. To try and jumpstart development, the cities of Tempe and Phoenix developed special land use regulations such as station area plans and (TOD) zoning. The City of Phoenix planning department then partnered with Arizona State University and the Saint Luke's Health Initiative on a federally-funded project called "Reinvent Phoenix" to assist neighborhoods located along the light rail to create long-term visions of station area development.[23] The project synthesized land use, economic, transportation, housing and health assessments into a participatory planning processes to create long-range plans in contextually sensitive ways while revitalizing and preserving the existing stable neighborhoods. For example, housing market analyses revealed a lack of affordable housing in some neighborhoods along the Light Rail, while **Health Impact Assessments** carried out with community members showed that some neighborhoods are "food deserts," lacking easy access to healthy food (see Chapter 8). Adaptation to climate change was also a focus of the project, and plans were created to reduce temperatures through tree, shade and park investments. Community members active during the planning process were asked to create a steering committee for their neighborhoods to steward the plans forward into the future.

Courtesy Aaron Golub

Native American Connections manages the Devine Legacy complex, an example of Transit Oriented Development in Phoenix, Arizona.

Health Impact Assessments - Detailed assessments, often led by community members, of the various health impacts of a project or planning process used to highlight important concerns or risks.

An example of the kind of TOD proposed in the Reinvent Phoenix plans can already be found in Phoenix. A local non-profit housing developer called Native American Connections builds and manages apartment complexes for low-income families in Phoenix, one of which is located right along the light rail.[24] The proximity to rail allows families to be accessible to many destinations without the burden of owning an automobile and many essential services such as schools and medical care are close by.

Rethinking Automobile Ownership

At first glance, trading the convenience of one's personal, private car for the occasional use of a shared car, owned and maintained by others and located somewhere out in the public realm seems supremely countercultural in the United States. It appears that there are places all over the nation, however, where this idea makes sense and has increased in popularity. Car-sharing is a system that allows members to use cars on a short-term rental basis—for as short as 30 minutes in some systems. The cars are placed in public areas in cities, rather than in car rental agencies. Then, members can use them by swiping a smartcard any time of the day. Though no car-sharing programs existed before 1994, in mid-2009, there were roughly 280,000 car-share members sharing about 5,800 vehicles in the United States,[25] with these numbers growing roughly 20 percent per year.

Courtesy Aaron Golub

Car-share in Berkeley, California.

Courtesy Aaron Golub

Car-Share in San Francisco, California.

Car-sharing dates back to the 1940s in Northern Europe, and most notably, with the electric car-sharing system in central Amsterdam during the 1970s and 1980s.[26] San Francisco saw an early experiment in car-sharing in its Short-Term Auto Rental program, though it only lasted from 1983 to 1985. Eventually, with improvements in communications technologies, modern car-sharing took off with systems introduced in Europe and Canada in the early 1990s. Portland, Oregon, was the site of the first car-sharing system in the United States, with its CarSharing-PDX opening in 1998.

Car-sharing takes place when a member makes a reservation online or by phone through a voice-operated menu some time before he or she needs it (though the reservation can be made instantly, so long as the car is available). The system shows, based on the person's location, where vehicles are available for the reservation period requested. The user can specify the kind of vehicle they want or do searches anywhere in the system—even in other cities, for members of a multi-city network like Zipcar. The car is available to the user once the reservation is made; a cardkey activates the car. Reservations can be extended on-the-go as long as the car is still available.

Numerous studies have been made of the transportation impacts of car-sharing. Car-sharing can have effects on several aspects of transportation systems, such as household car ownership and parking demand, car use, and demand for "alternative" transportation such as public transportation, cycling, and walking.[27] Research across North America shows extremely significant effects: after joining car-sharing groups, households went from owning an average of 0.47 vehicles (already somewhat lower than typical North American households) to 0.24 vehicles. Put another way: in the group of about 6,000 surveyed

Courtesy Aaron Golub

The windshield-located card reader on a car-share vehicle in Berkeley, California.

households that joined car-sharing, almost 1,400 vehicles were "shed"—equal to almost half of the vehicles the group owned. Even more vehicles were reduced because car-sharing households avoided planned purchases of vehicles.

The Rise of Bicycle Activism in the United States

Bicycling makes up a very small share of daily travel in the United States, with only about 1 percent of all trips. But, with increased gasoline prices and traffic congestion, growing concern about climate change, and interests in physical activity, bicycling has experienced a boom in many U.S. cities.[28] 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 percent of adults use bicycles as their main mode of transportation (up from 2 percent in 2001), and 16 percent ride a bike at least twice a week.

Bicycling is poised to be a substitute for many short-range automobile trips and has enormous potential to contribute to reductions in **vehicle miles traveled** (a measure of the total distance in vehicle travel). Nationally, roughly 72 percent of all trips less than three miles in length are by car, a spatial range that an average cyclist can cover easily. Bicycles do not require expensive, long-term capital investment or operating costs like that of transit and so can be deployed quickly. And, in many respects, bicycling is among the most equitable forms of transportation because it is affordable and accessible to almost everyone. **Bicycle space**, or an interconnected, coordinated, multifaceted set of safe bicycle lanes, paths, parking racks, and accompanying laws and regulations to protect and promote cycling, has been extremely difficult to implement in the United States. Lack of political will to develop bicycle space has been a major barrier. There is no strong national bicycle policy with dedicated funding programs as there are for automobiles. Advocacy for bicycling has been a largely local, fragmented, and isolated effort. Therefore, the few cities, such as San Francisco, that have established a political will to promote bicycling—and that have seen significant increases in bicycling—are worth considering.

Vehicle miles traveled - a measure of total travel by all vehicles. If 100 vehicles travel each 100 miles, the total vehicle miles traveled is 10,000.

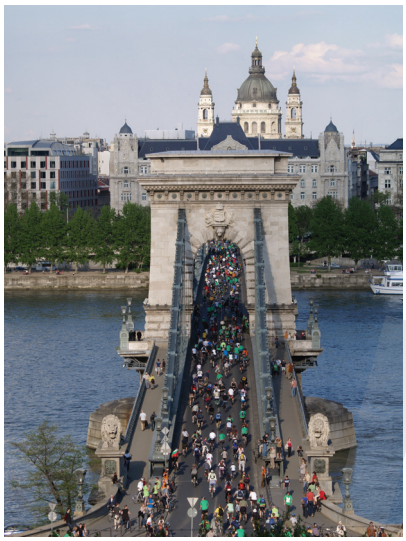
Bicycle space - coined by Jason Henderson, the well-connected set of bicycle-related infrastructure, such as bike lanes and paths, as well as bicycle storage facilities like bike racks and larger storage facilities at public transit stations.

San Francisco, California

In San Francisco, an 11,000-member bicycle organization has lobbied hard for the production of bicycle space, and the city has experienced a rapid upsurge in bicycling. Between 2005 and 2009, bicycling increased 53 percent, accounting for 6 percent of all trips in 2009 and amounting to 128,000 daily trips. In some inner neighborhoods of San Francisco, the mode share of bicycling is above 10 percent for all trips. This is despite the fact that much of the city terrain is quite hilly. How did this happen, when so few people bicycled there in 1990?

Through the early and mid-1990s, despite a growing and vocal San Francisco Bicycle Coalition (SFBC), the City of San Francisco's unspoken priority was to ensure that bike lanes did not impact car space. It was a lonely and sometimes daunting existence for San Francisco cyclists in those days. The frustration over the lack of political will to create bicycle space led bicyclists to create their own spaces. These were the spaces of **Critical Mass** bicycle rides which, beginning in 1992, occurred on the last Friday of every month in downtown San Francisco. Similar Critical Mass rides

Critical Mass - a number or amount large enough to produce a particular result; in this case, the number of bicyclists that can recapture urban space from the automobile, enabling the mass to progress through streets unimpeded, forcing motorists to have to wait for its passage. As such, critical mass is an act of civil disobedience meant to illustrate what a city might be like without automobiles and if street space were used for bicycle travel.



Bicycle demonstration in Budapest.

eventually spread to New York City, Chicago, and globally to cities like Rome and Vancouver. The name Critical Mass is as implied: a critical mass of cyclists that once reached, can recapture urban space from the automobile, enabling the mass to progress through streets unimpeded, and forcing motorists to have to wait for its passage. Critical Mass helped reframe the questions about urban sustainability, pushed open the debate about the use of street space, and showed the possibilities of a humane city.

Eventually, struggles between Critical Mass and the City's mayor led to a particularly violent clash in the fall of 1997. In response, the mayor directed his traffic department to hold hearings around the city in 1997 and 1998. Hundreds of cyclists attended these meetings, and the SFBC took a more aggressive position in its lobbying efforts. Although the SFBC made pains to differentiate itself from Critical Mass, the outfall from Critical Mass strengthened the SFBC, which had 1,700 members by 1998 and was gaining allies with some members of the city's board of supervisors.

Some key streets were made more welcoming to cyclists. When bicycle lanes were added to Valencia Street in 1999, bicycling increased by 144 percent. The success of the Valencia Street project further emboldened activists and proved that, with adequate infrastructure, more people would choose to bicycle. By 2004, 16 percent of all trips on the street were by bicycle. By the mid-2000s, and with almost 5,000 members, the SFBC had almost every local elected official concerned about the "bicycle vote" and very few elected officials spoke against bicycling, although ambiguity about how to implement bicycle space was widespread among many politicians. In 2005, with a clear pro-bicycle majority on the city's board, the SFBC pushed through a bicycle plan that is now adding 34 new bike lanes to the existing 45 miles.

Conclusions

Taking a social view of the problems leads us to a social view of the solutions. The social arrangement of industry, government, along with individual choices for convenience and identity formation create a complex web built around automobile dependence. Challenging this process will require profound and difficult social changes. Although there are few good examples of these changes, those examples assembled in this chapter give us a flavor of what social change can look like.

The public-transit oriented example from Curitiba showed a clear departure from standard models at the time. This model was developed and supported by a team of active citizens, planners, architects, and elected officials. Finding similar examples of such sweeping efforts will be difficult, but the efforts of Portland communities are inspiring nonetheless. Their rejection of transportation planning paradigms integral to the Fordist model was in effect a rejection of that model. The need for

high-performance driving to serve an ever-expanding suburban fringe was traded for less traffic congestion, lower automobile use, and improved public transit capacity. Trade-offs also may have occurred, such as lower economic performance and growth from the diversion of investments to other regions.

Similarly, the explosion of car-sharing illustrates that, indeed, many communities are willing to sacrifice convenience for other goals. Of course, for many, car-sharing is a rational approach to high parking or automobile ownership costs. But, those costs are integral to the Fordist model—they are the costs of identity because the automobile becomes part of how a person is valued. Rejecting car ownership on purely rational grounds is still irrational according to the model. We must wait and see how large of a dent car-sharing can make into the dominant model—right now, it appears that in places where the finances make sense, there is a willingness to reject Fordist roles.

Finally, in a similar vein, we find bicycle activists challenging the dominant urban management of roadways for automobiles, asserting an alternative vision for urban streets filled with bicycles rather than cars. That is, filled with things not extracted, produced, nor distributed by the international oil conglomerates or international automobile conglomerates. Producing bicycles is a minor part of the national economy, yet it can provide a significant amount of our mobility if that possibility were made real. Urban streets were used for thousands of years by humans, horses, bicycles, and streetcars before automobiles came along. There is nothing natural about any one of their roles in the streets—it is purely a social decision. Thus, moving forward with the understanding that our problems and our current state is socially produced, we can see more clearly how our solutions will require social changes involving a constellation of actors across multiple scales and approaches.

Several important lessons are found in the efforts of cities and citizens attempting to reduce their automobile dependence. The larger lesson is that urban practices, such as automobile dependence, water or energy use, and pollution, are results of 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. We saw how important the Fordist framework of mass consumption was to the overall production and maintenance of automobile dependence.

Effective cases of reducing automobile dependency can be found across all of these scales and institutions. We examined how at the regional scale, proactive citizens, neighborhoods, and city governments led movements against the expected city planning paradigm. They emphasized goals of walkability and public transportation over the typical reliance on roads and automobiles.

Other citizens have implemented visions for reduced reliance on automobiles by proposing reasonable alternatives. Groups around the world have implemented car-sharing services that reduce the need to own an automobile. The impacts on urban travel have been shown to be profound. Likewise, groups around the world have used the civil disobedience of Critical Mass to illustrate what cities more reliant on bicycles would look like. These acts of theater have successfully translated into real policy changes at the city and regional scales.

This chapter emphasized the role of citizens and activists together at a variety of scales to show that it is not enough to have a "right answer"—that with such technology or such a density we can reduce automobile use by such an amount. The

importance is in how citizens and governments implement these solutions. Thus, we can see that sustainability is 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.

Supplemental Readings

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