How Urban Design Affects VMT, Part I

by Hart Schwartz | March 12, 2018

This article is the first in a series looking at how urban design affects vehicle miles traveled.

- **A simple VMT equation highlights key transportation inputs linking urban design to VMT.**
- **Mixed-use design is seen by urban planners as a key element for reducing fuel consumption.**
- **Data on population density, a proxy for mixed-use, can assess long-term impact.**

http://energyfuse.org/urban-design-affects-vmt-part/

Clear recognition of the link between urban design and vehicle miles traveled (VMT)—crucial to understanding the relevance of urban planning movements pursuing "compact development" in reducing fuel consumption and oil dependence—often goes unnoticed. This article and subsequent ones in this series will directly address this gap. With respect to the compact design programs known as new urbanism and transit-oriented development, thousands of pages have been written—government reports, brochures, pamphlets, manifestos, design books—and many developments constructed. But in touring these developments or reading these extensive publications, it's easy to lose sight of the bottom line: How do their design features affect transportation outcomes?

This article will provide an overview of a logical framework to show what needs to be done in order to affect change in VMT and fuel consumption outcomes. What data really counts and why? A simple VMT equation can provide a consistent, unified framework which spotlights mode choice, trips, and trip distance as inputs into fuel consumption, and shows why these variables are directly targeted by compact development movements such as new urbanism and transit-oriented development. In addition to identifying the relevance to fuel consumption of these input variables, the VMT equation renders far more comprehensible the core function of the movements' common design element of *mixed-use* (which combines housing, commercial, retail, and cultural land uses in a compressed space).

Comparing population density statistics over the past century to transportation variables such as transit ridership and VMT can help assess potential impact on fuel consumption.

Overall, untangling the overlapping chains of causation between urban design elements, transportation inputs, and fuel consumption outcomes can help to understand whether the recent revitalization of many American urban cores—often dotted by the design features of compact development movements—can have meaningful long-term impact or is only of passing significance. Comparing population density statistics over the past century to transportation variables such as transit ridership and VMT can help assess potential impact on fuel consumption. Because the key design element of mixed-use is hard to measure, population density can be used as a proxy for whether cities are becoming more mixed-use and attaining the

intended goals of the compact development movements, or if not, how far these movements have to go before attaining their goals.

Unraveling the chain of causation: Urban Design, VMT & Fuel Consumption

The following VMT equation serves as the crucial pivot between urban design and fuel consumption:

- VMT = (number of vehicle trips) (length of vehicle trips)

If vehicles either travel more often, or longer distances per trip, then VMT will increase. Therefore, if urban design can impact these inputs, then it can impact fuel consumption:

- Fuel consumption = vehicle-miles-traveled / fuel-efficiency

If VMT increases in the numerator, then fuel consumption increases (assuming fuel-efficiency is held constant). Therefore, either more trips or longer trips will tend to increase fuel consumption.

Here is where urban design steps in. Compact development movements such as new urbanism or transit-oriented development hope to reduce both number and length of vehicle trips. Note that a third variable, mode choice, is implied. Choice of travel mode—personal vehicle, ride-sharing, transit, walking, biking, etc.—affects number of vehicle trips, and any trip transferred away from a motor vehicle reduces VMT and reduces fuel consumption.

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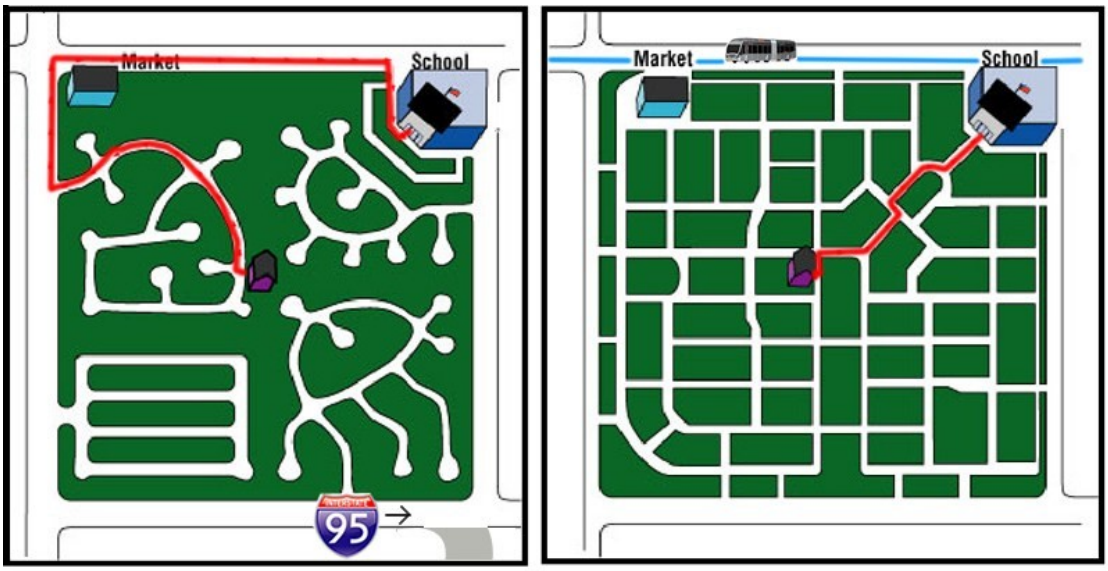
All of these variables are drawn together in an overarching desire for *mixed-use* development, a cornerstone, systemic pattern of design. Mixed-use is believed to impact all the travel input variables at once. Before proceeding further, it is important to briefly profile the compact development movements, to place their emphasis on mixed-use in clearer context.

New urbanism

New Urbanism is an urban design movement for which the “new” is misleading, because in fact the movement’s goal is to replicate styles of houses, streets, and neighborhoods that were common in the 1920s and earlier. Founded by Miami architect Andres Duany, new urbanist theory declares that homes placed close together, with little setback from the curb and little distance between the houses, on narrow interconnecting streets that intersect at right angles and have sidewalks, will promote walkability and community togetherness, increase population density, and reduce the need for vehicle travel.

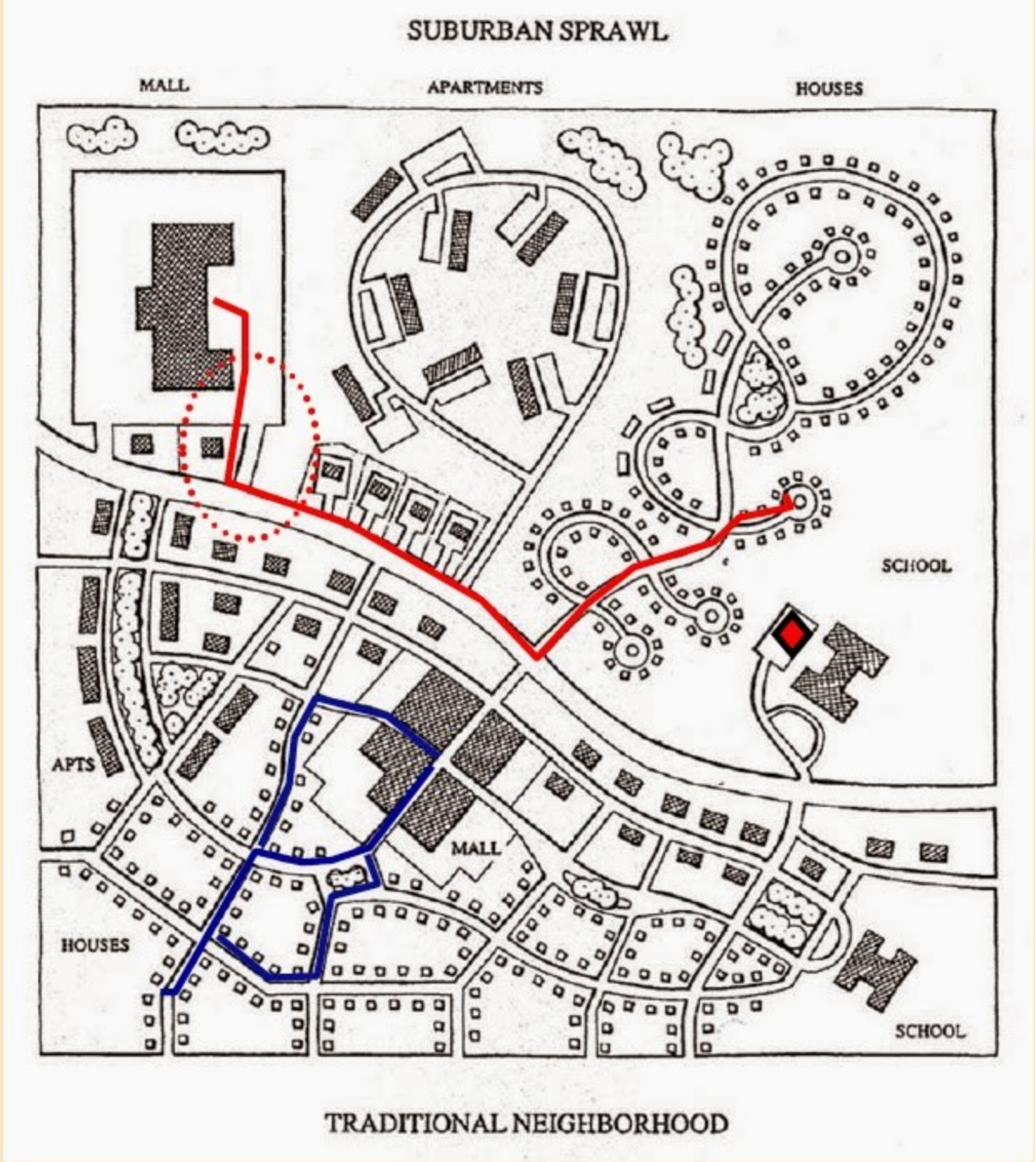
Suburban Sprawl Street Pattern **New Urbanist Street Pattern**



Driving-only transportation pattern Walkable connected transporation network

Source: *Seattle Transit Blog, & Congress for New Urbanism*

New urbanist design stands in stark contrast to contemporary suburban design trends. Modern sprawling suburbs tend to have winding roads, large houses set on large lots with ample space between lots, and cul-de-sacs feeding into connector roads that lead to the Interstate. Vehicle travel in sprawling suburbs tends to be a necessity because most developments are residential-only, meaning that driving is often the only time-practical way to arrive at daily destinations. New urbanism seeks to completely reverse this trend by placing disparate uses close enough so that walking can re-emerge as a viable travel mode.



Source: *The New Urban, "Walkable Neighborhoods: Street Block vs. Cul-de-Sac"*

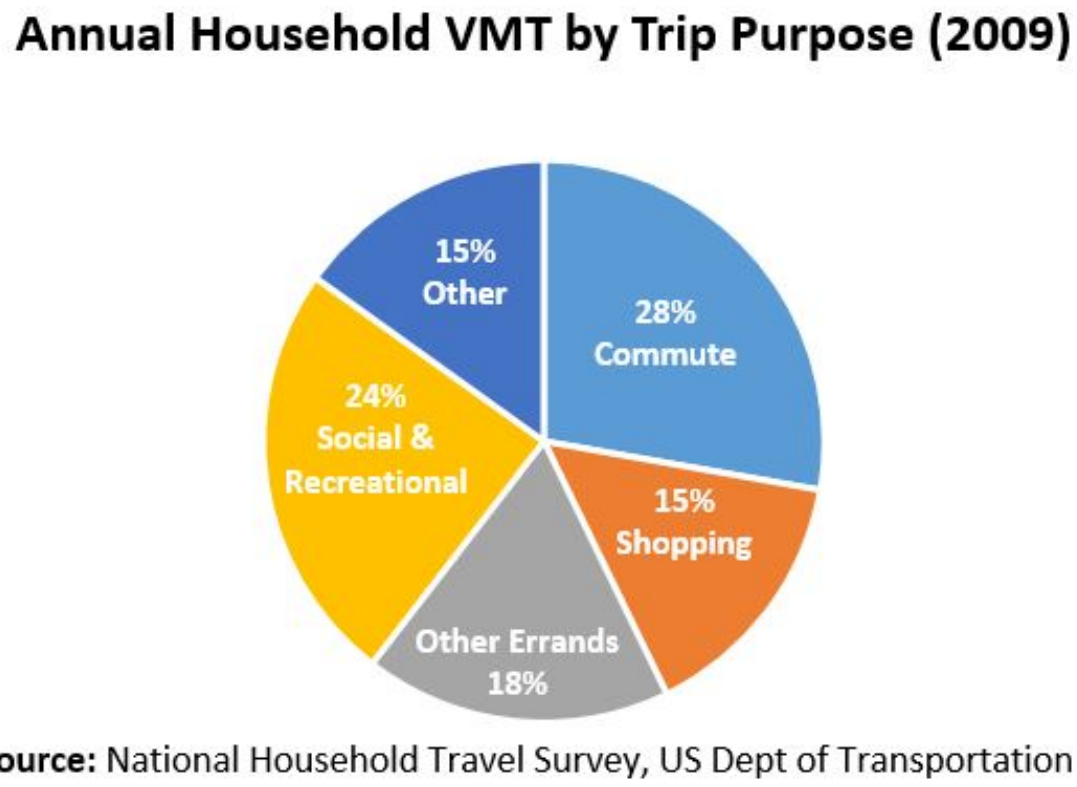
Transit-Oriented Development (TOD)

Often used in conjunction with new urbanism, transit-oriented development aims to stimulate walking and public transit use, by placing a dense mixture of land uses, such as retail, residential, and office, in clusters near transit stations. TOD theory holds that vehicle travel can be

substantially reduced if people can either ride transit to their job, or live within walking distance of work, as well as other common daily destinations. The TOD movement has attempted to either redevelop existing transit stations to include a greater mix of uses, or else construct new transit stations which anchor mixed-use, walkable districts. An excellent example of TOD would be Lindbergh City Center, a downtown Atlanta subway station, where the district around the station has been redeveloped with mid-rise office buildings, street-level retail, and medium-density apartment buildings all within a few blocks of the station.

Mixed-Use: Key Common Element

Both new urbanism and transit-oriented development seek the construction of mixed-use, walkable, compact city districts. The importance of mixed-use in reducing vehicle travel can be seen from statistics on the distribution of trip purposes, as highlighted in the following chart containing data from the National Household Transportation Survey (NHTS).



If different types of trip destinations are closer together in a “mixed-use” district, people can theoretically travel less often, take shorter trips, or dispense with driving altogether.

These statistics show that no particular type of trip accounts for more than 28 percent of all miles driven. This strongly suggests that mixing land uses in close proximity may indeed have a non-trivial impact upon VMT. The VMT equation outlined above says that if different types of trip destinations are closer together in a “mixed-use” district, people can theoretically travel less

often, take shorter trips in personal motor vehicles, or dispense with driving altogether. If shopping malls, work spaces, social activities, and other destinations (school, church, etc.) sit in closer proximity, it stands to reason that there could be fewer trips, shorter trips, or more walking trips. In other words, the inputs to the VMT equation would each be reduced by mixed-use design, and thus VMT and fuel consumption would be reduced.

Real-Life Impact? Mixed-Use Hard to Measure; Density Used as Proxy

The question naturally arises whether the prevalence of mixed-use design has been systematically measured, and whether this has correlated with transportation outcomes. Population density has sometimes served as a proxy to estimate mixed-use prevalence, because it is hard to measure the presence of mixed-use design and because districts with land uses placed in closer proximity logically tend to have higher population density. Using density as a proxy, the next article in this series will examine density statistics for central cities of metropolitan areas to see if mixed-use prevalence has changed over time, and to see whether such change correlates with transportation outcomes in terms of VMT, transit ridership, or vehicle ownership.

Change in short-term more likely at the margin

The statistical look in Part II, the next article, will identify dramatic long-term changes throughout the 20th century, and will underscore just how far new urbanism would have to go, to truly reach its goal of recapturing the urban design of the 1920s. As a previous article on The Fuse demonstrated, the relevant place to look, going forward, for change in vehicle ownership and travel statistics is at the margin. Individual decisions are made at the margin, so any long-term change will likely begin with a small change by a few individuals which eventually grows into a large, sweeping change. But when dealing with prebuilt patterns of urban infrastructure, etched into the landscape in concrete and steel, how much can truly change at the margin, when individual behavior is so conditioned by the physical environment in which it occurs?

How Urban Design Affects VMT, Part II

by Hart Schwartz | March 20, 2018

This article is the second in a series looking at how urban design affects vehicle-miles-traveled (VMT).

- **Some urban planners promote a return to the mixed-use, high-density cities of the 1920s, to reduce VMT and fuel consumption.**
- **However, population densities (as a proxy for mixed-use) have fallen so far since the 1920s that this goal may be unachievable.**
- **The most realistic trend-line is "blended density," whereby high-density and low-density coexist and offset each other.**
- **Recognition of mixed, blended land uses is crucial for forecasting, because fuel consumption will vary according to city district.**

The first part of the series on urban design and VMT explained that compact development movements (new urbanism, transit-oriented development) aim to impact transportation by either reducing the number of vehicle trips, the average distance of vehicle trips, or changing the travel mode choice away from

personal vehicles. A key feature of their programs, especially as embodied by new urbanism, is to place different destinations closer together in a *mixed-use* pattern of development that utilizes densely interconnected streets. Moreover, if transit stations are placed at the nexus of mixed-use districts, shared travel can be further encouraged, in a design style known as transit-oriented development.

Collectively, new urbanism and transit-oriented development are known as "compact development movements" because they aim to limit the expansion of developed land in American metropolitan areas. How can the extent of these movements' impact be evaluated, especially with respect to fuel consumption? For fuel consumption, the implication is that any reduction in vehicle trips or trip length, or to other travel modes, would reduce VMT, which in turn would cut fuel consumption.

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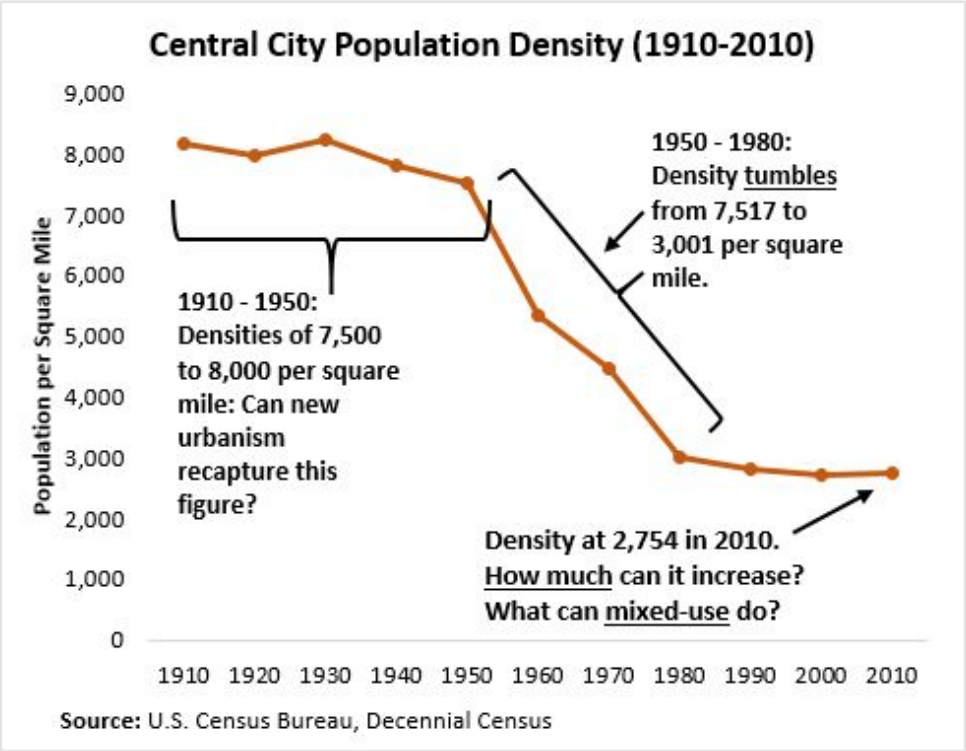
Because it's difficult to measure the prevalence of mixed-use design, population density has often been used instead. Dramatic declines in population density statistics over the past century make it apparent that instituting compact development programs similar to the 1920s might not be fully achievable. It would be difficult to increase density to levels seen a century ago. Recognizing this difficulty, the compact development movements have adopted a more realistic program of "blended density," whereby they accept that low-density, land-consuming design will continue to exist in the same broader metropolitan areas where compact, mixed-use districts are developed. In a complex offsetting process that resembles the so-called "whack-a-mole" game, the driving-friendly suburban sprawl patterns of the mid and late 20th century will continue to exist alongside the walking-friendly and transit-friendly resurgence of mixed-use, higher density design.

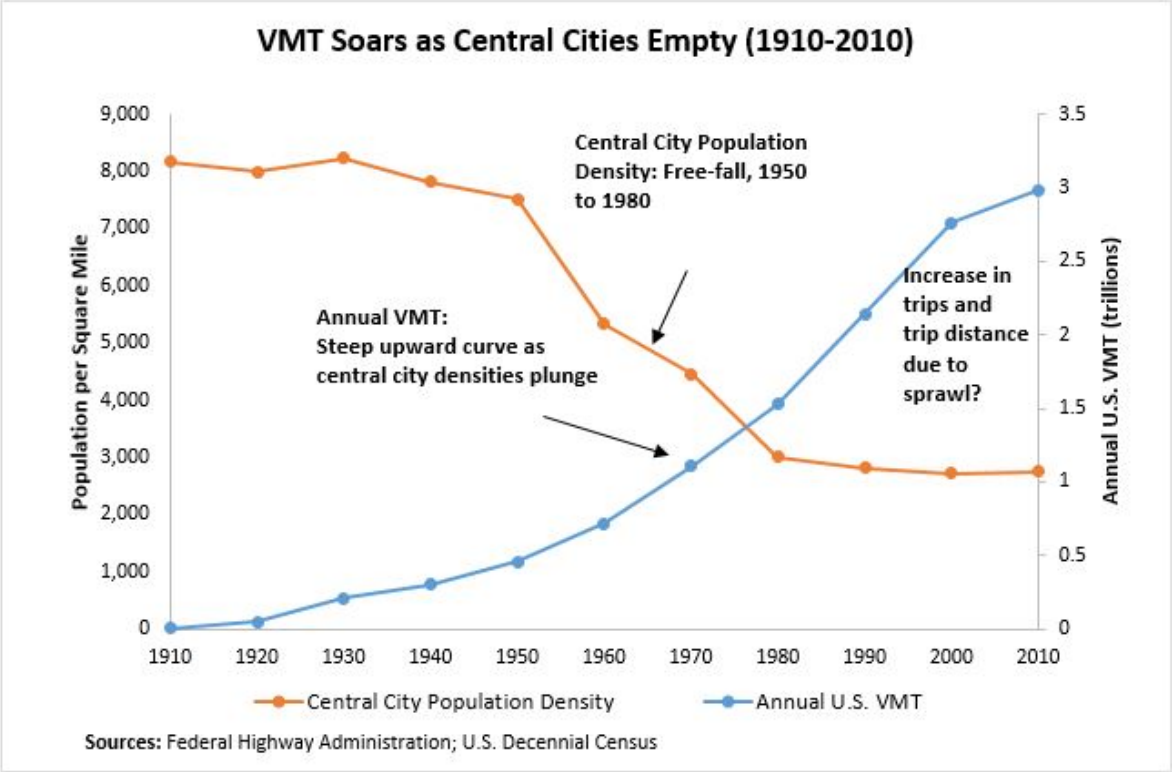
The bottom line is that the most realistic trend-line for urban design over the next few decades involves population density either holding steady or slightly increasing, without a national trend of everywhere reverting to the highly dense and walkable cities of the early 20th century. While certain cities may certainly either develop new pockets of intense walkability, or maintain existing walkable zones, these "city within a city" districts will likely be surrounded by lower density, driving-friendly areas. Other factors aimed at reducing fuel consumption, such as autonomous vehicles, ride-sharing, or other unforeseeable forces, will need to reckon with this "blended" environment in managing their roll-out and implementation. Recognizing the blend of uses is a crucial element of accurate forecasting.

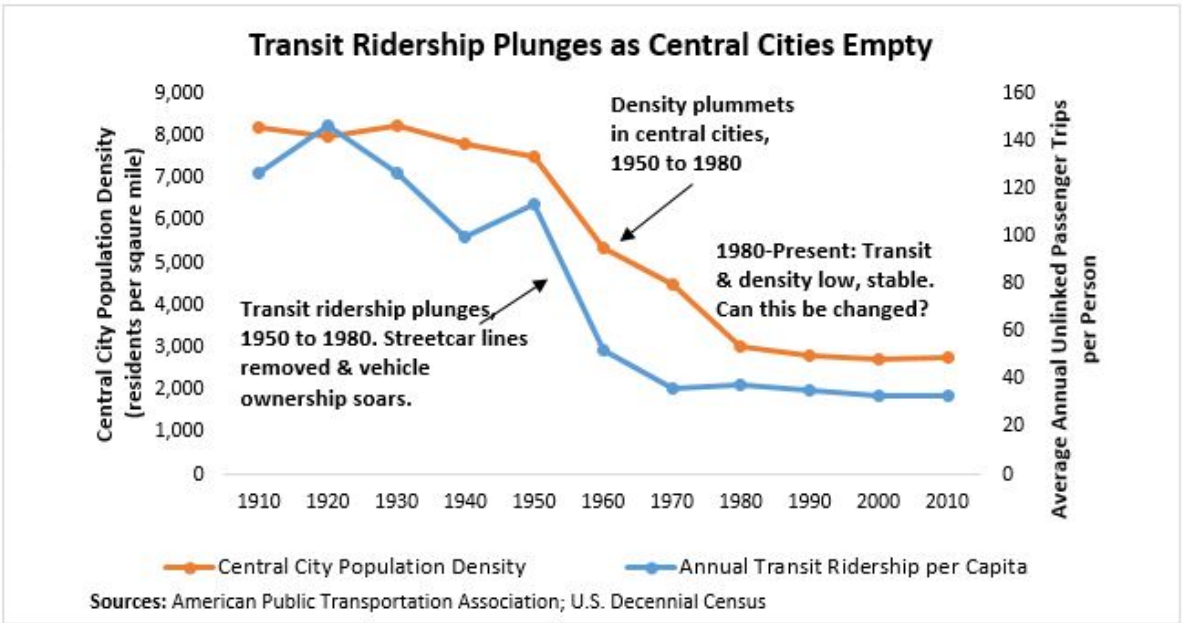
Can mixed-use design of the 1920s ever be recaptured? Long way to go

Looking at density statistics—as a proxy for mixed-use walkability—reveals just how far of an uphill climb is faced by compact development movements in attempting to utilize mixed-use, compact, walkable design to reduce driving and fuel consumption. Recall that these movements, especially new urbanism, openly declare that they seek to recapture urban design popular in the 1920s and earlier. This begs the question, what were population densities back then? The central cities of metropolitan areas have the longest tradition, of any land-use type, of relatively consistent boundaries, thus making them a suitable basis of long-term comparison. Between 1950 and 1980, a monumental transformation occurred in population density of central cities, rendering many urban landscapes vastly different in kind, in 2018, from those of a century ago.

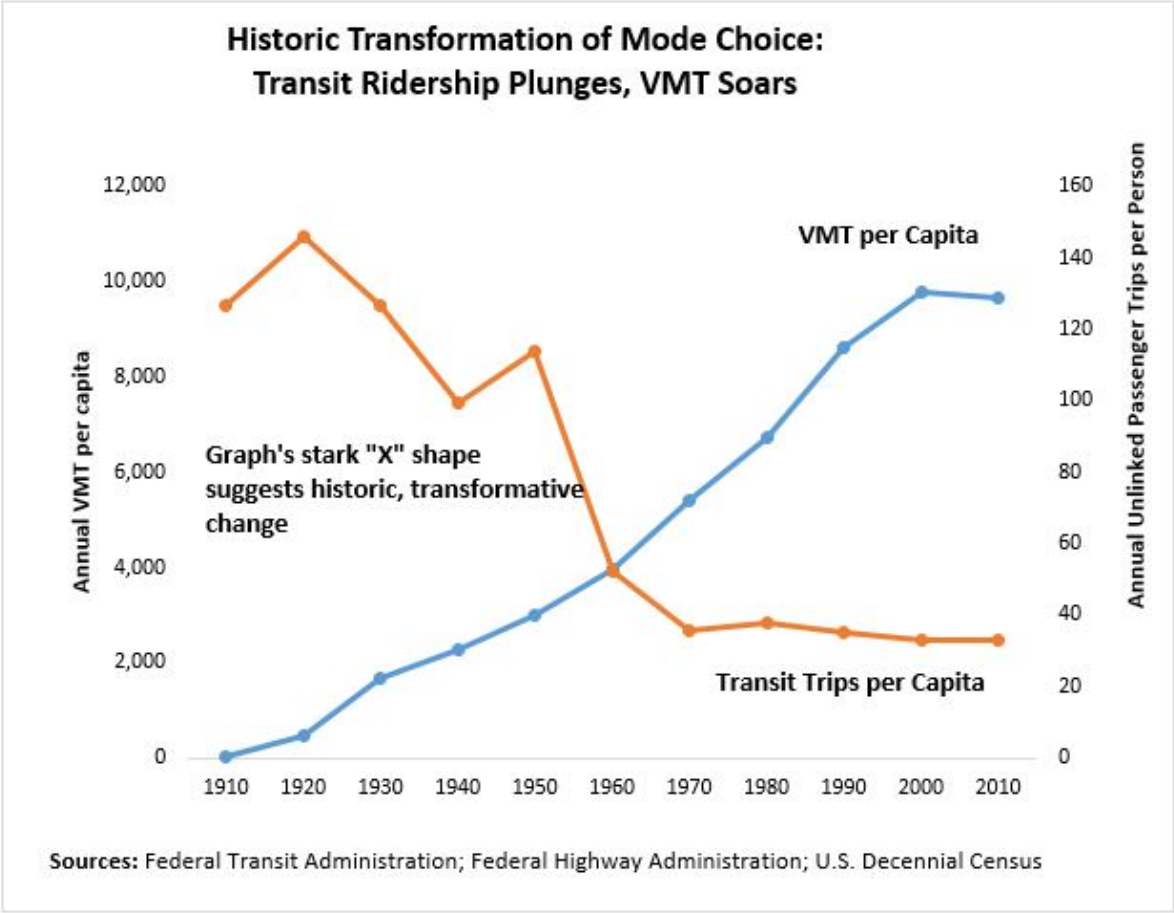


The impact of the above graph is hard to overstate. Is it virtually impossible for subtle elements of new urbanist design, such as front porches or placing stores and apartments in the same building, to increase population density from the 2,754 figure of 2010, back to the 7,990 of 1920 or 8,238 recorded in 1930? Such vastly re-increased density seems implausible, especially considering that most of those people who left central cities moved to suburbs which often have densities under 500 people per square mile Change has been all the more monumental if one contrasts plummeting central city density against plunging transit ridership and soaring VMT. Extraordinary changes in travel patterns have been strongly correlated with falling central city density, as shown in the following graphs. Do these changes represent sweeping infrastructural changes that will be very hard to undo?





These graphs may fairly be called an exclamation point. In just thirty years, between 1950 and 1980, central city densities plunged, VMT soared, and transit ridership plummeted. In terms of VMT inputs—number of vehicle trips, average trip distance, travel mode choice—number of trips and trip distance cannot be measured back to the 1920s, due to lack of data. But a historic transformation of mode choice, from transit to driving, can be seen in the following graph.



In the face of this expanded historical background, the objectives of new urbanism and transit-oriented development assume new significance. The low, stable central city density every decade since the 1980s, and the historically low transit levels against historically high driving levels, strongly suggest that recent efforts to spread mixed-use design during the last 35 years have had, at most, limited impact. While it is certainly possible that small districts in larger metropolitan areas have increased in density, there has not been a nationwide impact perceivable in statistics.

Whack-A-Mole: "Blended Density" as the new nirvana of urban design

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The immensity of the density challenge, along with the intensity of land-use contests in most metropolitan areas, have led compact development movements to define a limited goal of "blended density." The so-called "whack-a-mole" game represents the reasoning behind urban planners' thinking. So long as market demand exists to build low-density developments, the builders of compact, higher-density developments can only hope to displace lower-density developments to other parts of the same metro area. For instance, a developer who wins the right to create a high-density, mixed-use, retail/commercial/residential/office district in an abandoned area of the city center may simply induce a separate developer, who had been considering that very same city center space, to build a low-density strip mall somewhere in the suburban hinterlands. If one then measures the overall density of the metropolitan area, it may be unchanged, or

even have decreased, despite the success of the high-density project. Low and high densities co-exist within the same metro area and overall density undergoes minimal change.

This vexing dilemma has not gone unnoticed by compact development movements. Recognizing that they cannot necessarily achieve overwhelming area-wide increases in density due to the "whack-a-mole" dynamic, they hope instead to incrementally raise existing densities by marginally increasing the ratio of medium- or high-density developments to low-density sprawl. For example, building one high-density development for every low-density development would be better than building one high-density for every five or ten low-density. Adjusting the ratio could perhaps slow the rate of expansion of developed land area (a.k.a. sprawl), even if it would not stop sprawl in its tracks. Therefore, compact development literature often refers to "blended density" as a realistic, achievable outcome.

Impact on fuel consumption

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After a decade-long pause, VMT began to grow again in the mid-2010s. Many commentators have speculated whether renewed "urbanization" will lead to large reductions in vehicle ownership and VMT. Others have speculated on the potential for autonomous vehicles, ride-sharing, or other new technologies to reduce VMT, especially in supposedly re-densified cities. But the historical data reveal just the opposite: Density has fallen massively and stayed low, relative to what it used to be in the heyday of walkable, mixed-use cities, a century and longer ago.

Consequently, the historic and durable transformations in density and mode choice between 1950 and 1980 highlight the scope of the challenge in using urban design to reduce fuel consumption. Even the most fervent proponents of mixed-use, compact development must labor within an environment of massively reduced density, and have acknowledged the challenge of systematically implementing mixed-use within a "whack-a-mole" environment of contested land use. If even these movements have adjusted their expectations downward to aim for "blended density," and if density is so strongly correlated with vehicle travel, then what does the future hold?

Going Forward: Recognition of blended land-use realities

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Those interested in this topic should understand that, now and going forward, America's metropolitan areas, home to nearly 90 percent of Americans, contain a *hybrid*, *blended* system of land-use where many different land-use types *co-exist side-by-side*. Whether the task is selling vehicles, introducing autonomous driving, promoting ride-sharing, policymaking, or something else, strategists and investors should understand the mixed system of land use that exists. Ironically, while at a small scale, the new urbanists can only introduce their version of "mixed-use" within narrowly defined and targeted districts, when seen from a larger bird's-eye perspective America's metropolitan areas appear profoundly mixed-use, in the sense that "mixed-use" broadly understood includes both walking-oriented and driving-oriented districts and that land uses can be *functionally* mixed even when not walkable. That is, even if uses are physically far away from one another, they may in fact be close (i.e. mixed) in terms of time, if the dominant mode of transport for that district is driving..

Understood in this manner, different levels of density, different street patterns, and different styles of buildings all co-exist nationwide. Recognition of this co-existence ought to be a cornerstone, a starting

point for any serious discussions, in any realistic analysis of future fuel consumption and vehicle market trends.