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The Mass Mobility of America: A Multimodal Guide

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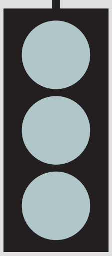
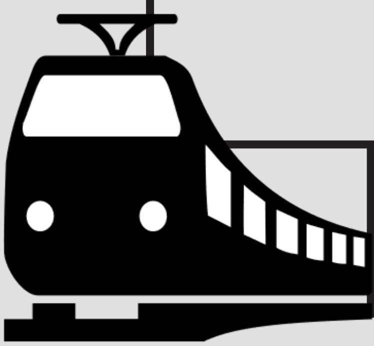


The Mass Mobility of America

A Multimodal Guide



Christian Carroll

Preface

America has a problem—and its root is mobility. With the world everchanging at the hands of technology and social media, other forms of once well-revered technology, such as the combustible engine and coal-powered locomotives, are now at a crossroads. The automobile still dominates the transportation landscape—this is seen through city layouts that have promoted sedentary lifestyles, an increase in infrastructure costs, and a rise in carbon dioxide emissions. All three of these issues are part of a bigger problem in modern society—a lack of affordable and reliable healthcare, a crumbling American transportation infrastructure, and a world facing issues of sustainability. Automobiles are an icon of America and have served as a statement of wealth and pride in American culture for many years. However, the private ownership of automobiles has become increasingly detrimental to society. Therefore, a society that invests in the public good and in alternatives to the automobile must become more attractive and profitable to curb the everlasting love for the American automobile. This starts with solving the mass transportation crisis that plagues the urban core of American metropolitan areas. New alternatives such as the Hyperloop One and self-driving cars have been discussed to great lengths recently, yet these alternatives are still in their testing phases. America, like much of Europe, should invest in mass transportation options such as light-rail and Bus Rapid Transit now so that a cultural transition towards more efficient forms of transportation will be much more viable within a population returning to communities with greater density.

About this Guide

One of the reasons large-scale mass transportation has not been implemented more often in American metropolitan areas is due to a lack of a cohesive development and layout guide for cities to follow. Therefore, this guide will layout the benefits, costs, and cultural implications of mass transportation options for small-sized, mid-sized, and large-sized metropolitan areas. The guide will be scenario-based, rather than overarching and generalized, which will allow planners to consult the guide as a reference. The guide will begin with an introduction of mass transportation and the history of mass transportation in Europe and America—this will include benefits, costs, and cultural implications of the period. After the introduction, the automobile, trains, light rail systems, bus rapid transit systems, subways, bicycles, and ridesharing will be discussed in a similar fashion but will also include place-based situations for each mode of transportation (city size, climate, demographics). A theoretical section will follow the mass transportation section and will discuss the potential benefits and downfalls of self-driving vehicles and the Hyperloop One—a magnetic-based form of transportation. Images will be scattered throughout the guide and sources will be cited frequently. A bibliography will be at the end of the guide and footnotes for specfic citations are also included.

Methodology

A methodology consisting of primary and secondary source research, interviews, and consultation will be followed. Primary sources will consist of historical accounts of transportation systems from multiple outlets—newspapers, opinion pieces, transportation companies, and urban businesses—and secondary sources will consist of transportation history accounts, modern journal discussions, and relevant news outlet pieces. Discussions with local planning agencies, Grand Valley State University faculty, and other professional partners will be conducted to gain a better understanding on the current context of mass transportation. Using these sources, a systems' thinking approach will be used to establish an interdisciplinary and detailed guide of future mass transportation development. This guide will be turned in and published through Grand Valley State University's ScholarWorks program.

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Section I: History of Mass Transportation

Europe: From the Wheel to the First Steam Locomotive

Transportation has always served an integral role in society. Whether it was the wheel in 3200 B.C.E.[1] or the Persian Royal Road in 475 B.C.E.,[2] society has always found a way to expand its boundaries. Initially, border expansion only occurred due to an influx of trade and was considered a sign of a strong "urban" economy. The first major transportation network that promoted the growth of an interregional economy was the creation of the Silk Road. The Silk Road was a catalyst for the Roman road network, global trade, and the creation of distinctive regional economies. Road networks such as the Silk Road led to "a highly varied spectrum of small and large, nucleated and dispersed, economically diverse and specialized settlements"[3] that would eventually dominate the urban landscape.

In conjunction with the Silk Road, the Roman road network established a connectivity precedence that had not previously existed. As a centralized road network, the Roman roads during the height of the Roman Empire tremendously impacted border expansion, mail services, and trade. While this was a major part of the Roman transportation network, "they paid even more attention to other means of transport such as maritime and river navigation [...] since those transports generated lower costs."[4] By diversifying transportation options, more avenues of trade and profit became available to businesses—and the Roman Empire was the first group to recognize this benefit. Another efficiency of the Roman road network was the development of a unified road system. Roman roads were formed based off natural landscapes, avoided large variations in elevation, maintained a "mile marker" (milestone) system, had convenient locations, and were suited for animal-drawn wheeled vehicles.[5] Therefore, the Roman road network established an efficient road system that would be replicated for centuries because "the presence of Roman roads, the division of land into hundreds and the establishment of parishes are all examples of the past interactions which had striated space in both a physical and a conceptual way."[6]

As the Roman road concept spread throughout Europe long after the Empire's collapse, new nations such as the Netherlands became experts with water management. Cities began to integrate their port systems with their road networks, which allowed "port towns [to] have a specific function, developing at strategic locations to control trade, forming part of its infrastructure and being one end of a spectrum of landing-places along the coast."[7] Cities started to become places of social interaction due to heavy development of integrated transportation networks. "By creating a street grid, dividing land and articulating power through tenurial links, social relations [were] 'coded,'"[8] which allowed cities to become such a spatial phenomenon that "industry gradually shifted from rural estate centers to these new settlements."[9] This pattern of social cohesiveness in cities has continued into modern society because cities are the apex of transportation networks.

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1 Megan Gambino. "A Salute to the Wheel." Smithsonian (2009).
2 Tomas Hoisaeter. "Polities and nomads: the emergence of the Silk Road exchange in the Tarim Basin region during late prehistory (2000–400 BCE)." Bulletin of SOAS 80, no. 2 (2017): 341.
3 Ben Jervis. "Assemblage Theory and Town Foundation in Medieval England." Cambridge Archaeological Journal 26, no. 3 (2016): 383.
4 Cesar Carreras and Pau De Soto. "The Roman Transport Network: A Precedent for the Integration of the European Mobility." Historical Methods 46, no. 3 (2013): 118.
5 João Fonte, César Parcero-Oubiña, and José Manuel Costa-García. "A GIS-Based Analysis of the Rationale Behind Roman Roads. The Case of the So-Called via XVII (NW Iberian Peninsula)." Mediterranean Archaeology and Archaeometry 17, no. 3 (2017): 163-189.
6 Ben Jervis. "Assemblage Theory and Town Foundation in Medieval England," pg. 387.
7 Ibid., 384.
8 Ibid., 385.
9 Ibid., 384.

United States: From Short Canals to the Transcontinental Railroad

With a much shorter history, the United States has gone through a variety of change as well. Initially, the United States lagged about a half century behind Britain in the innovation and development of transportation networks.[10] However, industry after the Revolution quickly fueled the development of urban areas. Cities became areas of intense devotion and diversity as "a visitor [to Philadelphia] would have witnessed people crowding into thirty-five churches representing fourteen denominations and eight ethnic groups."[11] The population of urban areas was heavily diversified due to the mixture of immigrants from Europe that came into port cities such as Boston, New York, and Philadelphia. This market diversification and urban growth fueled the rapid development of more viable transportation networks.

In the United States, the beginning of the nineteenth century started with the Local Era—an era in which short canals and turnpikes started to gain traction. Many preconstructed port cities, such as Boston, built canals (Middlesex Canal) to improve overseas trade in order to compete with natural port cities such as New York City. One of the first interregional roads established was Daniel Boone's Wilderness Road, which took you to the interior of the country through the Appalachians.[12] Most transportation during this time was from a short distance and was typically city-to-city. Next came the Trans-Appalachian Era, which lead to the creation of the National Road in 1806 and the Erie Canal in 1825.[13] These two innovations drastically increased competition in the region, which fueled the development of hybrid rail and canal systems throughout the Appalachian region. This allowed businesses to invest in the potential of transportation, which began with the creation of plank roads.

Many local communities attempted to increase their potential and wealth by investing in plank roads because "most of these investors stood to gain in three ways: returns on a profitable investment, rising land values, and increased sales generated by greater market access and cheap transportation costs."[14] In New York,

> More than 3,500 miles of wooden roads [were built between 1847 and 1853]. Financed primarily by residents of declining rural townships, plank roads were seen as a means of linking isolated areas to the canal and railroad network. A broad range of individuals invested in the roads, suggesting that the drive for bigger markets was supported by a large cross section of the population. Considerable community spirit animated the movement, indicating that New Yorkers used the social capital of the community to reach their entrepreneurial aspirations.[15]

The creation of plank roads throughout the United States allowed the free market to become much more integrated and revealed the potential of a promising transportation network. However, many of the plank roads became prematurely worn and caused many plank road companies to dissolve their businesses and invest in railroad transportation. This led to the beginning of a new era in the history of mass transportation.

10 Gary Nash. "The Social Evolution of Preindustrial American Cities, 1700-1820: Reflections and New Directions." Journal of Urban History 13, no. 115 (1987): 115.
11 Ibid., 120.
12 Edward Taafe. Geography of Transportation. Simon & Schuster, 1976: 79.
13 Ibid., 83.
14 John Majewski, Christopher Baer, and Daniel B. Klein. "Responding to Relative Decline: The Plank Road Boom of Antebellum New York." The Journal of Economic History 53, no. 1 (1993): 117.
15 Ibid., 106.

Section II: Forms of Mass Transportation

Trains

The Brief History & Background

Trains have been a part of American society since the Industrial Revolution. Trains were the guiding light of the American Industrial Revolution because the railroad greatly increased trade profits, shortened the distance between different regions of the United States, and created the first major transportation network of the United States. The dominance of the railroad lasted from the 1850s to the early 1900s until about World War I. With ten primary trunk lines that went through the core of the United States, many farmers and factories began to ship their products from their local regions (see Figure 2).[1] In addition to this development, the passage of the Interstate Commerce Act of 1887 led to the creation of a national rail system. Even with all these benefits, other established communities fell in economic peril because train routes often bypassed certain communities.

As the rail network grew and as World War I approached, many rail companies consolidated and closed unprofitable lines.[2] From World War I to World War II, the growth of the rail network stagnated due to the rise of road networks and the automobile. After World War II, the private rail industry—especially for passenger travel—declined rapidly due to the popularity and convenience of the automobile. By 1970, the privatized rail lines became part of the public rail system called Amtrak. This public rail system was formed under the Rail Passenger Service Act of 1970—this corporation still exists today.

1 Edward Taafe. Geography of Transportation, pg. 96.
2 Zdenek Tomes. "Applying the Life-Cycle Theory: the Rise and Fall of Rail Lines." The Journal of Transportation History 29, no. 1 (2008): 121.

Ideal City Type
Large

Type of Cost
Public & Private

Ease of Use
Minimal Knowledge

ADA Favorable
Yes

Income-Based Usage
●●Low-Income
●●Middle-Income
●High-Income

Key
● = Least Likely
●● = Likely
●●● = Most Likely

Benefits

The biggest benefit of rail lines is the control that private and public investors can exert on the system. Rail lines are fixed points, which allows for a higher quality of service from point-to-point. This alone allows the rail system, especially a high-speed system as compared to a conventional rail line, to have faster loading and unloading, higher safety, and lower labor costs compared to other modern forms of transportation.[1] Other benefits include the potential increase in population density if associated with a Transit-Oriented Development. This benefit is indirectly related to the extreme convenience of metro accessibility.[2] Using a "hub-and-spoke" system, high-speed rail is better fit for areas that follow dense, compact development patterns. This potential development in the United States can be seen in Figure 1.

1 David M. Levinson. "Accessibility impacts of high speed rail." Journal of Transport Geography 22 (2012): 288.
2 Ibid., 291.

Negatives

The biggest downfall of trains and high-speed rail is the lack of flexibility that other forms of transportation have such as bus rapid transit systems and automobiles. With the lack of a national system and a potential decrease in freight share of the rail lines, the development of a national high-speed rail system would be a hard feat to accomplish.[1] Creating a system such as this would be consequential because it would have higher fixed costs, higher energy costs, and extreme noise externalities.[2] With the rail industry in the United States already focused on freight—"railroads handled about 50 per cent of the total ton-miles of freight in the United States in 1939"[3]—creating a system solely focused on passenger transportation would be overwhelming as a society. The areas that would receive the most benefit from a high-speed rail system are areas with connecting metropolises and dense development, which would further lower the value of high-speed rail in modern suburban America. As a point-to-point system, trains abruptly stop once a railhead or major station is reached, which causes the system to be ineffective in reaching the outskirt suburbs.

1 David M. Levinson. "Accessibility impacts of high speed rail," pg. 290.
2 Ibid., 288.
3 Edward L. Ullman. "The Railroad Pattern of the United States." Geographical Review 39, no. 2 (1949): 242.

Light Rail Transit

The Brief History & Background

The development of light rail transit was a catalyst in the development of outskirt neighborhoods in major urban areas in the late nineteenth and early twentieth centuries. These "streetcar suburbs" were defined by upper-class blue-collar workers that controlled most of the economic assets of major urban areas. Light Rail Transit was an alternative to more expensive, long-range railroad trips—besides, many rail lines focused much of their income on commercial shipments as compared to the movement of urban regions. The streetcar, in conjunction with the interurban—a longer-ranged version of a streetcar, "challenged the steam railroad, carrying both passengers and light freight [...] sold electric power to towns under 100,000 [...] stimulated regional tourism [...] could also be rented out for parties [and] reviv[ed] hopes for a borderland life that earlier dense streetcar suburbs had obscured."[1] The Light Rail industry was a private industry that was tied by franchises issued by regions or municipalities that limited the fares of each ride. This helped Light Rail Transit become a promising industry during the early 1900s.

The industry and events that had the biggest impact on the development of Light Rail Transit was the development of the automobile and the Great Depression. These occurrences led to the consolidation of many rail companies and effectively decentralized the customer base of streetcars. The Light Rail Industry did not come back to the forefront for mass transportation in cities until the development of the first modern light rail line in Edmonton, Canada in 1978.[2] Modern Light Rail has many control variables such as geotechnical conditions, utility locations, right of way acquisitions, private sector participation, sources of finance, and underlying legal frameworks that determine the effectiveness of the system.[3]

Ideal City Type
Large

Type of Cost
Public & Private

Ease of Use
Minimal Knowledge

ADA Favorable
Yes

Income-Based Usage
•Low-Income
••Middle-Income
••High-Income

Key
• = Least Likely
•• = Likely
••• = Most Likely

1 Dolores Hayden. Building Suburbia: Green Fields and Urban Growth, 1820-2000. New York: Vintage Books, 2003, pg. 94.
2 P. Topalovic, J. Carter, M. Topalovic, and G. Krantzberg. "Light Rail Transit in Hamilton: Health, Environmental and Economic Impact Analysis." Social Indicators Research 108, no. 2 (2012): 330.
3 Peter E.D. Love, Dominic Ahiaga-Dagbui, Morten Welde, James Odeck. "Light Rail Transit Cost Performance: Opportunities for Future-Proofing." Transport Research Part A 100 (2017): 29-30.

Benefits

The biggest benefit associated with the development of Light Rail Transit is the rise of property values and accessibility near each station. This type of development is directly related to the development of Transit-Oriented Development, which promotes mixed-use, dense development near urban cores of an area (see Figure 2). As light rail systems have greatly grown in popularity— in 2010, "the 27 light rail systems in the United States, more than in any other country, were responsible for approximately 1.5 million daily unlinked passenger trips, double the volume for the year 2000"[1]—the perception of the system has been key to development. Light Rail Transit serves as a visual cue to residents and tourists that a city has increased mass transit usage and makes the area to seem much more approachable. With the help of this perception, downtown cores of many crumbling cities have been revitalized. LRT increases the social welfare of an area, reduces carbon dioxide emissions due to reduced car ownership and the use of electricity, and can lead to "an increase in shopping commerce generated adjacent to the transit line, development of new residential and commercial areas, and increased employment nodes."[2] These benefits are directly tied to the public perception and aesthetic that a light rail transit system creates—the intrinsic mobility of a city.

1 Steven Spears, Marlon G. Boarnet, Douglas Houston. "Driving reduction after the introduction of light rail transit: Evidence from an experimental control group evaluation of the Los Angeles Expo Line." Urban Studies 54, no. 12: 2781.
2 P. Topalovic. "Light Rail Transit in Hamilton," pg. 333.

Negatives

The biggest downfall of light rail transit is the fixed public cost that each light rail transit lines incurs on an urban area. The development of light rail transit lines has been found to have a mean overrun cost of 42% in the United States.[1] This means that light rail has raised in cost either because of deception and unjustifiable optimism or a change in scope, which has accounted for over 90% of all CAPEX (mean capital expenditure per kilometer) rises.[2] In order to ensure light rail transit projects do not "change in scope," a public-private partnership that follows the design, build, finance, operate (DBFO) should be used to assure that the investor maintains its commitment. Other downfalls of the LRT are residential relocation of the lower income brackets— "[...] small household size, low-income, being a young adult (under age 35) and low household car ownership are each independently associated with heightened propensity to have residentially relocated during the prior 5 years. Subsequently, conditional on having relocated, these same characteristics (except for low income) are associated with relocating in close proximity to the LRT network's access points (stations)"[3]—and the increase in rent prices near LRT stations. These issues are quite often hard to defeat because LRT systems lack rail flexibility and tend to have fixed stopping points, which is a similar issue that trains encounter (see Figure 1). LRT systems also tend to be much more expensive than Bus Rapid Transit systems—though operation costs vary, and public perception makes the LRT a somewhat more favorable option.

1 Peter E.D. Love. "Light Rail Transit Cost Performance," pg. 29.
2 Ibid., 30.
3 Xiaobo Liu, Yi Deng, Scott Le Vine. "Residential relocation in response to light rail transit investment: case study of the Hudson–Bergen Light Rail system." J. Mod. Transport. 24, no. 2 (2016): 145.

Subways

The Brief History & Background

Subways have been a part of dense, urban cities since the early twentieth century. The first major subway system in the United States was the Interborough Rapid Transit line in New York City, which was completed in 1904—which included another line and 28 stations by 1908.[1] By 1932, the system became under city ownership as was a public good for the city. Elsewhere in the world, cities such as Madrid, London, and Paris created subway systems of their own. The subway was a novel concept because it served as an "unseen" form of transportation as compared to other forms of transportation such as the streetcar. Sharing many similarities as the streetcar, the subway allowed developers to transport citizens on a fixed route without drastically altering the exposed infrastructure of a city. While costs were initially high for the creation of subways due to the complexity of development, lines have slowly dwindled in fixed cost.[2] However, through municipal ownership subways have the advantage of being a public enterprise but become costly due to the lack of private investment (see Figure 2).

Ideal City Type
Large

Type of Cost
Public & Private

Ease of Use
Minimal Knowledge

ADA Favorable
Yes

Income-Based Usage
●●Low-Income
●●Middle-Income
●High-Income

Key
● = Least Likely
●● = Likely
●●● = Most Likely

1 Kate Ascher. The Works: Anatomy of a City. The Penguin Press (2007): 26.
2 Chip Barnett. "NYC Comptroller: Subway delays could cost city $400M a year." The Bond Buyer (2017).

Benefits

Subways provide the fixed transportation benefits of Light Rail Transit without taking up the surface space of a city. However, subways and Light Rail Transit effectively have similar benefits. Much like LRTs, subways help reduce air pollution, promote dense growth, promote walkability, increase property values near stations, and increase the diversity of businesses near stations.[1,2,3] However, another benefit that subways provide that is not mentioned in LRT research is that subways create a high dependency consumer base (see Figure 1).[4] This means that subway users are heavily reliant on the subway system for daily transportation as compared to other forms of transportation—this is vital for a mass transportation system to be viable and profitable. Subways serve as a specialized form of mass transportation that requires a high degree of density.

1 Cacilda Bastos Pereira da Silva, Paulo Hilário Nascimento Saldiva, Luis Fernando Amato-Lourenço, Fernando Rodrigues-Silva, Simone Georges El Khouri Miraglia. "Evaluation of the air quality benefits of the subway system in São Paulo, Brazil." Journal of Environmental Management 101 (2012): 194.
2 Francisco Silva, Juan de Ona, Fernando Arán. "Impact of the Madrid subway on population settlement and land use." Land Use Policy 31 (2013): 632.
3 Siqi Zheng, Xiaoke Hu, Jianghao Wang, Rui Wang. "Subways near the subway: Rail transit and neighborhood catering businesses in Beijing." Transport Policy 51 (2016): 82.
4 Cacilda Bastos Pereira da Silva, et al. "Evaluation of the air quality benefits of the subway system," pg. 195.

Negatives

The biggest downfalls of the subway system are that it suffers from costly delays and has somewhat of a negative perception. Subways are typically underground, which keeps the system out of the public sight of view, which is beneficial to maintain developable surface area for a city. However, this also allows subway cars to appear much less aesthetic and it often gives them a negative connotation. This connotation, tied with constant delays, which cost almost $400 million a year to fix in New York City,[1] makes subways somewhat of an archaic, ill-perceived form of transportation. Subway systems also require increased labor hours during construction due to the system's complexity and often drain cities of their electricity supply—1.8 billion kilowatt hours of power in New York City.[2] Therefore, when introducing a subway system into a city, consider the public perception that may come along with the subway system.

1 Chip Barnett. "NYC Comptroller: Subway delays could cost city $400M a year." The Bond Buyer (2017).
2 Kate Ascher. The Works: Anatomy of a City. The Penguin Press (2007): 38.

Automobiles

The Brief History & Background

Automobiles define American culture and transportation. Originally run by steam engines, automobiles did not take off in production until the creation of the assembly line by Ransom Olds in 1901.[1] This concept greatly expanded with the creation of the moving assembly line by Henry Ford in 1913.[2] The assembly line reduced the cost of labor, increased production, and make the price of automobiles significantly cheaper. Overtime, automobiles have become much more expensive and intricate as the market has developed. Either way, this is the type of innovation that should drive the next wave of change in the transportation industry.

The government has always been quick to subsidize automobile development and infrastructure due to its significance to the American economy and culture. However, the automobile market has had many scares due to its reliance on oil and change in market interests. In the 1950s and 1960s, automobile sales were so profitable that most automobile companies stalled innovation to ensure maximized profit. This created "a domestic market characterized by oligopolistic competition."[3] The market quickly became vulnerable to import competition and began to practice "follow-the leader" pricing.[4] Gas costs were quickly becoming cheaper until the Oil Shock of 1973 and 1979. These two shocks single-handedly changed the automobile market. While V8-Engine family cars were being produced by American automakers, consumers desired more affordable options such as the mid-sized fuel-efficient cars that were being imported from overseas. The auto industry rain into another issue with the creation of CAFÉ requirements in 1979, which held automobiles to certain efficiency standards--a requirement made with the EPA.[5] This occurrence, combined with the decline of passenger cars built by U.S automakers and increase in truck and van sales, suggests that the automobile market is increasingly volatile and reliant on unsustainable sales of larger vehicles (see Figures 1&2) . This has yet again been shown by the recent gasoline surge of 2004-2007 during Operation Iraqi Freedom, where "the American automobile industry [...] experienced financial difficulties strikingly like those experienced by street railways following World War I.[6] Unfortunately, the street railways of the United States did not survive much longer after World War I due to a transition of public funding and the automobile will have a similar fate if a more efficient transportation option receives substantial unanimous support.

1 "Ransom E. Olds." REOlds Foundation.
2 "Henry Ford." Biography.
3 David W. Jones. "The Competitive Difficulties of the U.S. Automakers." In Mass Motorization and Mass Transit: An American History and Policy Analysis, 190. Bloomington: Indiana University Press, 2008.
4 Ibid., 194
5 Ibid., 194.
6 Ibid., 189

Ideal City Type
Small (Rural)

Type of Cost
Public & Private

Ease of Use
License Required

ADA Favorable
No

Income-Based Usage
•Low-Income
••Middle-Income
•••High-Income

Key
• = Least Likely
•• = Likely
••• = Most Likely

Benefits

Perhaps the biggest advantage of automobiles are their individualistic spirit and sense of pride. This sense of immedacy and freedom is what drives the American desire for the automobile. For instance, a vehicle manufacturer such as Ford can look a vehicle's intended use and say, what does the consumer want to get out of their vehicle? John Kwant, director of Ford's Smart Mobility program, explained that modern vehicles continue to be beneficial in American society because of the portion of disposable income that a vehicle may take from a consumer—wages have grown more than vehicle cost and new purchasing options such as leases and longer car loans have allowed for increased affordability.[1] While vehicle infrastructure may be starting to crumble, "expenditures from all levels of government for road transport have increased 6-fold in current dollars in the USA, compared to only a 1.5-fold increase in Germany."[2] This increase in expenditures serves as a double-edged sword—an increase in public cost but has also led to a decrease in car accident fatalities. In a market economy, income is a major determinant of the benefits of the automobile. In the United States, a higher income level equates to more vehicular use, more vehicular ownership, and longer travel distances.[3] In the United States, car usage is much cheaper compared to European countries such as Germany—road taxes and gas taxes are much lower, car use is more convenient, and it provides an inherit sense of pride that European citizens have much less of a desire to possess.[4] While the benefits may seem minimal, these factors play a major role into the decision to purchase and use an automobile.

1 John Kwant (Director of Ford Smart Mobility) in discussion with author, February 2018.
2 Ralph Buehler. "Transport Policies, Automobile Use, and Sustainable Transport: A Comparison of Germany and the United States." Journal of Planning Education and Research 30, no. 1 (2010): 80.
3 Ibid., 77.
4 Ibid., 80.

Negatives

With scholarly articles and research mostly pointing to the disadvantages of the modern automobile, the downfalls of the prized "American Dream" are ever-growing. The biggest issues with automobiles are access and affordability. There is a rather large portion of the United States population that either does not have access to a car or cannot drive because either they are children, unemployed, or elderly. Another downfall is in densely developed cities—factors such as limited and expensive parking, increased travel time due to traffic, and increased infrastructure usage lead to a huge disadvantage for the automobile.[1] Tied to this is an ongoing issue of oil vulnerability and the unknown associated with "peak oil." For instance, "the United States consumes 21 million barrels of oil a day, of which almost 60 percent is imported (up from 27 percent in 1985); gasoline is the single most important source of oil use, accounting for 45 percent of petroleum products [and] the likelihood of a temporary $15–$50 per barrel price shock in the next ten years at about 50 percent."[2] This dependency on a product that cannot be tamed and is controlled by many volatile governments in the Middle East is a major cause for concern. Other concerns tied to the automobile is the concern for pollution, which has not been curbed even with CAFÉ requirements (see Figure 3) due to the "rising share of light-duty trucks, which now account for half of new vehicle sales, average fuel economy of new passenger vehicles is still below its peak in 1987."[3] Trucks and SUVs are more expensive vehicles, which has widened the usage gap even further between low-income and high-income bracket groups. Investment into infrastructure for vehicles has become increasingly ineffective not only because roads are short-lived but also "due to rising urban property values and opposition from neighborhood and environmental groups."[4] Moving forward, these negatives need to be carefully evaluated to understand if automobiles are a sustainable and profitable form of mass transportation moving forward.

1 Ralph Buehler. "Transport Policies, Automobile Use, and Sustainable Transport," pg. 77.
2 Ian W.H. Parry, Margaret Walls, and Winston Harrington. "Automobile Externalities and Policies." Journal of Economic Literature 45 (2007): 377-378.
3 Ibid., 388.
4 Ibid., 393.

Bus Rapid Transit

The Brief History & Background

The development of the bus as a mass transportation option was first introduced by General Motors shortly after World War II. These bus systems began to take over cities and created an environment detrimental to dense, sustainable development. Buses were often "as a slow, unreliable and poor-quality transport mode."[1] This stigma is still associated with buses today, but the perception has slowly begun to change due to the development of Bus Rapid Transit (BRT). While "the modern concept of BRT was developed in the 1970s by Latin American planners, who sought a quick and relatively inexpensive way to speed up buses as the solution to deteriorating traffic conditions,"[2] many cities in the United States have turned to this form of mass transportation as a cheaper and more flexible option (see Figure 2).

1 Taotao Deng, John D. Nelson. "Recent Developments in Bus Rapid Transit: A Review of the Literature." Transport Reviews 31, no. 1 (2011): 83.
2 Ibid., 73.

Ideal City Type

●●●Mid-Size
●●Large

Type of Cost

Public & Private

Ease of Use

Minimal Knowledge

ADA Favorable

Yes

Income-Based Usage

●●●Low-Income
●●Middle-Income
●High-Income

Key

● = Least Likely
●● = Likely
●●● = Most Likely

Benefits

Compared to other forms of mass transportation such as subways and LRT, the biggest benefit of BRTs is that their routes are much more flexible. In the United States, LRTs typically cost $150-$250 million per mile as compared to $10-$30 million per mile for BRTs. This significant difference in cost leads to the benefit of the 80/20 rule—BRTs are considered roughly 20% the cost of LRTs but only capture 80-85% of LRT riders.[1] If a BRT is rapid, has half mile intervals per stop, has high density at each stop, uses dedicated median lanes, takes advantage of traffic signal priority (TSP), has level-boarding, and off-vehicle payment systems, it will be much more beneficial and have a higher return on investment.[2] This is the aspect of perception—if BRTs can be as attractive as LRTs and other forms of transportation, then more people will see it as a positive change for the community and begin to use the system more often—a prime example of this is Cleveland's Healthline, which has seen a return on investment (ROI) of over 400%.[3] BRTs increase the amount of developable land, increase property value, decrease overall congestion, and decreases travel time.[4] These benefits tied with a "complete streets" approach to BRT development will make "many employees who currently use their automobile [...] to choose an active transportation mode to make short trips within [an urban area] because of aesthetic improvements [see Figure 1]."[5] BRTs have a bright upside if perception can be turned around—and it is slowly changing.

1 Wes Guckert. "Bus Rapid Transit Systems: A Viable Transit Solution." ITE Journal 85, no. 11 (2015): 39.
2 Ibid., 39.
3 Ibid., 40.
4 Robert Cervero, Chang Deok Kang. "Bus Rapid Transit Impacts on Land Uses and Land Values in Seoul, Korea." Transport Policy 18 (2011): 102, 115.
5 Ramesh Gunda and Mohan Atluri. "Implementing Houston's First Bus Rapid Transit System." Institute of Transportation Engineers. ITE Journal 87, no. 4 (2017): 38.

Negatives

The problems associated with BRTs are like the problems that are associated with conventional buses and most of these problems come from perception. On the development side, "a bus service is generally perceived as being less permanent than a rail service. Local decision-makers and transport planners may question its ability to stimulate land development."[1] While this is a common concern that investors have when moving into a Transit-Oriented Development (TOD) focused on a BRT development, this problem can be mitigated by surrounding aesthetic that makes the station seem more permanent. BRT developments also have to share the crumbling infrastructure that automobiles have to use on a daily basis. This is a concern because BRTs will increase the rate at which vehicle infrastructure deteriorates. Another issue that arises near BRT stations is that "nuisance effects, such as noise, traffic disruption, air pollution from diesel engines and safety issues, may decrease property value."[2] This is a concern that is much harder to mitigate, but is similar to other concerns regarding almost any fossil fuel-based form of mass transportation.

1 Taotao Deng "Recent Developments in Bus Rapid Transit," pg. 89.
2 Ibid., 88.

Bicycles

The Brief History & Background

As a non-motorized, yet revolutionary form of transportation created during the Industrial Revolution, bicycles have served as a catalyst for recreation, mobility, and culture. Bicycles have many uses, but the use varies greatly on location. For instance, many countries in Europe, especially the Netherlands, use cycling to commute to and from work, yet in the United States most people cycle recreationally or competitively for non-work purposes. This difference targets a larger issue in American society of urban sprawl and a lack of proper bicycle infrastructure.

Throughout the years, cycling in America has gone through many phases of popularity. Initially, the bicycle served as a cheap, alternative form of transportation until the creation of the assembly line for automobiles. Then, safety for pedestrians, bicycles, and most other forms of transportation fell through the roof. The automobile, a private industry, became the government's promoted form of transportation. Bicycles quickly became obsolete and shadowed by many other alternatives until cities began to realize that bicycles served as a cheap alternative to multi-modal transportation. This began with the passing of ISTEA and its various forms (starting in 1991)—for most states this was an eye-opening move by the federal government because "each state receiving federal funds from the Surface Transportation Program and Congestion Mitigation Program—which is every state—was henceforth required to create the bicycle coordinator position to, among other things, develop 'facilities for the use of [...] bicyclists.'"[1] With a modern focus in urban areas geared towards environmental justice, transportation equity, and alternative transit options, the bicycle serves as a great bridge for edge dwellers of urban areas.

1 Ryan Seher. "I Want to Ride My Bicycle: Why and How Cities Plan for Bicycle Infrastructure." Buffalo Law Review 59 (2011): 596.

Ideal City Type
●●Small (Urban)
●●Mid-Size
●●Large

Type of Cost
●●Public
●●●Private

Ease of Use
Minimal Knowledge

ADA Favorable
No

Income-Based Usage
●●●Low-Income
●●Middle-Income
●High-Income

Key
● = Least Likely
●● = Likely
●●● = Most Likely

Benefits

The biggest advantage of bicycles as a form of mass transportation is cost, which is why "nearly 2.1 million adults in the United States ride a bicycle each day, and of that number nearly 800,000 use their bicycle to commute to work."[1] Bicycles are largely a private enterprise, with minimal public sector involvement besides for the creation of bike infrastructure—this makes cycling a much more individualized experience that many Americans still desire (i.e. the automobile). With a low relative cost of transportation, many citizens tend to support a bike infrastructure millage even though the cycling rate in a community may be less than 5%.[2] A case study in Washington D.C. revealed that "some potential benefits of bike sharing including increased mobility, consumer transportation cost savings, reduced transportation infrastructure costs, reduced traffic congestion, reduced fuel use, increased use of public transit, public health improvements, and greater environmental awareness."[3] These benefits alone prove that bicycles are a low-cost, high-benefit option for urban areas looking to grow their mass transportation options without significantly altering the layout of an urban area. Another noted benefit of bicycles and their associated infrastructure, which alone increases connectivity, is the growth of business profits—for instance, "[...] in the Outer Banks of North Carolina, a $6.7 million investment in bicycle facilities produced an estimated $60 million in economic activity through bicycle tourism."[4] Clearly, bicycles serve many functions of larger mass transportation projects yet are a much more cost-effective option for cities tight on money.

1 Ryan Seher. "I Want to Ride My Bicycle," pg. 585-586.
2 Timothy L. Hamilton, Casey J. Wichman. "Bicycle infrastructure and traffic congestion: Evidence from DC's Capital Bikeshare." Journal of Environmental Economics and Management 87 (2018): 75.
3 Ibid., 73-74.
4 Ryan Seher. "I Want to Ride My Bicycle," pg. 593.

Negatives

The biggest downfalls of bicycles are their sensitivity to distance and their reliance on a continuous trail/road network. Realistically, bicycling and "bikesharing systems are meant to encourage short to medium distance rides, ideally complementing existing public transit, providing an alternative to walking to and from a major transit center, or linking two routes that do not overlap."[1] Many cities recognize this and try to improve other transportation options, but funds are often limited. This issue indirectly correlates with the issue of acquiring right of ways to establish dedicated bike paths and trails in front of urban businesses—this is due to a multitude of issues including the business valuing its property, aesthetic, and/or its general distaste for added traffic in front of the business. In Europe, "the prevalence of extensive and highly connected cycling infrastructure networks [...] correlates with high rates of bicycling."[2] However, the United States does not have as many dense, compact urban areas with proper bicycle infrastructure, a strong cycling culture, and different types of riders (recreational, road, trail, commuter, etc.), which holds back the potential of cycling. Another issue associated with the creation of bicycle infrastructure is a "spillover effect" where automobile drivers avoid areas with dense bicycle traffic due to slower travel time and end up causing more traffic congestion elsewhere in the city.[3] This effect has a negative effect on city as a whole because it causes more pollution, decreases road efficiency, and could lead to more expensive infrastructure repairs down the line. With the United States being an automobile-favored society, the safety of cyclists is a major concern that often gets overlooked for other infrastructure improvements. If cyclists have the proper infrastructure, feel safe, and enjoy their routes, then they will be much more likely to ride to work or other locations. Therefore, a new approach that favors increased public funding for alternative transportation modes would be vital to the success of the bicycle in a modern American city.

1 Timothy L. Hamilton. "Bicycle infrastructure and traffic congestion," pg. 73.
2 Jessica E., David M. Levinson. "The missing link: bicycle infrastructure networks and ridership in 74 US cities." Transportation 41 (2014): 1189.
3 Timothy L. Hamilton. "Bicycle infrastructure and traffic congestion," pg. 85.

Ridesharing

The Brief History & Background

While ridesharing may seem like a unique and modern form of mass transportation, its history dates to the World War II era. Ridesharing began as an employer effort to conserve rubber production and save fuel consumption during World War II. Employers would create a bulletin-board matching system in which would use the board as a platform to find ride "partners."[1] During the 1970s, employees and employers responded to the oil shocks with new ridesharing initiatives such as "employer-sponsored commuter ridesharing programs" that helped match workers that lived near each other, vanpooling (company vehicles, company transit routes, leased-out company vans), HOV lanes (high-occupancy vehicle lanes on highways), and park and ride facilities.[2] These initiatives helped increase awareness of vehicle usage and congestion issues. As gas prices dropped, ridesharing programs dropped significantly, but some employers began to practice "employer-based trip reduction programs (EBTR)" in high congestion districts that required each employee to have an average vehicle occupancy rate (AVR) of 1.5 persons or less.[3] This system was hard to practice and did not see much success, which led to other opportunities such as dial-a-ride and "prearranged" online ride-booking.[4] The prearrangement of ridesharing made it largely inefficient and ineffective until the creation of smartphones and social media with companies such as Uber and Lyft leading the charge. While "ridesharing's modal share has declined since the 1970s [...] [from] 20.4% of American workers [...] to 10.7% in 2008 [...] enacting policies to increase carpooling is the most effective strategy to reduce energy consumption besides prohibiting driving [see Figure 2 for more details]."[5]

1 Nelson D. Chan, Susan A. Shaheen. "Ridesharing in North America: Past, Present, and Future." Transport Reviews 32, no. 1 (2012): 96.
2 Ibid., 101.
3 Ibid., 102.
4 Ibid., 104.
5 Ibid., 93, 94, 96.

Ideal City Type
•Small (Rural)
•Small (Urban)
•Mid-Size
•Large

Type of Cost
Public
•Private

Ease of Use
No Prior Knowledge
•Minimal
License Required

ADA Favorable
•Yes
No

Income-Based Usage
•Low-Income
•Middle-Income
•High-Income

Benefits

Ridesharing allows individuals to minimize their pollution and lower automobile congestion without potentially leaving the comfort of their own car—depending on the type of ridesharing practiced. The benefits of ridesharing are threefold—individuals have a much lower cost per mile for traveling, the environment receives less pollution (noise and emissions), and urban resources can be reallocated due to the decrease in automobile traffic.[1] Using these extended benefits, private companies can save costs from time lost from traffic and will be incentivized to promote private ridesharing companies such as Uber and Lyft or even create a system of their own (see Figure 1). By using ridesharing, individuals are more likely to use an alternative mode of transportation compared to commuting in a single-person occupied vehicle if ridesharing was not available—for "37% of respondents would use subway [...], 28% would use private cars, 16% would use taxi and 13% would use bus."[2] Using these savings in carbon dioxide emissions, which "is approximately equivalent to cumulative emissions of 29 thousand cars driving on the road for one year,"[3] the fight against climate change could take a step in the right direction. Ridesharing also has the effect of making participants more willing to consider a change in their mode of transportation—for "about 55% of the respondents reported they may change (46%) or will change (9%) their willingness to buy new cars or replace their old cars in the future, and 28% of them may not change their willingness; only 17% of respondents are not affected by the existence of ridesharing service at all."[4] While ridesharing may not be a drastic step in curbing urban mass transportation issues, it still turns the dial in a positive direction and is much more feasible because it is run by private companies.

1 Bilong Shen, et al. "Dynamic Ridesharing." SIGSPATIAL Special 7, no. 3 (2015): 3.
2 Biying Yu, et al. "Environmental benefits from ridesharing: A case of Beijing." Applied Energy 191 (2017): 148.
3 Ibid., 148.
4 Ibid., 149.

Negatives

While ridesharing may decrease the amount of people directly driving to a location, some studies reveal that ridesharing may increase greenhouse gas pollution. "Since [ridesharing companies] have made it so convenient to get from one place to another, it's possible that Uber and Lyft have actually increased the number of cars on the road, upped greenhouse gas emissions, and, for some segments of the population, replaced public transportation."[1] This is a troubling revelation, especially considering that many ridesharing companies fail to share their emissions and ridership data publicly. While these companies have made it easier to live without a car in modern American society, ridesharing companies have no emission standards compared to taxi services and often serve a "non-commuter" demographic that uses these ridesharing companies to go to social events rather than commuting to work. [2] However, "if Uber, Lyft, and Sidecar draw people away from the Muni, buses, BART, and taxis, [cities like] San Francisco will have to change public transit supply to match the decreased demand. That in turn could make the system even less reliable, and people with higher incomes might reject it altogether."[3] While this issue has yet to be studied thoroughly, it is a concern that should not be overlooked by decision-makers. Another inconvenience of ridesharing is that these companies could be a breach to personal security and do not allow the individual to use their own personal vehicle to get from point A to point B.[4] This is a tough issue to tackle in an American society that puts so much value on personal freedom and automobiles.

1 Gigaom. "Why ridesharing companies like Uber and Lyft have yet to prove their environmental friendliness." Newstex Trade & Industry Blogs (2014).
2 Ibid.
3 Ibid.
4 Nelson D. Chan, Susan A. Shaheen. "Ridesharing in North America," pg. 96.

Section III: Theory-Based Vehicles

Hydrogen-Based Vehicles

The Background

Hydrogen-based vehicles are one of the most realistic alternatives to gasoline-powered vehicles for a multitude of reasons. Currently, "hydrogen is [primarily] consumed for production of ammonia, other chemicals and in petro-chemistry."[1] However, scientific breakthroughs and technological advances could allow hydrogen-powered vehicles to become more of a reality. This is because "there are essentially two ways to run a road vehicle on hydrogen. First, hydrogen in an internal combustion engine is burnt rapidly with oxygen from air. Second, hydrogen is 'burnt' electrochemically with oxygen from air in a fuel cell, which produces electricity (and heat) and drives an electric engine."[2] With the narrowing of tests on hydrogen cell production and the gradual decreased use of fossil fuels as peak oil is surpassed, alternatives to oil must be found in order to maintain the ever-increasing flux of automobiles in the world (see Figure 2 for more details).

Benefits

Hydrogen-based vehicles may not serve as a tool to reduce traffic congestion or personal vehicle use, but it has a variety of benefits ranging from significantly reduced pollution to increased safety. Benefits of hydrogen fuel include a fuel that "emits almost nothing other than water at the point of use; it can be produced using any energy sources, with renewable energy being most attractive; [and] it works with fuel cells [which] may serve as one of the solutions to the sustainable energy supply."[3] As the most versatile fuel and most abundant element in the universe, hydrogen would been an ever-lasting fuel option that would alleviate many stresses associated with nonrenewable energy sources. On a vehicle basis, hydrogen-powered vehicles will have a reduced explosion/fire rate compared to internal combustion engines, tougher fuel tanks, safer pipeline transport, and no environmental damage from leaks.[4] While much is still unknown and hydrogen-powered vehicles may not alleviate many of the mass transportation issues, it serves as a strong environmental transportation alternative.

Negatives

The biggest downfall regarding hydrogen-based vehicles is that storage is a major issue that has yet to be solved (see Figure 1). Hydrogen requires much bigger tanks as compared to oil and would not currently be feasible for the size of a modern automobile.[5] Therefore, a breakthrough would need to happen to make this a feasible option in the future. Another issue is that hydrogen-based vehicles do not help lower congestion of major urban areas. Other issues will most likely arise as the technology and research advances this type of transportation.

Self-Driving Cars

The Background

All over the world, private companies in many different industries are changing their business models and including self-driving car research in their future outlooks. Areas across the world are becoming "geofenced" to test self-driving car technology—for instance, "Singapore, with its high population density, small physical area, and high adherence to traffic regulations, has proved to be an ideal environment for adopting driverless cars."[6] Most automobile companies have some sort of level 2 self-driving system in place that allows adaptive cruise control with lane following—this is just the next step towards making self-driving cars a reality. In fact, this is a "popular theory about how driverless vehicles will take their place on the roads [which] involves gradually increasing levels of automation of tasks currently performed by humans while still retaining human supervision of the driving task."[7] Some theorists believe that "once [driverless vehicles] are safer than human drivers when it comes to risks to 3rd parties, then it should be illegal to drive them: at that point human drivers will be the moral equivalent of drunk robots."[8] This is just one of the many implications that self-driving cars bring to the table.

Benefits

The biggest benefits of self-driving cars include safety, efficiency, and the reduction of unused space for vehicles (parking, etc.). Driverless cars will become much cheaper to insure or rent because the likelihood of an accident is drastically lowered. If vehicle accident should occur, the blame should fall of the vehicle manufacturer because the rider is no longer fully responsible (within reason).[9] From an urban planning perspective, housing density can be increased due to gains in space from parking structures and equity will be increased because a person will not need to know how to drive to get around.[10] These benefits paired with the added benefit of convoy driving[11] (simultaneous driving that can increase space on the road) will allow for a more flexible transportation network, especially in rural areas. Fleet services will allow automotive companies to maximize the vehicle time on the road, which will allow these companies to utilize their market strategies more efficiently.[12] Eventually, the "cloud-based" road network will lack the necessity for traffic utilities as all vehicles will be uniformly programmed with each other.

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1 Sunita Sharma, Sib Krishna Ghoshal. "Hydrogen the future transportation fuel: From production to applications." Renewable and Sustainable Energy Reviews 43 (2015) 1152.
2 Ibid., 1156.
3 Ibid., 1155.
4 Ibid., 1156
5 Ibid., 1156.
6 Mike Daily, Swarup Medasani, Reinhold Behringer and Mohan Trivedi. "Self-Driving Cars." Computer 50, no. 12 (2017): 20.
7 Robert Sparrow, Mark Howard. "When human beings are like drunk robots: Driverless vehicles, ethics, and the future of transport." Transportation Research Part C 80 (2017): 207.
8 Ibid., 206.
9 Ibid., 209.
10 Ibid., 211.
11 Ibid., 211.
12 John Kwant (Director of Ford Smart Mobility) in discussion with author, February 2018.

Negatives

The biggest issue associated with self-driving cars is human awareness and skill. As self-driving technology progresses, "at some point in the not-too-distant future, when driver assist systems become sufficiently reliable, the human "supervisor" will stop paying attention. Human beings quickly cease to pay attention to – or even to perceive – features of their environment that are not relevant to the tasks in which they are engaged."[13] This problem tied with a loss of driving skill creates a serious safety hazard that should not be overlooked when production of self-driving cars becomes feasible in the near future. "Furthermore, once driverless vehicles become reliable enough, people are likely to rely on them completely. Busy parents will put their children in the car and instruct it to drive them to school. Pet owners will send their pets to the vet without making the trip themselves. People will fall asleep, or read a book, enjoy being drunk, or choose to have sex, while the car drives itself."[14] These issues somewhat defeat the purpose of self-driving cars—as the rider would have to be aware of the situation at hand. Other issues associated with self-driving cars is that major policy changes will have to be implemented to ensure success of the system—such as areas designated as "self-driving" only and the phasing out of regular automobiles, which will be difficult because most people hold onto their vehicle for about ten years at a time. Personal attachment and pride in vehicles will also halt many individuals from transitioning to this new type of vehicle. This attachment is likely to be tied with an increase in vehicle miles traveled due to an increase in access and population through the United States,[15] which would put even more stress on America's crumbling road infrastructure. Another common concern and unknown is that this "cloud-based" system could be hacked and lead to major safety and security breaches. While self-driving cars may seem like a safer alternative, their future has a long way to go before it will become a more beneficial mass transportation option.

Hyperloop One

The Background

Elon Musk and SpaceX has come up with a "fifth mode" of transportation that could be revolutionary in the mobility of the world. The Hyperloop One uses linear electric motors, repelling magnetic fields, and solar batteries to move "pods" at a maximum speed of 1220 kilometer per hour—this beats out the travel time in a modern jet by over fifty percent.[16] The Hyperloop One would use individual pods linked together of about twenty-eight people per ride to transport them from point to point (which equates to 840 people per hour and 7.4 million per year).[17] The system could be used for cargo as well and is currently being tested in California, the UAE, and potentially Russia.

Benefits

The Hyperloop One is a technological feat that may change the world. For comparison, the Hyperloop One is somewhat like the tube system that drive-thru banks use for transactions outside the bank, but on a much larger scale. With its 1220 kilometer per hour speed and tubular design, the Hyperloop One overcomes land and sea restrictions that boats and vehicles experience, runs unimpacted by outdoor weather conditions, and is completely renewable.[18] With these benefits, the project already seems to knock out issues that all forms of transportation have had since the dawn of time. Not only does the Hyperloop One provide these benefits, but it also moves large fixed populations in an equitable manner, has low operating expenses, and it does not alienate land for development of the system.[19] While the Hyperloop One may still be in its infancy, the initial tests and theories seem to be very promising.

Negatives

The biggest downfall of the Hyperloop One is the initial cost to invest into the system since it is such a raw form of technological advancement. Other initial concerns include the reliance on solar-battery powered "pods" in areas that may not receive enough sunlight to power the "pods."[20] This problem is currently being researched by the Hyperloop One team and may be solved soon. For now, other issues have not risen due to the infancy of the project.

Conclusion

Mass transportation is an issue that has plagued America for centuries and has only gotten worse with the growth of the automobile industry over the last one hundred years. Investmest in America's future needs to start now, and it starts with a stronger, more coherent focus on the crumbling infrastructure of American roads. Automobiles are the crown jewel of American culture, yet many Americans don not realize the toll that these vehicles take on society. A lack of safety, pollution, and inefficiency has slowly begun to plague urban cores of America, but a drastic change has yet to be made by the government and private companies. While the automobile does bring some benefits along with it, a change in its technology is paramount to a brighter, cleaner future for America. This starts with public and private investments into various types of multimodal transportation such as BRTs, high-speed rail, and even the Hyperloop One. If other forms of transportation become more viable and attractive, more people will begin to use these other forms, but if the automobile and its crude oil continues to be incentivized by governmental subsidies and unrealistic gas taxes, then a drastic change will be hard to achieve. In a capitalist economy, private companies need to be the leaders of the future and help curb this trend of inactivity. Eventually, the government and public sector will catch up with the private industry and realize that an internal combustion engine society is not beneficial economically, environmentally, or socially for America. This guide is meant to help individuals realize the benefits of alternative transportation options—the benefits of a cleaner future. Therefore, the choice is yours to make this a reality and remember: change is a positive force that leads to innovation and technological breakthrough.

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13 Robert Sparrow, Mark Howard. "When human beings are like drunk robots," pg. 207.
14 Ibid., 208.
15 John Kwant (Director of Ford Smart Mobility) in discussion with author, February 2018.
16 E.E. Dudnikov. "Advantages of a new Hyperloop transport technology." 2017 Tenth International Conference Management of Large-Scale System Development (MLSD) (Moscow, 2017): 3.
17 Ibid., 1.
18 Ibid., 3.
19 Ibid., 3.
20 Ibid., 4.

Figures

Trains

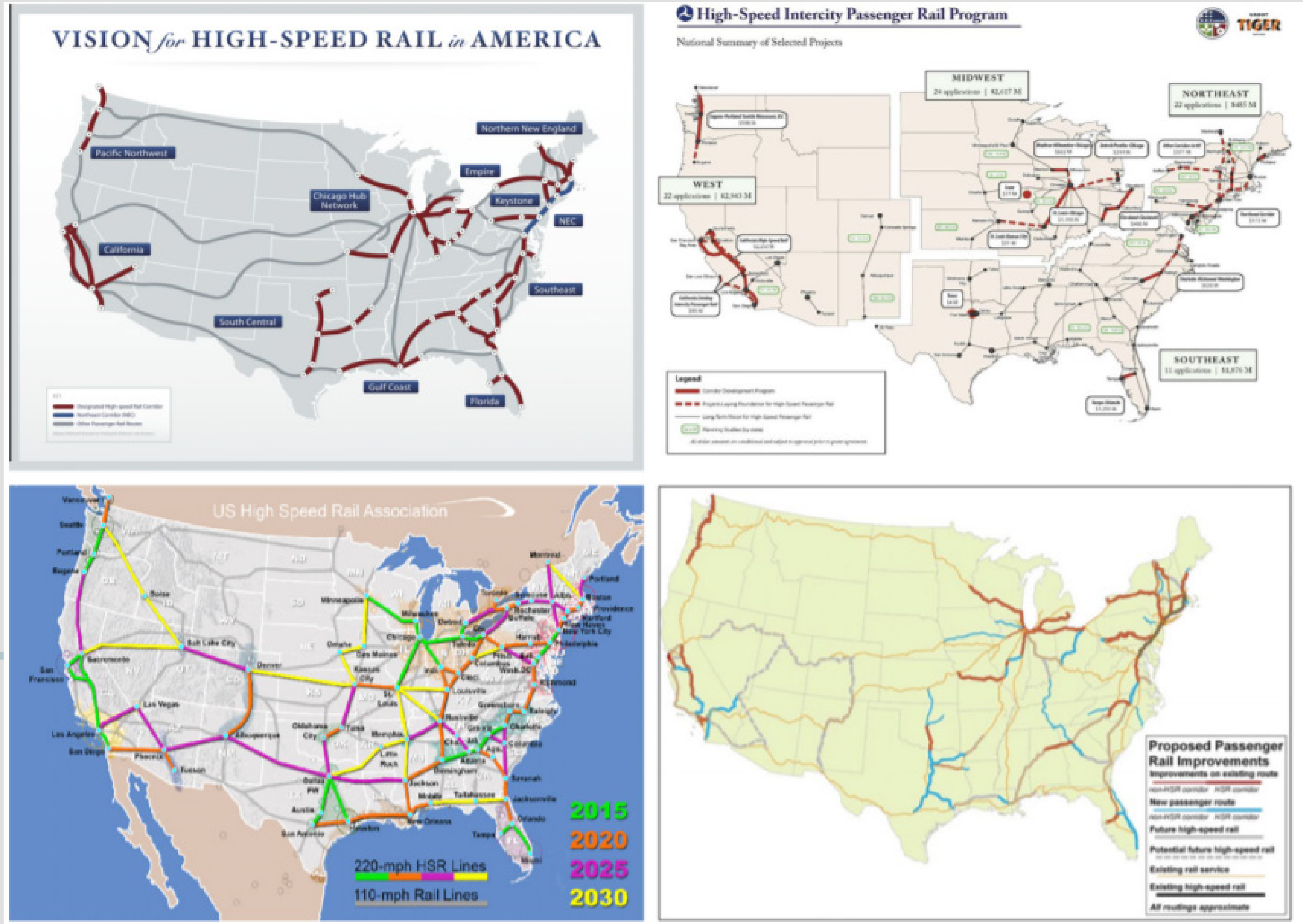

Figure 1: Potential US High-Speed Lines

This figure shows various theoretical high speed rail projections for the United States.

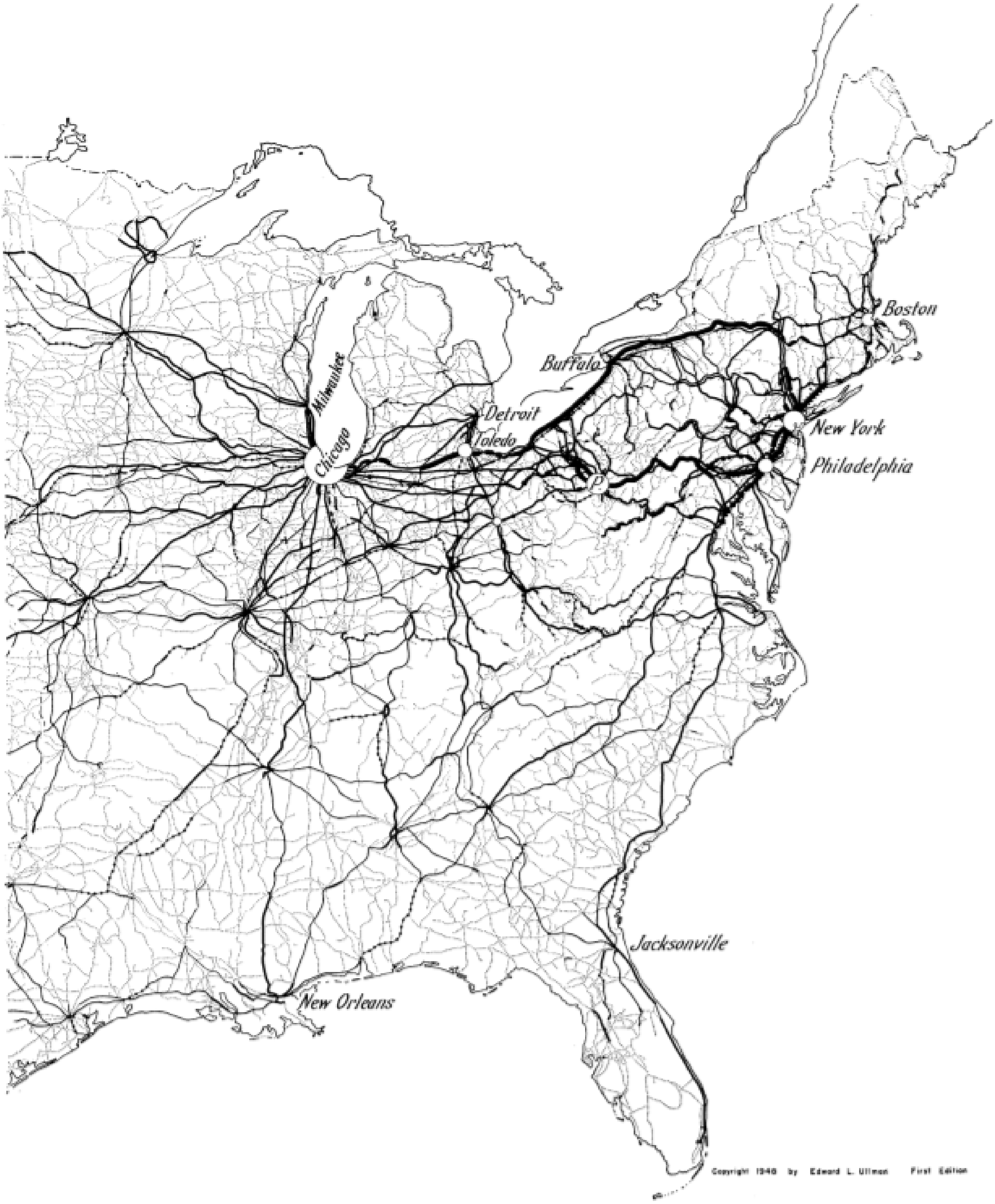

Figure 2: US Train Routes in 1949
This figure shows the railroad density
and traffic of the Unites States in 1949.

Light Rail Transit

Figure 1: LRT in NYC

This figure shows some LRT lines in New York City.
Notice how the lines are fixed.

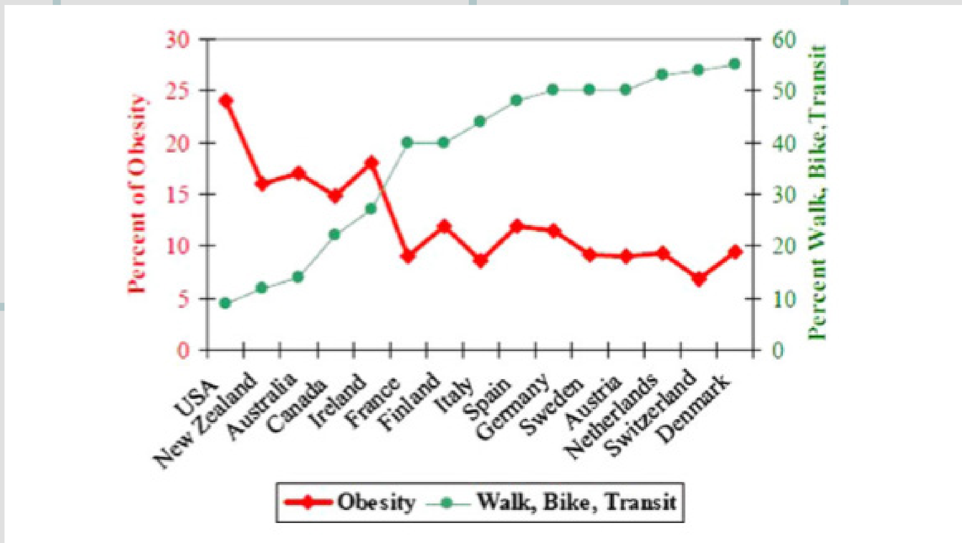

Figure 2: Obesity Rates

This figure shows how Transit-Oreinted Development improves overall well-being.

Subways

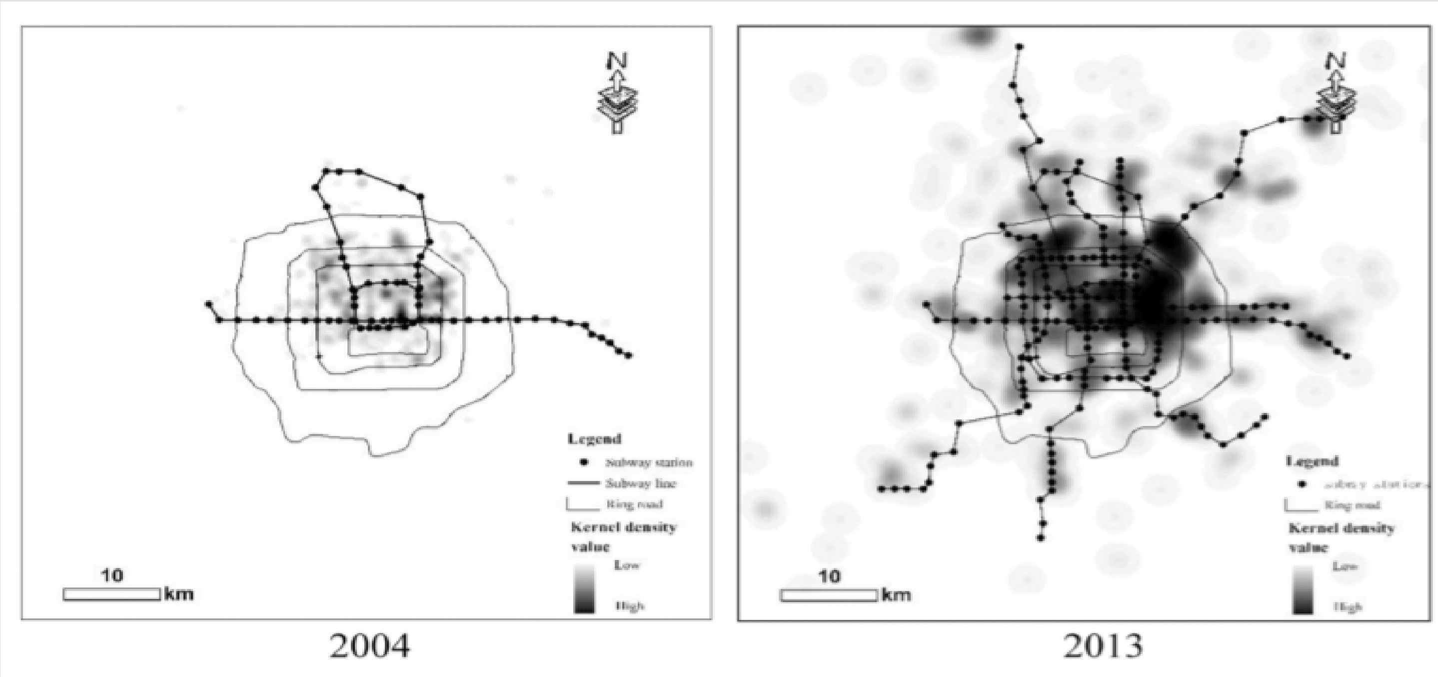

Figure 1: Subway Routes & Catering Locations in Beijing
This figure shows the density of catering locations in relation to subway lines.
Notice the intense growth from 2004 to 2013.

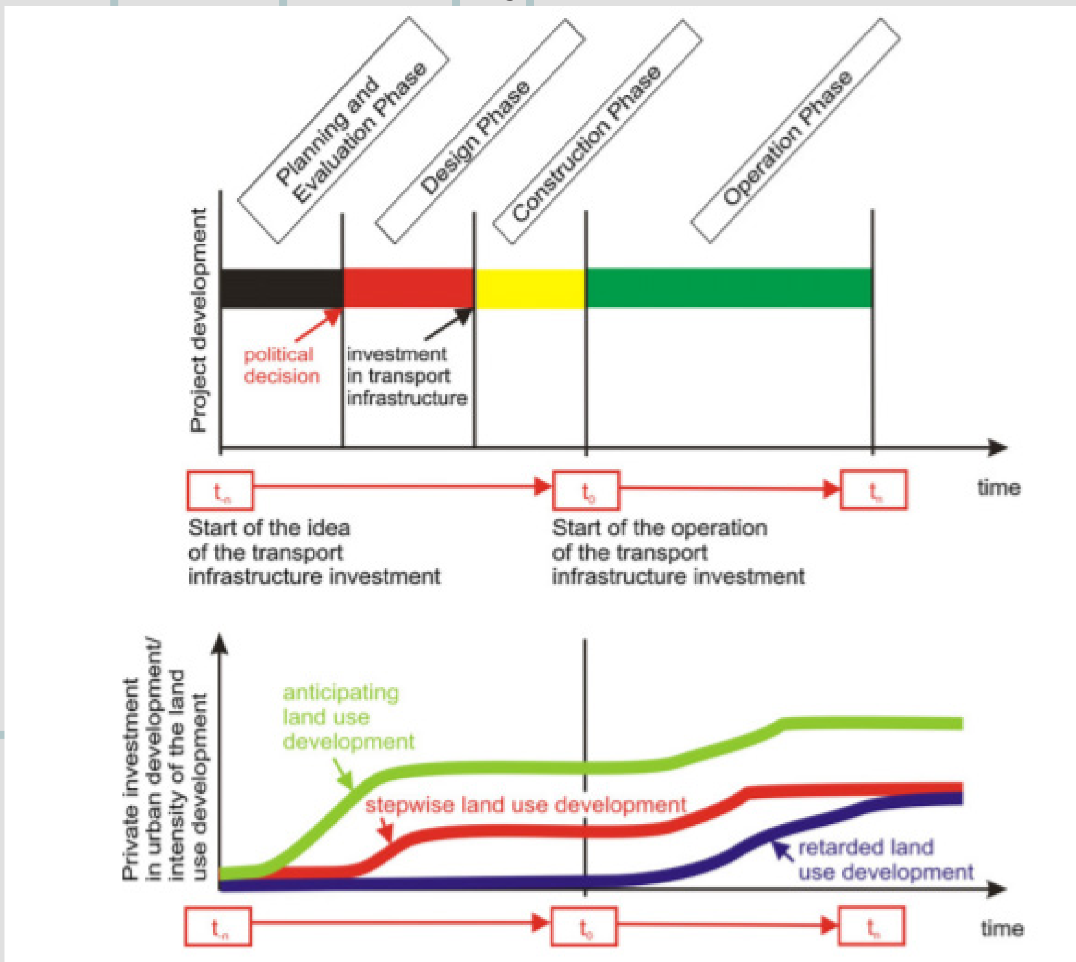

Figure 2: Land Use Development of Subways
This figure shows the land use development process of subway station creation.

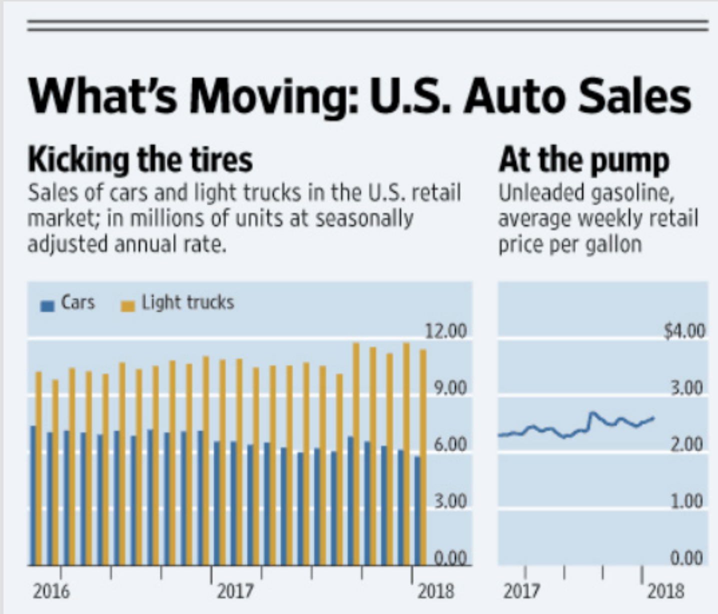

Figure 1: Auto Sales Trends
This figure shows auto sales trends from 2016-2018. Notice the sales of light trucks compared to cars in relation to gas costs.

Thursday, February 01, 2018

Segment totals, ranked by Jan unit sales

	Jan 2018	% Chg from Jan '17	YTD 2017	% Chg from YTD 2017
Cars	**381,452**	-10.8	381,452	-10.8
Midsize	**158,803**	-12.6	158,803	-12.6
Small	**161,936**	-13.0	161,936	-13.0
Luxury	**60,691**	1.8	60,691	1.8
Large	**22**	-63.3	22	-63.3
Light-duty trucks	**773,433**	8.0	773,433	8.0
Pickup	**186,831**	5.0	186,831	5.0
Cross-over	**399,204**	13.6	399,204	13.6
Minivan	**34,113**	-1.9	34,113	-1.9
Small Van	**4,919**	-3.1	4,919	-3.1
Large Van	**24,122**	5.6	24,122	5.6
Midsize SUV	**66,220**	-1.9	66,220	-1.9
Large SUV	**23,432**	-1.5	23,432	-1.5
Small SUV	**17,481**	14.2	17,481	14.2
Luxury SUV	**17,111**	-1.3	17,111	-1.3
Total SUV/Cross-over	**523,448**	10.1	523,448	10.1
Total SUV	**124,244**	0.2	124,244	0.2
Total Cross-over	**399,204**	13.6	399,204	13.6

Source: www.motorintelligence.com

Figure 2: Auto Purchase Trends
This figure shows the growth in SUV and Light Truck sales as compared to cars.

Agreed standards by model year, 2011-2025 [edit]

2011-2025 CAFE standards for each model year in miles per gallon.[51]

Model Year	Passenger Cars				Light Trucks			
	footprint: 41 sq ft (3.8 m^2) or smaller (e.g., 2011 Honda Fit)		footprint: 55 sq ft (5.1 m^2) or bigger (e.g., Mercedes-Benz S-Class)		footprint: 41 sq ft (3.8 m^2) or smaller (e.g., Chevy S10)		footprint: 75 sq ft (7.0 m^2) or bigger (e.g., Ford F-150)	
	CAFE	EPA Window Sticker	CAFE	EPA Window Sticker	CAFE	EPA Window Sticker	CAFE	EPA Window Sticker
2012	36	27	28	21	30	23	22	17
2013	37	28	28.5	22	31	24	22.5	17
2014	38	28	29	22	32	24	23	18
2015	39	29	30	23	33	25	23.5	18
2016	41	31	31	24	34	26	24.5	19
2017	44	33	33	25	36	27	25	19
2018	45	34	34	26	37	28	25	19
2019	47	35	35	26	38	28	25	19
2020	49	36	36	27	39	29	25	19
2021	51	37	38	28	42	31	25	19
2022	53	38	40	30	44	33	26	20
2023	56	40	42	31	46	34	27	21
2024	58	41	44	33	48	36	28.5	22
2025	60	43	46	34	50	37	30	23

Figure 3: CAFE Standards

This figure shows EPA standards for passenger cars and light trucks. Read this chart from left to right and use the top columns to read the cells properly.

Bus Rapid Transit

Table 1

Comparison of operating speeds (km/h) of cars and buses along three road segments with exclusive median bus lanes.

Source: Seoul Development Institute (2005a).

Description		Before (June 2004)	After (August 2004)	Percentage change
Road A	Bus (exclusive lane)	11	20.3	85.0
	Car (other lane)	18.5	19.9	7.6
Road B	Bus (exclusive lane)	13.1	22.5	72.0
	Car (other lane)	20.3	21	3.4
Road C	Bus (exclusive lane)	13	17.2	32.0
	Car (other lane)	18	19.1	6.1

Table 2

Number of formal public complaints about bus services, before and after median-lane BRT services and other service reforms.

Source: Seoul Development Institute (2005a).

Type of complaints	April 2004 (before)	December 2004 (after)	May 2005 (after)
Transport card and fare	59,871	4820	640
Service routes	1216	44	15
Service schedules	1638	141	29
Bus stops, route maps	561	24	4
Service for bus driver	392	40	30
Publicity of route and fare	331	19	1
Other (suggestion, transfer)	981	48	34
Total	64,990	5136	753

Figure 1: BRT Lane Dedication

This figure serves as a comparison between BRT lane dedication before and after improved Transit-Oriented Development. Table 2 shows a decrease in complaints against the bus system.

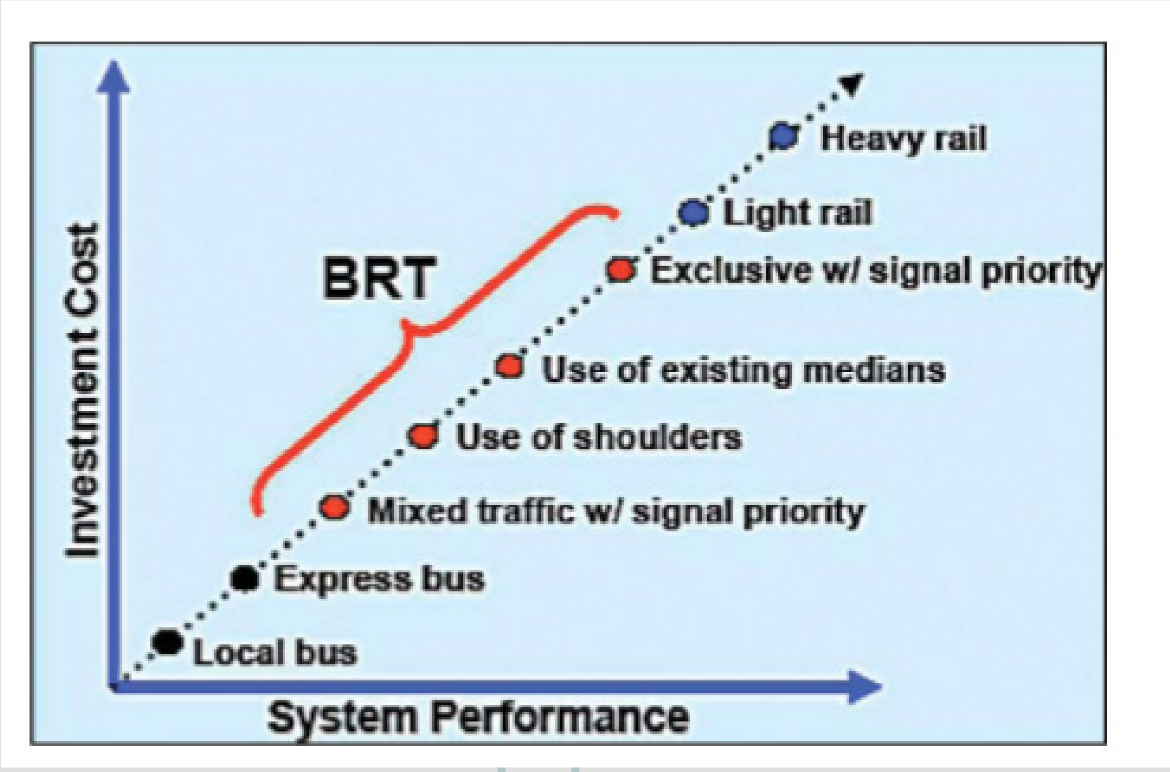

Figure 2: BRT Applications
This figure shows the optimal investment range of BRT systems.

Ridesharing

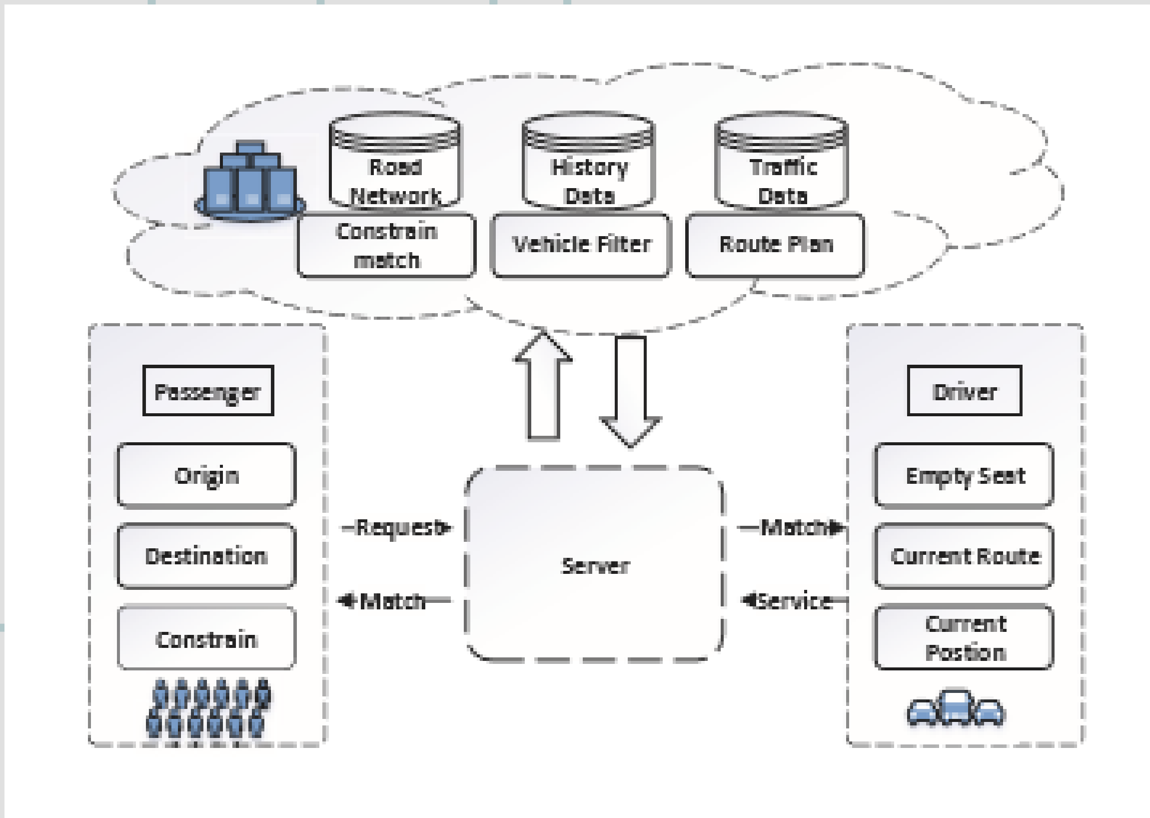

Figure 1: Dynamic Ridesharing
This figure shows the systems thinking approach to the entire ridesharing process.

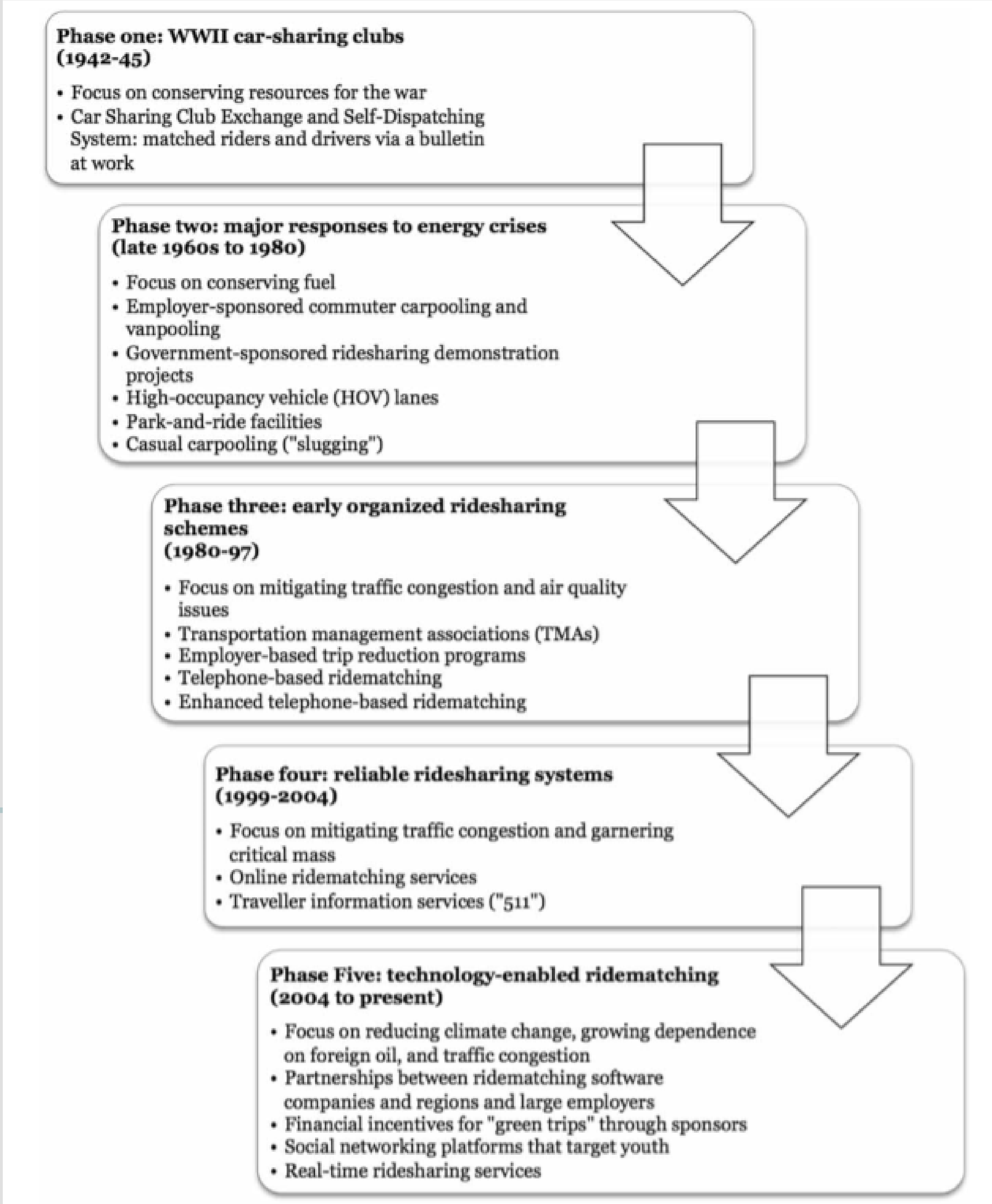

Figure 2: Ridesharing History

This figures shows the history of ridesharing and its ever-changing developments.

Hydrogen-Based Vehicles

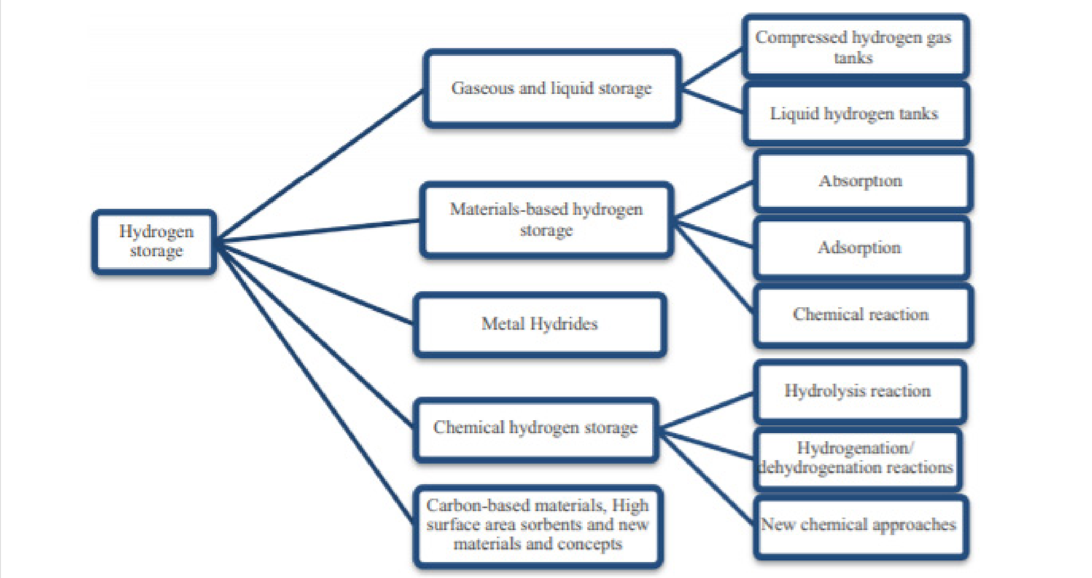

Figure 1: Hydrogen Storage

This figure explains the complex process of hydrogen storage.

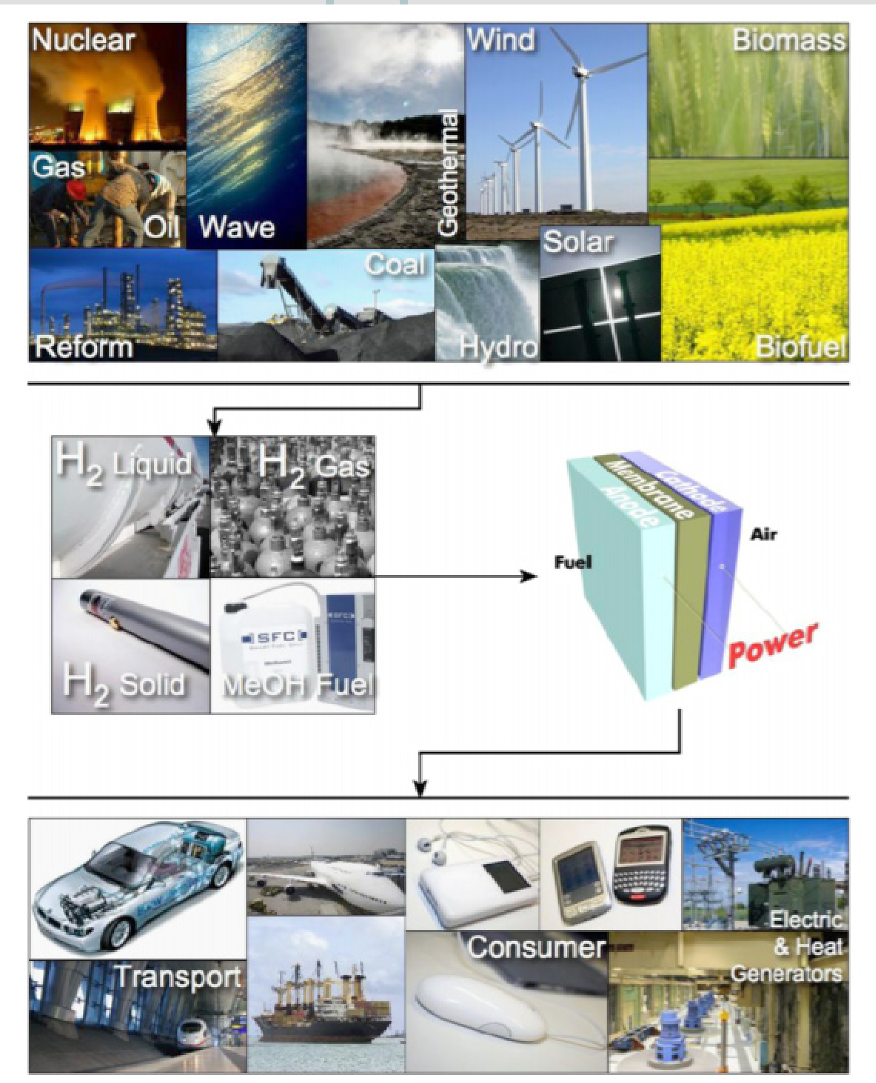

Figure 2: Hydrogen Process

This figure shows the process of converting hydrogen into a fuel source for automobile transportation.

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