

**Sociotechnical actor-network evaluation of urban development plans intended to reduce  
automobile dependency of American cities**

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**Henry Nester**

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

Signed, Henry Nester.

Advisor

Pedro A. P. Francisco, Department of Engineering and Society

## Introduction

A century of automobile-centered urban development has brought American cities up against a scalability asymptote in terms of the economic, environmental, and social costs of further growth along these same lines, and it is long past time to search for new development paths to follow in the future (Newman & Kenworthy, 1999). Almost everyone depends on their car to travel to work, shops, and leisure activities (in fact, they have to in most cases). This pattern of life development feels natural, convenient, effortless - so long as we avoid examining it closely.

When we do examine our automobile-centered development more closely, we find vast hidden costs which will only grow if we continue along the current path. Automobile-centered development is expensive economically (gas prices are high and roads take tax dollars to maintain; “Highway and Road Expenditures”), environmentally (emissions contribute to atmospheric carbon; Bronner, 1997), medically (stress, injury, and pollution; US EPA, 2015), and socially (time spent in traffic is time not spent enjoying life, and car-centric development leads to social isolation; Bozovic, 2021). Furthermore, the current patterns of development are entrenched, because of a century of investment (Jacobs, 1961) - it will be costly and difficult to change to a different system, but well worth it in the long run.

Many Americans are unhappy with the problems that result from car-centric development, but they accept the current system because no clear, viable alternatives have been presented to them. The aim of this sociotechnical research is therefore to understand what alternative transportation systems and development patterns have been proposed to help America to alleviate its car dependency, focusing on urban areas. A literature review will help me to assess what the major proposals are, as well as learn their strengths and weaknesses. These proposals are not mutually exclusive, and the optimal solution may well lie with some combination of them. My sociotechnical research aims to evaluate the effectiveness of each development plan for reducing automobile dependence and enhancing the quality

of life for residents. An actor-network analysis of one of these proposals will help to illuminate the way it might operate in practice.

## **Background and significance**

### **A brief history of car dependency in America**

The 1930s were a decade of decline for the trolley in American cities, as the automobile moved in to take its place. Almost all trolleys tracks had been ripped up by the 1950s. The conventional view is that this occurred as a “natural” result of free market forces (Bronner, 1997; not that this is enough to imply the best path was taken), but according to Jacobs (1961), special interest groups, including the oil, steel, and automobile companies, lobbied heavily in Congress for this transition, which they knew would increase demand for their goods.

In the postwar period, Eisenhower’s Interstate Act connected America’s cities with high-speed roads (Le Clercq & Bertolini, 2003), and as a result of “white flight” from the cities, large suburbs sprang up (Jacobs, 1961). Cars became a requirement, instead of a luxury option, for Americans.

### **The poorly hidden costs of car dependency**

The direct costs to consumers of purchasing, maintaining, parking, insuring, and fueling an automobile are much larger than most Americans would expect. According to the calculations of Gössling et al. (2022), a typical small car costs \$400,000 over its ten-year lifetime. Because of this great sunk cost, car owners are very likely to choose to drive rather than use public transit. However, direct costs to consumers are not the whole story: the government covers another \$250,000 or so of road maintenance and compensation for the negative externalities of driving cars (social, medical, environmental) detailed later on (Gössling et al, 2022).

The state and federal government expenditures on roads in 2020 came to \$204 billion, or around 6% of all spending, and the amounts grow each year (*Highway and Road Expenditures*, n.d.). These tax allocations are considered to be for “maintenance,” but in reality, over half of these expenses are used for expansions, improvements, and entirely new constructions made necessary as the number of drivers

grows. Each new road built must then be maintained forever, increasing costs indefinitely to the point of being a great burden on the taxpayer.

These are only the most direct, obvious economic costs of car-dependence in America. At the turn of the century, over sixty thousand square miles of land were paved in the United States (that's enough concrete and asphalt to pave the state of Georgia). This includes parking lots: America's quarter-billion automobiles spend most of their time idle at home, but there are still two billion parking spots available (mandated by building codes, in fact) (Reid, n.d.), so that each car really takes up eight cars' worth of space at all times – more space than most Americans have to live in. Environmental costs aside, this has a significant environmental impact: we've set aside here a tenth of the land we could grow crops on in order to make way for the automobile. In addition, the air pollution from automobiles (especially ozone, which is naturally present only in the stratosphere) harms our crops. The USDA estimated a \$4 billion loss each year to wheat alone in 1998 (wheat crops typically are worth \$20 billion annually; Bronner, 1997). Thus we see that automobile use has a nonnegligible effect on our food supply – and one of which most Americans are entirely unaware.

The health issues that result from car dependence in America are serious and as widespread as the car itself, but we still don't know the full extent of the impact of cars on our health. We are the proverbial frogs, slowly boiling ourselves and unable to feel the pain.

One obvious issue is the danger presented by breathing in air polluted by automobiles, which contribute some 80% of air pollution. The dangerous substances in car exhaust are carbon monoxide, which suffocates and causes drowsiness in any concentration because it renders hemoglobins inoperable and prevents the uptake of oxygen; nitrogen oxides, which contribute to smog; and hydrocarbons, chance arrangements after combustion, lots of which are known cause cancer (Bronner, 1997). Even a healthy person is harmed (lungs continually irritated and inflamed are vulnerable to infection, but the effect of air pollution on those with respiratory issues (asthma, emphysema, etc.) is

horrible. In Los Angeles, an especially polluted city, the average child has lung capacity 30% below the average (US EPA, 2015).

Noise pollution is another major issue (US EPA, 2015). Cars run on dozens of explosions a second, and being close to these damages our ears. Less noticeably, continual exposure to road noise impairs sleep, raises stress levels in the body, causes anxiety, and leads to inflammation and poor concentration. These issues are serious, but ignored because we “have to have our cars.” (In my view, an unconscious desire to avoid road noise has driven the rapid adoption of noise-cancelling headphones).

Driving leads to sitting for long periods instead of active motion – walking or cycling – which has massive consequences for public health. America has serious issues with obesity and cardiovascular health (*Obesity-Related Cardiovascular Disease Deaths Tripled between 1999 and 2020*, n.d.) which would be combated by simply walking around a bit every day, but there is no time for many workers who walk only to get from desk to car and back. Injuries from car crashes are frequent and life-changing as well (Bronner, 1997): a dozen pedestrians and a hundred drivers are killed in auto accidents each day in America.

### **The difficulty of transitioning away from cars**

Given the high and rising costs of car dependency, Americans should desire to move away from it, but this transition seems impossible. For one thing, automobile infrastructure, and communities built so that cars are required, represent a massive sunk cost, which would be partially lost in the transition. America’s roads are an asset worth \$2.4 trillion (*The Economic Importance of the National Highway System* | FHWA, n.d.). Additionally (and this is the problem I want to address in this paper), I believe Americans feel helpless to escape car dependency *simply because there are no clear alternatives*. We see this “learned helplessness” as a pattern in American life: segregation remained an issue until people like Martin Luther King discussed a future without segregation in the public square (“Martin Luther

King, Jr.”). My research aims to answer this important question: What are the various proposals that exist for escaping car dependency, and what are their respective strengths and weaknesses? How would the best one operate (in an actor-network sense) in practice?

## **Methodology**

My sociotechnical research effort will consist of two main phases: a literature review and an analysis using sociotechnical frameworks to draw conclusions. The literature review will survey the proposals for urban development that aim to address the problems of car-dependent cities, employing a pro-con analysis to evaluate the effectiveness and potential issues of each.

The sociotechnical analysis will employ the theory of actor networks to synthesize the data I gather in the previous two phases (the literature review and interview campaign) and allow me to evaluate the various urban development plans on the basis of their effectiveness at enhancing the quality of life for residents of American cities. I plan to construct an actor network consisting of: the mobility infrastructures (roads, railways, cycle lanes, etc.), mobility technologies (automobiles, trains, bicycles, etc.), spatial distributions of activities (e.g. the locations of homes, offices, and shops), development administration, and resident population.

The reason I choose to include the resident population is that the ideology of residents surrounding their city's development path can have an outsize impact on how effective each development proposal ultimately is (Nello-Deakin & Nikolaeva, 2021). My research thus far suggests that residents participate in the network not only in a technical sense, as consumers of mobility who make economically rational decisions about how and where to travel, but also in a social sense, as transportation activists. According to some theorists, city dwellers with a strong ideology around urban development can make decisions about mobility that are economically irrational (Dieleman & Wegener, 2004; Le Clercq & Bertolini, 2003). Thus a common sentiment among residents about how a city should develop can serve as a kind of "social momentum" to amplify policies and enact change.

### **Sociotechnical framework: actor-network theory**

In actor-network theory, technology or technology systems are considered to be emergent phenomena of networks of living and nonliving actors (Latour, 1992). The actor network usually



includes not only the technology itself, but also its users, stakeholders, and any parties affected by externalities. People – actors with agency – can shape the behavior of the actor-network; conversely, people’s behavior can conform to forcings from other actors (Latour, 1992).

The purpose of this paper is to evaluate the effectiveness of various urban development plans intended to reduce car dependency in the US. Urban planners typically consider a city’s transportation systems in isolation, using mathematical models to calculate their efficiency. I believe a better understanding can be reached by examining these transportation systems as just one part of an actor-network, alongside of passengers and destinations. Actor-network theory allows us to understand what the patterns of use of a transportation system will be, which is really what we are interested in.

I plan to select one of the urban development proposals from the literature review, or a combination of these, which seems most promising. Next, I will draw an actor-network graph showing the actors and their interactions, all labelled, and include a detailed discussion of these interactions. This information will be drawn from sources in the literature review. The analysis should help me to see some of the benefits and drawbacks of that system in greater detail than seen in the literature review.

## **Literature Review**

The findings of my literature review are presented here with each urban development concept in its own section. A summary at the end explains why one combination of these proposals was selected for further analysis.

### **Compact city**

The compact city (also known as “smart growth” or “new urbanism”) proposal for urban development is straightforward: increase the density of a city (the number of activities and residences per unit area), and cars will become unnecessary and inconvenient. In terms of policy, development (especially vertical growth) must be encouraged in urban areas while being discouraged in suburban areas (Dieleman & Wegener, 2004).

From a theoretical standpoint, the compact city proposal means removing the symptom of car ownership (urban sprawl, made possible by cheap, flexible transport) in the hope that the disease will also be cured (Dieleman & Wegener, 2004). It’s uncertain whether the compact city would work in practice – drivers might simply avoid the compact city center because their cars cannot travel there, encouraging low-density development on the outskirts. This is exactly what has happened in Amsterdam (though countered by other policies; Le Clercq & Bertolini, 2003). Another issue with the compact city is that cost-of-living is strongly correlated with density, so that most workers are excluded from living in the compact areas and the suburban commuter paradigm continues unchecked.

### **Multimodal development**

Instead of targeting low urban density, which is really a symptom of car dependency, multimodal development proposals assume that the problem is a spatial segregation of activities by type, which increases the distances which must be crossed. For example, modern zoning separates residences, homes, and offices, usually in the name of quality of life for residents (it is unhealthy and uncomfortable to live right next to a power plant, for example). Multimodal development means that a

city should be maximally inhomogeneous: mix today's zoning categories together, and you might be able to walk from your house to your office, passing the stores you frequent along the way.

In terms of policy, multimodal development would require rewriting zoning laws to reduce spatial segregation (obviously some establishments should not be near residences, but there is no reason for others to be so distantly separated). In Amsterdam, these policies were implemented using the A,B,C zoning system. The areas nearest to rail stops were zoned A for any activity with many visitors per day (large corporate offices, stores), and almost no parking was made available. The areas somewhat more distant were zoned B and allocated for activities with fewer visitors (smaller shops and medical facilities). The areas zoned C had plenty of parking, but were most rarely visited of all (Le Clerq and Bertolini, 2003). This policy was quite effective wherever it was successfully implemented at reducing car dependency.

The theoretical basis for multimodal development is also more sound than that of the compact city. Hagerstrand (1970) and Zahavi (1974) theorized that people choose transport to maximise their action-space – the set of activities they can pursue, subject to economic, physical, and legal constraints – which would not require a car if the city were built according to multimodal development.

### **Self-contained neighborhoods**

Self-contained neighborhoods are a refinement of the multimodal development proposal to bring some order to what could otherwise be a chaotic development path. Also known as the village city proposal or cellular city proposal, the basic idea is that a city consists of repeated units, each of which is self-sufficient in that it contains homes, offices, and shops in tight proximity (Lattimore, 2006). These units would be weakly connected by public transit. The downside of the self-contained neighborhood approach is that it must be chosen in advance, before the city is built.

### **Transit-oriented development**

According to Dieleman & Wegener (2004), transit-oriented development involves designing a city around a hierarchical system of transportation modes: freeways, light rail at the largest scale, streetcar, buses at the medium scale, and cycle lanes, pedestrian walkways at the smallest scale. The authors take Portland, Oregon as a case study and find the transit-oriented development policies have been extremely effective in that city at reducing urban sprawl and the distances driven.

Transit-oriented is the ideal solution for new cities, but can be difficult to integrate into existing car-dependent cities. For example, a case study of transit-oriented development in Los Angeles (Schuetz et al., 2018) examines the variation of employment density and type over time in the vicinity of public transit nodes in and finds that public transit has been largely ineffective in reducing urban sprawl and car dependence. The empirical data does, however, provide two key lessons to the designers of urban public transit: transit nodes should be placed to encourage high-density multifunctional land use in undeveloped areas, rather than attempting to serve medium-density activity centers distributed according to previous development patterns (Schuetz et al., 2018). If care is not taken, public transit simply becomes a mode of transit parallel to and inferior to cars.

Furthermore, a case of study of Amsterdam (Le Clercq & Bertolini, 2003) suggests that transit-oriented development actually encourages people to travel greater distances (in accordance with Hagerstrand and Zavahe's maximal action-space theory). The authors attribute the steady decline of car dependence in Amsterdam not to the continual improvement of the light rail network (which was actually playing catch-up to connect Amsterdam's growing peripheral cities), but rather to the strong pursuit of multimodal development.

### **Natural city**

The natural city paradigm of urban development is the most far-fetched of all the proposals I encountered in my literature review, but also the most powerful. Cities are considered as ecosystems made of buildings, vehicles, people, and nature, and they should be designed with sustainability and

balance of these elements of mind. A central element of the natural city proposal is “rewilding,” the incorporation of natural elements (trees, grass, rivers) directly into cities (Register, 2006). The natural city should be our ultimate goal as we search for urban development proposals to reduce car dependency, but the proposal doesn’t seem to be a practical first step.

### **Summary**

Given the strengths and weaknesses of each of the proposals, the most promising proposal seems to be a combination of two of the approaches studied: self-contained neighborhoods, each built according to the principles of multimodal development and weakly linked by a transit system. In the actor-network analysis, I will pay attention to the tendencies of this type of city over time – in particular, I want to know, will this proposal eventually bring us closer to the ideal, something like the natural city?



## Discussion & Results

I carried out an actor-network analysis as described in Methodology of the city described at the end of the Literature Review and arrived at the actor network shown in Fig. 1. The actors are shown as circled text, with cause-effect arrows labelled to indicate interactions between the actors. These interactions are complex, reflecting the complexity of a city; an explanation follows.

In the top-center of the actor network are the human actors who live and make their livings by means of the city. I chose to lump knowledge workers, blue-collar workers, and business owners together as simply “residents” because the similarities in behavior with regard to transportation are greater than the differences. I brought out gardeners, grocers, and restaurateurs to see how a typical supply chain might operate in this type of city, as well as a few other self-employed individuals (shop owners and artisans) to see how they would fit into the economy. Companies here are similar to present-day national corporations with offices in multiple cities – except that most employees will live in the same self-contained neighborhood as their company’s office, removing the commute.

For the sake of argument, the economy is treated as a capitalistic exchange of goods and services for money (indicated by a \$). In this city, residents rarely leave their own self-contained neighborhoods to pursue economic activity. Self-contained neighborhoods are not expected to be perfectly self-sufficient in their production; instead, neighborhoods can specialize in producing certain goods for other neighborhoods, similar to the way the cells of a body differentiate to serve distinct functions. Any imbalance of production between neighborhoods is then distributed by means of the light rail system – for example, if one neighborhood produces plenty of machined parts but has no gardens, it can trade with another neighborhood in the opposite situation.

Social intercourse, like monetary intercourse, would also stay bound within each self-sufficient neighborhood, simply because the vast majority of social interactions happen between people inside their home neighborhood. A resident’s most significant relationships are with his neighbors (who are

also his coworkers if he works for a company with offices set up near his home), which furthers his sense of belonging in his community. This has excellent results for the social and mental health of residents, leading to optimism about the future and voting and activism to reflect that hope.

Residents' optimism about their city is the first element in a positive feedback loop to accelerate change. Urban planners, noticing voting habits and enthusiasm wherever the new proposals are enacted, will write more policies promoting multimodal development and self-contained neighborhoods. These policies lead to changes in land-use patterns: we see spatial desegregation within neighborhoods, and beneficial differentiation between neighborhoods. These land-use patterns in turn determine and constrain Hagerstrand's action-space of residents, altering their economic and social behavior into the healthier patterns which created their optimism about the future in the first place. This positive feedback loop becomes the driving force behind an expansion of the new urban development proposal across the landscape, replacing the old car-dependent system wherever it grows.

A second, perhaps less important, positive feedback loop also drives the success of this urban development proposal. The action-space of residents, constrained by the lack of cars to mostly nearby activities, informs their choice of transportation mode. Residents will typically choose to walk shorter distances, and take the buses/streetcars for medium distances within their neighborhoods. Light rail will bring them to other neighborhoods on those occasions when they need that access. If residents need flexible transportation, they can depend on the bike. The department of transportation will pay attention to the transit choices of residents and build new infrastructure according to needs. When the transportation infrastructure determines residents' action-space, this closes the second feedback loop.

This actor-network analysis suggests that two important feedback loops, one operating through changes to land-use patterns and the other through changes to the distribution of transportation infrastructure across modes, would drive the success of a city planned according to both the multimodal development proposal and the self-sustaining neighborhoods proposal.



## Conclusion

Having examined several major proposals for urban development, including the compact city, multimodal development, self-sustaining neighborhoods, transit-oriented development, and the natural city, I found that the combination of multimodal development and self-sustaining neighborhoods seemed the most promising in terms of reducing car dependency in the United States. An actor-network analysis allowed me to study the synergies and positive feedback loops which would drive the success of this proposal (briefly, policies written according to these proposals would change land-use, shrink the action-space, leading to a healthier community which votes for more of the same policies and expands its influence to surrounding areas).

More research is needed in order to determine exactly how multimodal development policies could be implemented in the United States, but my analysis has helped to illuminate the dynamics driving the success of these policies. Many Americans feel that nothing can be done to break the destructive cycle of car dependency in their country, in large part because in the public square any alternative proposals either denounced as impractical or else not discussed at all. By enumerating a few of the many proposals that exist, and showing that one combination of them has great merit, I believe that this research can provide citizens with greater hope for America's future.

As African-American poet Lucille Clifton wrote, "We cannot create what we cannot imagine." There is hope for our car-dependent cities, then, in the imagining of a different and better future. In her science-fiction novel *The Dispossessed*, Ursula LeGuin imagines a beautiful city, Abbenay, built with the principle of multimodal development in mind:

"The squares, the austere streets, the low buildings, the unwalled workyards, were charged with vitality and activity. As Shevek walked he was constantly aware of other people walking, working, talking, faces passing, voices calling, gossiping, singing, people alive, people doing things, people afoot...He passed a glassworks, the workman

dipping up a great molten blob as casually as a cook serves soup. Next to it was a busy yard where foamstone was cast for construction. The gang foreman, a big woman in a smock white with dust, was supervising the pouring of a cast with a loud and splendid flow of language...The activity going on in each place was fascinating, and mostly out in full view. Children were around, some involved in the work with the adults, some underfoot making mudpies, some busy with games in the street, one sitting perched up on the roof of the learning center with her nose deep in a book...It was all there, all the work, all the life of the city, open to the eye and to the hand. And every now and then down Depot Street a thing came careering by clanging a bell, a vehicle crammed full of people...These were the Abbenay omnibuses, and as they passed one felt like cheering.” (LeGuin, 1974).

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