On The Potential Impacts of Land Use Change Policies on Vehicle Miles of Travel.

1. Purpose and Context.

The steady post World War II growth in US highway travel has its roots in the demands of a growing and increasingly mobile population, and in the physical layout of geographically expanding cities. In developing vehicle miles of travel (vmt) forecasts to year 2020, DOE s Clean Energy Futures Study (Chapter 6) focuses its attention on the first of these two sets of causes.[1] That is, the focus is on how people and businesses respond to price, income and socio-demographic changes within existing urban and regional infrastructures, and how technological advances and policy instruments might reduce fuel consumption within build environments much like those in existence today. The purpose of this present study is to broaden this perspective to consider how policies that change the physical layout of cities might be used to reduce the demand for vehicular travel. Specifically, this paper is devoted to an assessment of trends and policy instruments that can alter the arrangement and density of traffic generating and attracting land use in ways that reduce the demands for private automobile travel. This includes policy instruments that influence the building of transportation infrastructures, notably highways, since these in turn exert considerable influence on the location and utilization of residential, commercial, industrial and recreational forms of traffic supporting land use.

2. Outline of The Paper.

This paper is organized as follows. Section 3 provides a conceptual framework for considering the complex set of forces that combine to shape traffic growth. Section 4 examines the growth in aggregate highway vmt in the United States over the past two decades, and how this trend is projected to continue according to a number of recent vehicle miles of travel forecasts.[2] With this as background, Section 5 examines the potential for reducing vmt through policies that influence the spatial arrangement and use of traffic generating and attracting land uses and the built structures they support. The focus is on policy instruments that might have significant aggregate impacts if they were to be adopted in cities and regions across the United States. This includes various aspects of smart growth management, including the use of growth management boundaries, land use zoning, and land developer incentives and impact fees. Section 6 looks at the potential for influencing vmt more directly, through investments in the nation s transportation infrastructure. Section 7 summarizes the study s findings and puts them in the context of the Moderate and Advanced Clean Energy Future Scenarios discussed in Chapter 6 of the main report.

3. Understanding VMT Growth - A Conceptual Framework.

Past efforts to explain the growth in US highway travel attribute most of it to changes in three factors:

- socio-economic and demographic growth and change within the US population: notably significant growth in the number of drivers and workers, as well as growth in disposable incomes, number of households, and vehicle-ownership.

- changes in the costs of travel: including declining real fuel prices, the use of more efficiently fueled vehicles, and reduced door-to-door travel times - the last of these made possible by the shift to an

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1 Specifically, the National Energy Modeling System s (NEMS) vmt forecasts described in Chapter 6 of the main report are based on population increases and changes in vmt per capita. These latter are assumed to result from anticipated changes in real income and in the per mile price of gasoline, a continued increase in the rates of female driving, and maintenance of high mobility levels among the coming generation of older drivers (EIA, 1997).

2 As described in Chapter 6 of the main report.

automobile dominated traveling population supported by extensive highway construction and associated traffic management programs;

- changes in land use and the associated built environment: notably changes in the types, mix, density and spatial arrangements of land that alter trip distances as well as vehicular trip frequencies. Particular attention is given to the phenomenon of urban sprawl as the dominant form of urban growth over the past half century.

Figure 1 shows how each of these factors enter into a travel demand- transportation supply dynamic. The traffic patterns which manifest themselves result from the interaction of variables across all three factors, making it difficult to forecast with accuracy the effects of any single variable. The rest of this section is used to explore these relationships.

Effects of Population Growth and Socio-Economic Change on VMT Growth. Starting in the bottom left corner of Figure 1, population, income, employment growth and social change act as the principal travel generators, translating demand for access to people, goods and services into vehicle miles of travel. Much of the growth in travel over the past four decades can be tied both geographically and temporally to population, job and income growth and to the growth in private automobile and truck traffic this has

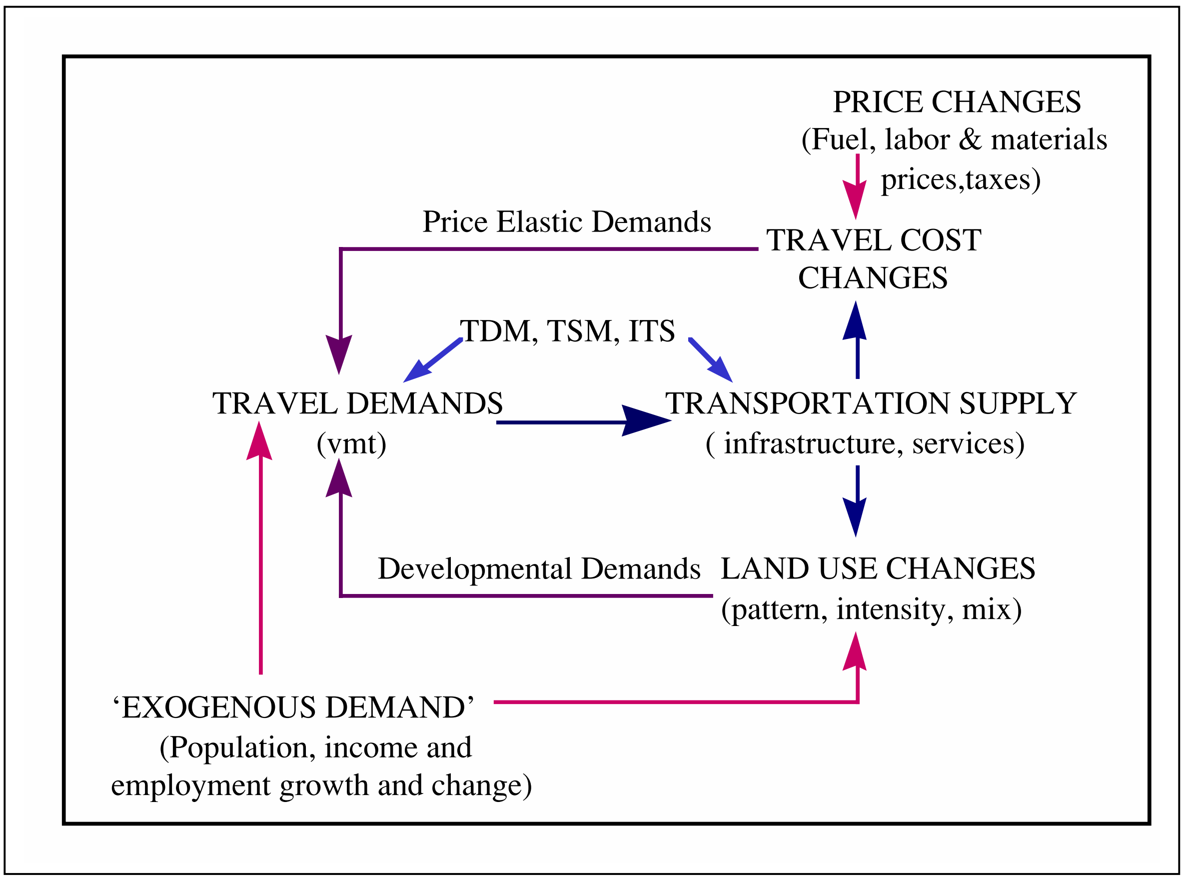

Figure 1. Sources of VMT Growth and Their Interaction.

encouraged (see Greene, 1996; Heanue, 1998; TCRP, 1998). Over 92% of this vmt occurs in passenger cars, motorcycles or four-tire light trucks and vans (FHWA, 1997). The remainder is heavier duty commercial truck traffic whose continued growth has closely mirrored the growth in gross domestic product over this same period (Greene, 1996). These demographic and socio-economic changes also influence the land market and lead to changes in land use that in turn alter the nature of travel demand. In Figure 1 this land use-travel connection is termed developmental demand.

Effects of Land Use Change on VMT Growth. A second cause of vmt growth (or decline) is change in the spatial arrangement, density and mix of urban land use. In general we can expect more highway travel to occur, other things being equal, when different types of land use (e.g. residential and commercial) are more widely separated and each is less densely occupied. In contrast, higher density, mixed use of land has been shown to reduce vehicular travel in many instances, at least within limited geographic areas (see Cervero, 1989; Southworth and Jones, 1996 for some examples and references respectively). This includes land use arrangements that encourage the use of public transit as well as walking and cycling.

Land use also plays a major part in determining traveler behavior through its impacts on trip frequencies as well as trip lengths. The well-publicized flight to the suburbs from the 1950's on allowed many American families to take advantage of lower per unit land and hence lower housing costs. This plus the same response of many business establishments in moving away from traffic congested urban centers has created what planners now term urban sprawl . As US cities have spread outwards the intensity of land development has varied a good deal. Leapfrogging of new residential, commercial and industrial developments has left many pockets of undeveloped or little developed land within most large US cities. The overall result is to create greater distances between what are often single use, segregated and often geographically extensive land developments. A second trait of this rapid geographic expansion of our cities has been the emergence of multi-centered metropolitan areas. Perhaps the need to limit daily commuting, along with other natural benefits of spatial agglomeration, contributed to this phenomenon. As a result, much of the non-CBD employment in our largest metropolitan areas is now concentrated within higher density land areas that range from small suburban activity centers to large, semi-autonomous edge cities (Garreau, 1991; see also Gordon, et al, 1991).

How aggregate vmt evolves over the next two decades will depend in part on whether US cities continue to expand geographically as they have done for the past three decades, or if such expansion is now reaching limits that will, for a number of reasons, encourage more infilling of development within existing urban boundaries. These competing forces are the subject of Section 5 below.

Effects of Travel Cost Changes and Transportation Capacity Increases on VMT Growth. Travel cost changes, shown in the upper right of Figure 1, also alter demands for travel where demand is elastic with respect to price. The per mile financial costs of travel have been either falling or have remained stable for most US travelers over the past thirty years, while expenditures on transportation as a portion of the typical household budget have remained remarkably constant[3]. As a result, it is possible to get more miles of travel out of these expenditures today than it was in previous decades.

Thanks to extensive highway building programs it is also possible to travel farther in the same time. A major factor in the evolution of US cities has been the supply of transportation supporting land use,

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3 Lower fuel costs plus improved vehicle fuel economy have contributed to this. Sl Marie-Lilliu estimate that the fuel costs of driving a kilometer in the US in 1995 were they were in 1973, and nearly 70% below their high in 1981. Kitamura (1988) presents ev personal consumption expenditures on transportation remaining "remarkably stable" over 1953- 1983. Transportation costs averaged 18.2% of expenditures for the average U.S. hc of which 8% were expenditures on vehicle purchases, and the rest were mainly vehicle op expenditures (Davis, 1997, Table 4.2). Zahavi et al (1981), among others, present emp supporting the idea of reasonably narrow household travel expenditure "budgets".

notably the development of an extensive system of high capacity urban and inter-urban highways. This moves us to the center of Figure 1 and the link between travel demand and transportation supply. Here causal relationships tend to be complex. Once demands change significantly governments and businesses, as well as individual households, respond to these changing needs by purchasing new vehicles, introducing new travel services and building new travel supporting infrastructures. This new transportation capacity, notably the extensive network of high volume highways now in place across the United States, has had its own effects on travel, an effect often termed induced demand .

The travel time savings that result from using these new facilities are often the cause of further changes in the spatial and temporal pattern of not only traffic but also land use. Where such highways induce shifts from higher occupancy modes such as bus or rail transit, higher vmt results. Where they cause drivers to take longer but faster trips in order to use the new facility overall vmt may also increase, when looked at regionally (i.e. across all roads and travelers affected). Where they cause trips to be made that were previously considered too onerous or expensive to take, such highways may initiate entirely new tripmaking, some of which may have been a latent demand for travel that was previously suppressed due to high levels of traffic congestion. In all of the above cases an increase in vmt has resulted from a reduction in travel times for at least some portion of the traveling public.

New transportation capacity may also create new vmt indirectly through changes in the types, spatial arrangements and intensities of non-transportation land use it encourages. Highways, transit lines, air, bus, rail and truck terminals, and parking structures collectively occupy a significant percentage of land in every American city. They in turn have served to attract (or in some cases deter) further land development as both residents and businesses seek to gain maximum access to other places for the purposes of doing business, commuting, shopping, visiting people or engaging in recreational activities. Both the direct and indirect effects on vmt from transportation infrastructure supply are the topic of Section 6 below.

Also shown in Figure 1, and acting directly on the travel demand-transportation supply dynamic, are various Travel Demand Management (TDM), Transportation System Management (TSM) and (as yet still limited in scope) Intelligent Transportation Systems (ITS) projects. For the most part these are locally applied traffic advisory, restraint or control instruments that act within a particular transportation infrastructure with the aim of controlling the levels of traffic congestion and associated air pollution within US cities. The widespread adoption of real time traveler information and guidance systems, as part of both US DOT and private sector initiatives to bring ITS technologies into wide-spread use, may offer significant congestion reduction potential once the more advanced technologies reach the market place .[4] Both the 1991 ISTEA and the 1998 TEA-21" federal legislation has given a strong impetus to these traffic management efforts.[5] The aggregate impacts of these initiatives on vmt, however, remain to be seen. In some cases travelers ability to avoid traffic congestion may increase vmt through the use of more circuitous but faster travel routes.

4. Recent Forecasts of Highway VMT Growth.

The past half century of rapid growth in vehicle travel has been accommodated by extensive highway construction programs. The result is that today few locations are considered remote and the levels of inter-place accessibility within all of our major metropolitan areas must be considered high-- as long as a person has a private vehicle at his or her disposal (BTS, 1997). With the high levels of accessibility to places that existed in the 1980’s and 1990’s highway vmt continued to grow rapidly, at an annualized rate of more than 3.2 % per year between 1981 and 1995 (FHWA, 1997).This rate of growth noticeably

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4 These technologies are also considered a part of the Advanced Transportation Scenarios in Chapter 6 of the main report.

5 ISTEA refers to the Intermodal Surface Transportation Efficiency At of December 1991.
TEA-21 refers to the Transportation Equity Act For the Twenty-First Century of July, 1998.

exceeded the annualized percentage increases in population (around 1.0%), jobs, or disposable income over the same period.

Figure 2 shows the historical trend in aggregate annual vehicle miles of travel growth on US highways from 1981-1997. Also shown are a number of recent vmt forecasts of how this annual growth is expected to continue through the years 2010 through 2020. This includes the US DOE s CEF-NEMS baseline forecast described in the Chapter 6 of this report. It also includes two alternative vmt forecasts by the Federal Highway Administration (US DOT, 1997), and a vmt forecast derived for the US Environmental Protection Agency (see Pechan and Associates, 1997).

The MCU and MEI projections shown in Figure 2 are taken from the US DOT s latest biennial surface transportation needs report to the US Congress. The federal government s re-allocation of Highway Trust Fund revenues to States and Metropolitan Planning Organizations (MPOs) makes use of the highway infrastructure needs estimates presented in this report. These needs are in turn based on the MCU projection shown in Figure 2. The US EPA forecast shown in Figure 2 was added for further comparison. It too starts in 1995 and projects forward from the US DOT s historical vmt data series. It uses Bureau of Economic Analysis projections of Metropolitan Statistical Area population growth to disaggregate and adapt vehicle class-specific estimates of nationwide vmt derived by EPA s Mobile 4.1 Fuel Consumption Model (Pechan and Associates, 1997, Chapter II).

Table 1: Alternative VMT Forecasts.

	FHWA		**Forecasts:**		
Total VMT (Thousand Million)	**1995 Base**	**1999**	**2010**	**2015**	**2020**
NEMS Baseline Forecast	---	2,603	3,219 (23.7)*	3,452 (32.6)	3,677 (41.3)
US DOT MCU Forecast	2,423	2,653	3,285 (23.8)	3,572 (34.7)	--
US EPA Mobile Source Forecast	2,423	2,636	3,273 (24.2)	--	--

* Numbers in brackets are the percentage VMT increases based on each model s 1999 baseline

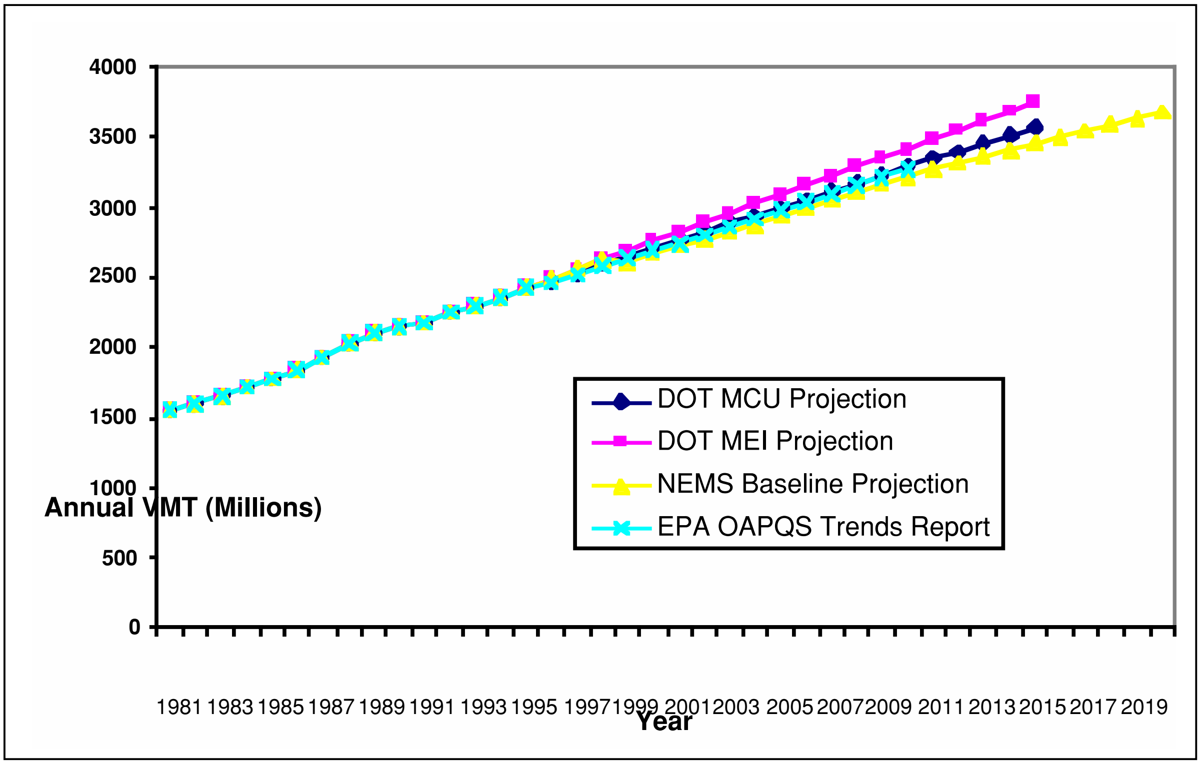
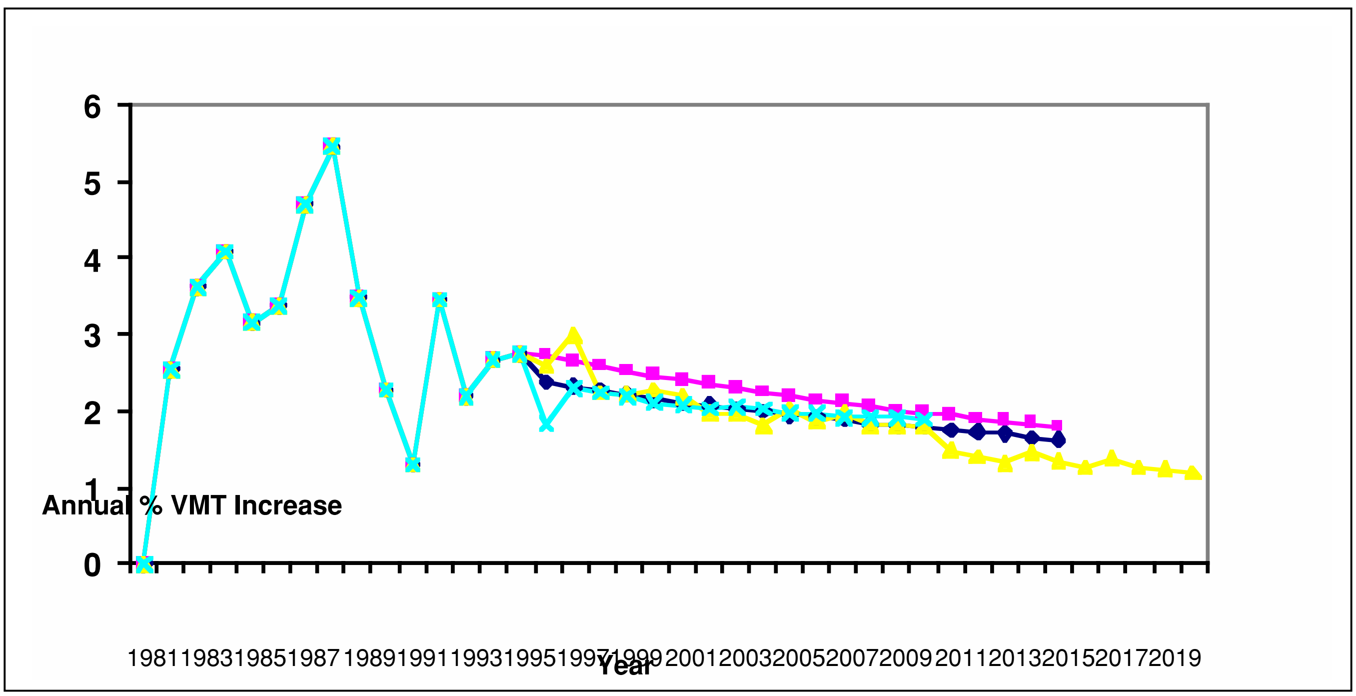

4000
3500
3000
2500
2000
1500
1000
500
0
Annual VMT (Millions)
DOT MCU Projection
DOT MEI Projection
NEMS Baseline Projection
EPA OAPQS Trends Report
1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015 2017 2019
Year

Figure 2. Annual VMT Estimates 1981-1997 and Four VMT Forecasts.



Up to the 2010 time frame these forecasts are very similar. As displayed in the bottom graph in Figure 2, the CEF-NEMS forecast has an average annualized vmt increase of 1.95%. This compares with similar statistics of 1.96% for the US DOT s preferred MCU forecast, and 1.99% for the example EPA-OAPQS forecast shown, taking 1999 as the base year in each case. After 2010, however, the US DOT and CEF-NEMS forecasts diverge significantly (the EPA forecast stops at 2010). Again taking 1999 as the base year, the CEF-NEMS baseline forecast implies an annualized vmt growth rate of 1.78%, versus a rate of 1.88% implied by the DOT s MCU projection. Further slowing down in the annual rate of vmt growth is then projected from the CEF-NEMS baseline forecast, producing a 1999 - 2020 annualized vmt growth rate of 1.66%. Extrapolation of either the DOT or EPA forecasts to 2020 would yield significantly higher vmt estimates. By comparison, differences between the NEMS Baseline, Moderate and Advanced vmt scenarios are quite small. Table 1 shows the absolute vmt differences implied by the forecasts shown in Figure 2, differences that suggest caution in accepting any single model s forecasts of vmt reductions, included those produced by the existing NEMS scenarios.

Both the US DOT and CEF-NEMS forecasts contain the notion of a diminishing annual rate of increase in traffic as we move into the second decade of the twenty-first century, if at different rates of change. This is based on the assumption that a good deal of the vmt growth over the past thirty years has been fuelled by a few clearly identifiable social and demographic trends that are likely to have less effect a decade or so from now. Specifically, we can expect a slowing down in a) the increased rate with which women are catching up in their driving habits with men (almost completed by 2010 according to the CEF-NEMS forecast); b) a leveling off in the trend towards smaller households, with its implications for lower vehicle occupancy rates and reduced joint travel opportunities; c) a near saturation point in vehicle ownership, with an average of more than one vehicle per licensed driver already reached, and d) the gradual aging of the baby-boomer generation and with it a slowing down in the amount of trip-making due to a noticeably older population profile than any before in the nation s history.

A potential fifth source of vmt increase or decrease is the widespread adoption of tele-commuting, tele-shopping and other ways of substituting information systems for personal travel. (see Chapter 6 of the main report). Currently, there is no strong evidence to support significant vmt reductions, while a counter-argument may also be made that more information has the potential to generate more travel. Rising real incomes as well as a growing familiarity and satisfaction with high levels of personal and household mobility are other potentially counterbalancing forces, as is the continued low cost of operating an automobile. Nor is it certain that the next generation of older (but healthier) Americans will cut down on driving to the degree that the current older generation of drivers has done.

All of the above trends and counter-trends are operating within a gradually evolving built environment in which land use arrangements and built structures tend to remain in place for many years at a time. How such trends, as well as current attitudes toward travel, might change under different forms of land use or under different future highway building programs is much less clear. Section 5 and 6 below explore the possibilities.

5. Impacts of Land Use and Urban Structural Change on VMT.

VMT and Metropolitan Growth - The Debate Over Urban Sprawl. Clear empirical evidence exists for the rapid geographic expansion of the majority of the more populous US cities over the course of the past half century. In the recent review *The Costs of Sprawl - Revisited* (Burchwell, et al, 1998) the authors identify increased vmt as one of the major negatives associated with this type of sprawling urban development. Specifically, they conclude that a strong link exists between increased vmt and the following five elements (out of a list of ten) which they associate with the notion of sprawl:

- low density development
- spatially segregated land uses

- leapfrog development
- transport dominance of the motor vehicle
- widespread commercial strip development

Much of the low density development their literature review refers to is residential in nature, reflecting the American family s post-World War II flight to the suburbs, while spatially segregated land uses have resulted from the imposition of locally developed land use zoning practices. Leapfrog development refers to the practice of developing residential, commercial or industrial properties on sites that are initially at some distance from the rest of the urbanized area. With connections between these increasingly widespread parcels of developed land necessitating the construction of intervening highway miles the automobile has become the only economical form of travel between many places within a metropolitan area. Finally, the emergence of the American commercial strip development is a natural business response to providing rapid access to auto-driving customers moving along lengthy radial highways.

An important observation from this same study is that sprawling development has been very much the norm in the USA over the second half of this century: with about one fifth of the nation s more than three thousand counties experiencing significant levels of low density and leapfrog forms of development. That is, sprawling cities are not unusual. They have been actively embraced by the American public.

Much less clear is what if anything to do about such growth. Will the phenomenon termed urban sprawl begin to slow down over coming decades as more efficient (and not just transportation-efficient) forms of urban development become necessary? A valid question is how long will this sort of urban development be able to continue. The substantial and growing costs of supplying current development practices with additional transportation capacity is now a problem for fiscally strapped local and regional governments. A solution that has been debated extensively, in both the public forum and the planning literature, is the adoption of smart growth policies. For the most part these policies advocate more transportation efficient urban land utilization practices. From the perspective of vmt reduction the basic logic for this is straight-forward. The more spatially compact and more varied the uses to which land is put within a given area, the shorter the travel distances involved and also the greater the opportunities to substitute walking, cycling or bus and rail transit for low occupancy automobile travel.

Obtaining both sustainable and socially viable vmt reductions is far from straight forward, however. An extensive review by Southworth and Jones (1996) found the potential for a wide range of land use policy impacts on vmt but little solid, quantitative evidence as to their eventual and aggregate outcomes. A major difficulty for generating forecasts is the comparatively poor state of empirical data on the topic. These authors did conclude that past empirical, theoretical and simulation studies suggest a considerable influence of urban spatial structure on travel, with as much as half of the variability in aggregate vmt ascribed to structural variables such as land use intensity, spatial pattern and mix when tripmaking is looked at across different urban systems. However, a much more conservative set of findings was common among the limited number of studies that lend themselves to forecasting the impacts on vmt of specific land use-based policies. These studies suggest that even significant policy induced changes in urban spatial structure will bring about vmt reductions of only a few percentage points. The principal reason for this appears to be the following. While there is considerable inertia in existing urban infrastructures, there is considerable flexibility, thanks to the automobile, in the ways people can move between structures. The costs of changing current built environments is high. The apparent or perceived costs of adapting travel requirements to them much less so. These latter costs are also more easily distributed across a large number of actual and potential travelers.

An important caveat to this latter conclusion, however, is that past US studies have based their analyses on historical data. They are therefore reflecting aggregate travel trends from an era of localized, highly fragmented control, or lack of it, of urban land use - controls that vary a good deal across as well as within different metropolitan regions. Those analysts more optimistic about the potential to change the way we travel sometimes point to comparisons between US cities and their foreign counterparts, with the latter evolving under very different forms of land use control (for example, Newman and Kenworthy, 1989). These comparisons tend to show much greater variability in the relationships between land use intensity and travel. However, these differences have typically come about as the result of decades of development under different planning rules and regulations. While one type of city may appear more travel efficient than another, transforming an already highly evolved city into a more travel efficient one is a challenge whose costs (for transportation, housing, and other public services) have yet to be evaluated in any comprehensive manner.

There are reasons, however, to expect the increasingly public debate over urban sprawl to continue, and to bear some fruit. First, there is a growing belief, and some supportive empirical evidence that low-density land intensive developments are more expensive to maintain: not only with the necessary local, collector and arterial streets but also with sewer, power, and other traditional municipal services. Second, there are a number of additional sources of anti-sprawl activism. Most notable are a variety of quality of life concerns, and principally concerns over the following:

- rapid consumption of prime farmlands,
- the loss of wetlands and other natural environments,
- the growing levels of automobile and truck traffic congestion and associated air pollution,
- the effects of high volume highways on neighborhood cohesion, aesthetics and safety, and
- the search for resource sustainable communities .[6]

As Meck (1999) points out, Americans views of land use have evolved over the course of the present century from one of land as a commodity simply to be bought and sold, to one of land as also a resource that requires management. This includes the management of both urban and rural land and how the former impacts the latter.

Influence of Local Land Use Controls. The major tool for controlling or directing land development in the United States is zoning, nearly all of which occurs at the local level. Most of the zoning regulations passed today are for the purpose of either encouraging certain forms of land development that bring with them increased economic activity (fiscal zoning), or for discouraging land uses that may lower this level of activity in the future, or that reduce the desirability of communities as places to live (exclusionary zoning).

A second instrument some local governments use to control land use is the development impact fee. Such fees shift some of the burden of financing new infrastructure from the community at large to individual landowners or land developers who, in return for paying the fee, are assured of adequate provision of facilities and services (sever, water, etc.) by the local government. How and how much such fees can be used to contribute towards more compact, mixed-use land development depends on specific circumstances. For example, a local authority might offer credits against such development fees in return for an agreement to develop mixed use residential and commercial properties on a site. Similarly, the need to help finance major sewer or water trunk-lines to connect new development areas to the rest of the city may encourage would-be developers to adopt sites already within easy (i.e. less costly) reach of existing trunk lines.

More flexibility in zoning and financial incentive practices are required in order to encourage more compact, higher density and mixed land use arrangements. These include the ability of local governments to offer financial or permit-based incentives for land developers to increase floorspace-to-footprint ratios,

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6 [6] A recent survey of the Internet by the author revealed a number of sites devoted to such issues, with data on a growing number of local, regional and statewide urban growth initiatives. See, for example, the sites listed under http://darkwing.uoregon.edu/~rgp/GrowthMgmt/Links.htm; http://www.sustainable.doe.gov/transprt/ trintro.htm; http://www.ficus.usf.edu/; and http://www.plannersweb.com/sprawl/ sprawl7.html; and http://www.plannersweb.com/ sprawl/sprawl6.html#tn.

or to negotiate zoning re-classifications across different land parcels if the net effect will reduce overall vmt (see Cervero, 1989, for examples).

The net effects on travel from specific zoning regulations, development impact fees can be difficult to anticipate. There is a growing body of evidence to support the conclusion that land use controls which encourage higher density, mixed-use of land development can lower within-community vmt. Similarly, the mixing of retail activities into commercial centers can also encourage less vehicle travel under the right circumstances. Such land use controls may also benefit when coordinated with local street designs that support more transit, pedestrian and bicycle friendly neighborhoods. An US EPA supported study by Apogee/Hagler Bailly (1998) provides the most recent review of this literature, which contains a number of studies completed over the past decade. These include studies under the headings of Transit-Oriented Development, Neotraditional Development and Traditional Neighborhood Development.

The potential for vmt reductions from synergistic combinations of urban design, land use zoning, financial incentives plus transportation demand management practices does appear to exist. While the ability to quantify such effects, including their sustainability and implementation costs, is not yet to the point where a high degree of confidence can be placed on reasonably generic policy packages[7].further efforts in this direction are certainly warranted. The fully realized travel reduction benefits of some of these new land use arrangements are likely to require a number of years, and application within a significant number of communities, to manifest themselves. Their success will depend to a large extent on the way they influence households attitudes towards travel.

Since a good deal of today s travel occurs across as well as within local government boundaries, lack of coordination between local land use plans within the same metropolitan area can also produce unexpected results. For example, a new office development, even if it offers a high density replacement for commercial activity within an existing urban center, may induce additional vmt depending on the distance to the surrounding jurisdictions from which it subsequently draws its employees (which in turn often depends on recent commercial and residential developments in those locations also). Nor does an improved jobs-to-housing balance within a particular jurisdiction necessarily reduce regionwide commuting vmt. Recent empirical studies (Giuliano and Small 1993; Peng, 1997) indicate that even the elimination of barriers such as exclusionary and fiscally-motivated residential zoning practices and not-in-my-backyard attitudes to affordable housing developments seem unlikely to induce significant aggregate vmt savings. Other, non-regulated barriers to sustainable job-housing balancing policies may also be significant. These include the high residential as well as employment site mobility of labor in today s cities, the significant number of two-or-more worker households complicating the residential siting decision, and the fact that commuting is only one quarter of all weekly household travel. As a result, commuting time is only one among a number of similarly important factors affecting a family s choice of an amenity-accessible residence or workplace.

Looked at from a regional (i.e. metropolitan areawide) perspective, the concentration of employment within a finite number of higher density suburban activity centers appears more likely to offer a sustainable vmt reduction policy than does an effort to create a more residentially balanced workforce (for some preliminary evidence supporting this idea, see Miller and Ibrahim, 1998). However, just how many, how large and how far apart these urban activity sub-centers ought to be in order to minimize vmt (and also limit congestion, provide multi-purpose access, control housing and public service costs) remains a research issue (see Southworth and Jones 1996, Chapter 4 for some early studies).

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7 From a purely technical perspective, correlations between land use indices and between these indices and the socio-economic attributes of travelers (such as income and vehicle ownership) complicate quantitative analyses of the effects of policies on mode choice, trip lengths and frequencies (Southworth and Jones, 1996; Apogee/Hagler Bailly, 1998).

In summary, zoning and development impact fee-based policies that might have a substantial influence on lowering regionwide vmt would seem to require inter-jurisdictional study and inter-governmental cooperation. To obtain such cooperation seems to require a more pro-active role by state and regional governments.

Developments in Statewide Land Use Planning. As a recent Government Accounting Office study points out, while States have inherent powers to regulate land use, these powers have traditionally been delegated to local jurisdictions (GAO, 1999). However, fueled by growing concerns over both the environmental and economic impacts of local land use practices, the past decade has seen s number of State Departments begin to pay greater attention to land use issues.

A recent review by Beimborn et al (1999) describes how a number of states have now begun to incorporate land use into their statewide transportation planning activities. This involvement is shown to cover a series of increasingly more active and influential forms of participation, from the development of environmental impact statements associated with specific land development projects and National Environmental Protection Act (NEPA) compliance, to the active involvement of State Departments in land use control. Among the most influential forms of involvement, and those capable of having significant impacts on vmt, are various approaches to urban growth management.[8] These include concepts of sustainable or smart growth. Approaches to implementation range from financial incentives for local communities to grow in more compact ways, to the mandatory development of local urban growth plans.

In all cases, these efforts by States to impact land development are based on finding indirect ways to compensate for their lack of direct controls over local land use policies.[9] Leading examples of such efforts include the Maryland Smart Growth initiative, which uses the prioritization of project specific funding as a lever to encourage more compact urban development at or near locations with existing infrastructure. The state also directs some tax revenue towards the purchase of properties, property rights or selected easements in rural areas threatened by urban sprawl, as well as operating a grant program that subsidizes home buyers who agree to live near their work locations.

In the states of Florida, Oregon, New Jersey and Tennessee various urban growth management programs are also in place, each intended to support transportation efficient land use strategies.
Florida s growth management program is based around the notion of establishing concurrency as a necessary component of local transportation and land use planning. Under this approach any new land development must wait until the public services needed to support it can be supplied concurrently with the impacts of the development. This in theory limits new developments from being built if a local government cannot do so and still maintain its current levels of service to existing developments[10]. Florida law also requires careful review of the impacts of developments that may have a substantial effect on the health, safety or welfare of citizens in more than one county.

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8 At the 1999 Conference on Growth Policy held in Nashville, Tennessee (Bringing The Pieces Together Conference, June 22) as many as 30 State governments were said to be looking at alternative urban growth policies. For many examples of recent local and regional efforts within various States see US EPA s Smart Growth Network website at http:/www.smartgrowth.org

9 Only the state of Hawaii has a role in direct control of local land use (GAO, 1999).

10 Facilities and services include roads, sanitary sewers, solid waste, drainage, potable water, parks, recreation, and mass transit, with school concurrency an option. If the infrastructure is not available, a local government cannot approve new development.. Each community determines the need for public services and facilities to serve existing population and future growth, at an established and adequate level of service for at least 10 years (see FICUS website at http://www.ficus.usf.edu/query/default.htm).
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Oregon s Transportation and Growth Management program, initiated in 1993, provides grants to cities, counties and MPO s to develop and update local transportation plans which implement urban growth management strategies. The program also provides consultation teams to help local communities develop transit, bicycle and pedestrian supportive land use arrangements. Efforts to increase transit ridership within the state include a focus on transit supportive land use arrangements (see Cervero, 1993, for a summary of other US experience).

The most recent statewide growth management initiative is the Tennessee Growth Boundary Policy Act of July 1998.[11] This legislation requires every county in the state to develop and adopt a comprehensive land use plan by July 2001. Where possible, such plans should re-use already developed land, revitalize urban centers, and encourage more mixed-use developments. Each Urban Growth Boundary should demarcate a reasonably compact region capable of accommodating 20 years worth of residential, commercial and industrial growth, while considering the effects of such boundaries on surrounding agricultural land and other jurisdictions. Ideally, such legislation will encourage the joint consideration of growth by adjacent communities, in place of previous unilateral and uncoordinated annexations of land from one jurisdiction to another.

Impacts of Federal Policies on Land Use. While the federal government has no direct role in local or regional land use decisions, except under special circumstances, it too can affect the pattern of urban development through indirect means. A recent GAO report on the federal government s influence on urban sprawl (GAO, 1999) found no empirical evidence to support significant positive or negative effects as a result of its various spending, taxation and regulation programs.[12] However, it also concluded that current empirical evidence on the subject was quite limited.

One area where federal taxation policy might in theory influence urban form is housing related taxation. While claims have been made that past policies encouraging single family ownership have contributed to suburban sprawl, Southworth and Jones (1996) concluded that the effects of home mortgage deductions on current urban mobility patterns are unknown, as are the effects of federally supported personal and corporate income taxes. GAO (1999) came to similar conclusions pertaining to the deductibility of mortgage interest payments and property taxes, as well as the exemption from taxation on capital gains for owner-occupied homes, under the Taxpayer Relief Act of 1997 (HR 2014/PL 105-34). While even uniformly applied housing taxes are known to have differential spatial impacts no-one has yet found a way to use such tax instruments to encourage travel efficient urban development. An alternative approach currently being experimented with in Chicago is the provision of Location Efficient Mortgages . These mortgages are used to make housing more affordable in areas that favor transit or other forms of energy efficient and environmentally cleaner travel, based on the premise that the resident of such housing can save significant money annually through reduced vehicle ownership costs (and hence become a lower investment risk). [13]

Two possible areas where at least marginal changes in vmt might come about through federal land impacting programs are the US Department of Agriculture s (USDA) Farmland Protection Program, and the federal support for Brownfield developments. This USDA program offers tax exclusions that make it no longer necessary for family-owned farms to sell off productive land to pay estate taxes. Similarly, the

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11 Details of this bill can be found at http:// www.legislature.state.tn.us/bills/100gahtm/ 100_BILL/SB3278.HTM

12 other than the impact of the considerable federal monies used to maintain and extend the nation s transportation infrastructure discussed in Section 6 below.

13 The LEM results from research funded by the U.S. DOE, US EPA and the Federal Transit Administration as well as several private foundations. The market test of the LEM is sponsored by Fannie Mae, the nation s largest supplier of homeownership capital. For more information see the following web site: http://www.locationefficiency.com/lem-text.html

exclusion from taxation of land subject to conservation easements (i.e. land whose owners have agreed to place restrictions on its use) may help to preserve at least small amounts of prime or unique farmland from future urban development (GAO, 1999).

Brownfields are defined by the US EPA as abandoned, idled, or under-used industrial and commercial facilities where expansion or redevelopment is complicated by real or
perceived environmental contamination. They offer an opportunity to alter future urban development by re-vitalizing older industrial and commercial sites in central cities, leading to more compact and perhaps mixed use urban development. Under the Brownfields Tax Incentive offered as part of the federal government s Taxpayer Relief Act of 1997 environmental cleanup costs for properties in targeted brownfield areas are fully deductible in the year in which they are incurred -- rather than having to be capitalized over a period of years. The idea is to encourage land purchases geared to rapid clean-up and re-development. This $1.5 billion incentive program is expected to leverage $6.0 billion in private investment and return an estimated 14,000 brownfield sites to productive use.[14] However, to have noticeable and sustained impacts on vmt, it seems likely that such developments will also need to be supported by capital investments in better schools, retail services, and other neighborhood facilities. Otherwise, suburban families are unlikely to re-locate back to these older and more central locations (Dunphy and Fisher, 1996). One possibility here is to bolster such efforts by locating federal government facilities in these older neighborhoods in an effort to create the critical mass of employment needed to rejuvenate more compact and mixed use urban activity centers.

Currently, the costs of planned inner city renewal versus the costs of allowing the urban land market to initiate its own brand of urban infrastructure replacement and in-filling remains unquantified. The same comment applies to planned urban area/urban boundary expansions. One difficulty is the length of time required to make such comparisons. It can be many years before the infilling of previously undeveloped land occurs. In some cases higher development densities and lower regionwide vmt might result. Our current lack of quantitative information makes it difficult to either prescribe policies or to forecast aggregate travel effects on the basis of alternative and politically viable land use control policies.

6. Added Transportation Capacity Effects on VMT.

A key component of urban structural change is the location and capacity of transportation infrastructure itself. Highways, transit lines, parking structures and transfer terminals make up the majority of this infrastructure, and they collectively account for a significant percentage of the land occupied by our cities. Of particular interest because of their direct impacts on private vehicle use are investments in highways and parking lots. The principal policy instruments here are funding for, and permitting of, site specific construction. The principal issue is usually whether to build or not.

Effects of Added Highway Capacity On VMT. With the generally high levels of place accessibility now established in US cities the benefits of adding new highway capacity are increasingly being challenged. At issue is whether new road building, notably when applied to major highways, alleviates traffic congestion and air pollution, or whether it induces even more travel and with it more fuel consumption and mobile source emissions over the long run. This has led to a number of recent studies seeking to shed light on the empirical relationship between road building and traffic growth. Vmt in these studies is estimated as a function of the number of highway lane miles added to the system and the elasticity of highway travel demand is estimated with respect to travel costs, most notably travel times.

Of these studies only two were found that offer empirical evidence for such travel cost elasticities at the fully national scale *and* also provide statistical relationships between vmt and additional highway capacity. The first study to derive such a statistical relationship was carried out at Oak Ridge National Laboratory in the early 1990's, using cross-sectional and time series data from the 1980's (Miaou et al,

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14 See the US EPA brownfields website at http://www.epa.gov/brownfields/

1990; Rathi et al, 1991). As part of a study for the Federal Highway Administration to estimate suburban highway needs to the year 2005, a vmt forecasting model was developed from which statistically significant relationships were obtained between daily vmt per capita and the supply of primary highway lane miles within US urbanized areas.

Specifically, cross-sectional and annual time-series data on both vmt and lane-mileage additions was drawn from sampled highway sections reported in the FHWA s Highway Performance Monitoring System (FHWA, 1999) between 1982 and 1988. The study divided cities into large, medium and small sized urbanized areas and combined this HPMS data with socio-economic data on 339 of the largest US cities. This data was used to fit a series of regression models relating daily vmt per capita to a number of explanatory variables[15] including a measure of primary highway supply deficiency for medium and large urbanized areas (areas with over 0.1 and 0.5 million populations, respectively).[16] The results indicated a significant latent demand for travel below a supply level of 2.15 lane-miles of primary highway per 1000 population on the order of 13% (in this case added to an estimated annual growth rate of 2.36 % for the period 1985 to 2005).

The implication of this result is that high levels of congestion in our largest urbanized areas, notably those with over half a million population, are already suppressing additional vmt. Greene et al (1994, pages 90-91) subsequently showed how these findings are equated with a travel demand elasticity with respect to travel time of approximately -0.5 in conditions where significant traffic congestion exists.

A more recent study by Noland (1999) provides a second set of statistically significant results relating vmt growth to the provision of lane-miles of high functional class highways. Using data from the FHWA s Highway Statistics series for each of the 50 States between 1984 and 1990 Noland fitted a number of cross-sectional time series regression models to estimate the aggregate annual non-local[17] vmt per State as a function of the State s highway lane-miles[18]. Separate models for interstates, arterials and collectors and for urban versus rural roads were generated using a range of econometric modeling techniques. The results again support the finding that more travel is correlated with more highway capacity, with elasticities varying a good deal across model formulations but falling for the most part in the range 0.2 to 0.5 for short run and 0.7 to 1.0 for long run effects. Both urban and rural roads were found to have similar long run elasticities, suggesting that capacity increases are triggering fundamental land use changes that increase vmt in both types of area.[19]

Applying these results to his vmt forecasting model Noland found that 28 % of total primary highway vmt growth could be attributed to growth in highway system capacity, almost all of this induced vmt finding its way onto the system within five years. That is, major highways not only facilitate travel, they often encourage it. Noland equates this extra travel to roughly 43 million metric tons of annual carbon

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15 Specifically, the natural log of daily vmt per capita was estimated as a function of the natural logs of real income per capita, employment and number of driving licenses per 1000 persons, a yearly time index, and a primary highway supply deficiency measured in lane-miles per 1000 persons.

16 This supply deficiency measure was obtained by identifying a reference supply level defined as the number of lane-miles of primary highways (=freeways and expressways plus other principal arterials) below which vmt would start to show signs of restraint due to lack of access to highway facilities.

17 traffic on local roads is left out of the analysis.

18 plus State population, State per capita income, and average cost of gasoline in each State per million BTU.

19 Elasticities are positive here since we are comparing added vmt to added lane-miles, the latter assumed to be a surrogate for reduced travel costs. Noland found that collector roads have the largest long run elasticities, sometimes exceeding 1.0, and that while urban roads tend to have higher short run elasticities, in the long run both urban and rural road elasticities tend to be similar

emissions in the year 2012.[20] roughly equivalent to a policy of increasing light duty vehicle fleet efficiency (for gasoline) by about 2.5% annually between 1999 and 2012: to over 47 miles per gallon.

While neither of these two studies strictly prove a causal relationship between vmt and added highway lane miles, both provide strong indications that induced demand effects are real and need to be considered when looking for ways to evolve more travel efficient, and congestion-mitigating forms of urban land development. In this same vein the US DOT s most recent needs-based vmt projections (US DOT, 1997; recall Figure 2) have for the first time explicitly recognized that travel demand is elastic with respect transportation costs and that significant levels of induced vmt may result under different infrastructure investment scenarios.

US DOT (1997) generated two different vmt forecasts, termed respectively the Maintain User Costs (MCU) Scenario and the Maximum Economic Investment (MEI) Scenario.[21] Under the MCU scenario investments in highway infrastructure, including new capacity as well as operation and maintenance, are assumed to maintain their 1995 base year levels of service. Since user costs (notably travel times) remain generally constant, this scenario contains no appreciable level of additional induced travel demand. This in turn implies that new traffic in this scenario results from natural growth in the population, its income, and business needs, and any changes in activity location. Under the MEI scenario highway capacity is increased to the point at which the DOT s benefit-cost analysis[22] estimates further investment to be uneconomic (i.e. the benefits-to-costs ratio is less than 1.0). The additional lane miles of highway supplied in this case are assumed to reduce traffic congestion, making travel less costly. This reduced cost in turn is assumed to induce more travel. Based on a literature review, a demand elasticity with respect to travel cost of -0.8 is assumed over the short term (up to 5 years): with a higher long term (5 to 20 years) demand elasticity of -1.0. These elasticities result in an estimated annual vmt growth rate, including induced demand effects, of 2.25% (versus 1.96% for the MCU Scenario) through year 2015.

The US DOT report notes that the investments in highways implied by the MEI scenario far exceed any previous levels of government expenditures in this area (US DOT 1997, page 57) The MEI is therefore an unrealistic build scenario that places an upper bound on public highway investments. Using a lower short range travel cost elasticity parameter would be one way to reduce such estimates. Here there is a large body of empirical evidence to draw on in addition to the above referenced studies (Goodwin, 1992; Watters and Yong, 1992; Dargay, 1993: Cohen, 1995; Cohen and Gorina, 1998). Most results from this literature fall within the range of -0.2 to -1.0, and conclude that long run elasticities (roughly, periods over 5 years) are higher than short run elasticities. This is to be expected given the wider range of options for adjusting one s travel activities over time (e.g. changes in vehicle ownership, residence, destinations visited).

Geography as well as time frame is also important in considering such induced travel effects. Empirical analysis on a sample of highway sections in California by Hansen and Huang (1997) and Hansen (1998) also suggests that longer run (up to 10 years after) travel cost elasticities are likely to be higher when assessed at the county or metropolitan area level (in the range -0.6 to -0.9) than at the individual road segment level (range of -0.3 to -0.4). This in turn suggests that a good deal of the traffic that is induced by added highway capacity occurs away from the location of the infrastructure expansion itself. Using

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20 assuming no changes in levels of congestion and traffic flow dynamics that may also affect emissions.

21 Forecasts are based initially on an analysis of Highway Performance Monitoring System data submitted to FHWA by each State DOT (FHWA, 1999) These projections are subsequently modified (reduced) to match the travel growth projections developed by each of the individual MPOs, based on MPO proposals to shape demand for travel in their areas to attain air quality and other development goals through such actions as transit expansion, congestion pricing, parking constraints, capacity limits, and other local policy options - DOT 1997, page 60.

22 Using the Highway Economic Requirements System (HERS) software see US DOT 1997, page 58 et seq.

data on the growth in vmt in Milwaukee, Wisconsin from 1963 to 1991, and applying the travel cost elasticity from this recent literature, Heanue (1998) found the effect of reduced travel times caused by regionwide highway network improvements to be responsible for 6% to 22% of traffic growth, the upper end of this range approaching that implied by Noland s (1999) study described above.

Expectations From Future Highway Building Programs. Short of what would be very unpopular political decisions to limit highway building programs, it seems likely that the fundamental relationships between highway supply and passenger travel demands reflected in the above studies will continue throughout at least the first half of the Clean Energy Futures forecasting period (i.e. to around 2010). However, a question that remains to be answered is how much new highway infrastructure is going to be built over the next twenty years? Some empirical light is shed on this question by Greene et al (1994). These authors used a regionwide traffic congestion index developed by Schrank et al (1993) to estimate a relationship between the annual freeway and arterial lane-mileage needs of 50 urban areas and the lane-miles actually added between 1987 and 1990. By holding the levels of congestion constant (a somewhat similar approach to that taken in the US DOT s MCU scenario described above) their results indicate an elasticity for combined freeway and arterial expansions of about 0.81. That is (Greene et al, 1994, page 84):

$$M = m^{0.81} \quad (1)$$

where m = lane-miles needed and M= lane-miles actually added. This annually based measure implies that for an average annual need of 100 extra lane-miles of higher order highway required to maintain current levels of congestion we might expect 41.7 to be built, producing 417 miles of new capacity over ten years. This equation also indicates that as lane-mileage needs grow fewer of them are actually supplied. At some point the costs of trying to supply such needs for new capacity will become difficult for local and regional governments to sustain, leading to increased levels of traffic congestion within the nation s largest cities. Under the above described Maintain User Costs (MCU) scenario the US DOT estimates that the combined cost of highway system preservation[23] and expansion to meet future traffic growth will grow from $43.1 billion annually in 1996 to $49.4 billion dollars annually by 2015 (in constant 1995 dollars). Of these costs $29.1 billion, or 67.5% of the total, is required annually to preserve the existing system of highways and bridges. The remaining costs, totaling $14 billion in 1996 rising to $20.3 billion in 2015, are associated with capacity expansion[24], some $10 billion a year of which were ascribed to metropolitan expansion (US DOT, 1997, page 63) [25] . In constant dollar terms total highway expenditures have failed to keep pace with vmt growth. In 1987 cents per vmt these expenditures dropped 28.1% between 1975 and 1995, from 4.1 cents to 3.0 cents (US DOT, 1997, pages 44-45).

With such figures in mind it seems inevitable that most of our larger urbanized areas will soon face a difficult financial challenge in trying to maintain so many miles of already built highways. Most of these highways have an expected pavement life of around twenty years before major rehabilitation is required. As a consequence, a continued and rapid areal expansion of many of the nation s urbanized areas is likely to become problematic as expanding urban area boundaries put pressure on peripheral communities to connect themselves to the rest of their metropolitan region. Put simply, as urban areas expand geographically the average distance between intra-urban communities increases. Therefore, maintenance of the same level of intra-urban highway network density becomes increasingly difficult to support. Just

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23 System preservation costs consist of the investments in resurfacing, rehabilitation and some reconstruction required to preserve and maintain existing highway pavement and bridge infrastructure.

24 Capacity expansion in this case involves adding highway lanes or adding new roads to address capacity deficiencies. Adding roads to encourage economic development was not included in the totals.

25 Definitions of system preservation and capacity expansion and what constitutes a scenario differ somewhat over this period, but the basic point about system preservation requiring a larger percentage of total future costs is valid.

how, and how fast, growing levels of traffic congestion will induce compensating land development patterns is likely to be a key factor in future urban systems evolution.

Regional Intelligent Transportation System Architectures. Both of the above US DOT needs-based vmt scenarios in theory anticipate the effects of MPO-planned Intelligent Transportation System (ITS) and other Transportation System Management (TSM) developments: but only in the sense that they are used to decrease the highway lane mileage needs projections resulting in a 6.5% and 4.5% decrease in the total investment requirements reported for the MCU and MEI scenarios respectively (US DOT, 1997, page 63). That is, they are assumed to offset some future highway infrastructure supply costs by substituting more efficient operations for extra lane capacity, via such strategies as freeway surveillance, high-occupancy vehicle lanes, ramp metering and signalization control. Their effects on aggregate vmt are implicitly assumed to be limited (in either direction). However, the net effects on travel of ITS technology remain to be seen. These systems require both an extensive capital investment by government and the private sector, notably in computers, telecommunications, and in other components of what are likely to become highly coordinated regionwide traffic surveillance and control architectures.[26] At the same time they will provide easily adjusted operational control and surveillance of local traffic movements through such technologies as intelligent freeway ramp metering and arterial signal coordination. Within a 2020 time frame more advanced vehicle guidance and control technologies may also begin to enter the marketplace. If more efficient management of road space leads to greater system capacity it too might have the effect that added lane-miles have on induced demand. However, how both transportation suppliers and travelers will respond to these more advanced technologies is currently an issue for speculation.

Transit Capacity Expansion and Ridership Growth. There seems to be only limited potential for bus and rail transit to erode aggregate nationwide vmt by the year 2010, and perhaps also by the year 2020. While transit serves a very useful and often very necessary role in certain niche travel markets its popularity remains limited when compared to automobile travel. In 1995 bus transit accounted for less than 0.3% of all highway miles driven in the US. In terms of ridership this is a little under half of all transit passenger miles, the remainder is mainly ridership on rail rapid transit systems (US DOT, 1997). Over the past decade the occupancy of autos has also been declining, with driving alone being the choice of almost three quarters of all US commuters in the 1990's (TCRP, 1998). Between 1985 and 1995 rail transit capacity increased at 2.1% per year (annualized), while non-rail capacity increased at 1.2% over the same period (FHWA, 1997). However, while rail transit patronage increased at 1.3% per year over this same period, bus transit patronage fell by 1.1% per year. It should also be noted that most of this transit ridership is concentrated in a small number of the largest US cities, with one third of all transit trips occurring in New York City alone (TCRP, 1998).

A recent study for the Federal Transit Administration found that transit fare reductions alone may not be the answer to increased ridership (TCRP, 1998). More promising are increased service levels (e.g. shorter headways between successive vehicles) as well as policies that encourage higher parking prices as a deterrent to private auto use (see below). The US DOT s 1997 Biennial Conditions and Performance report estimated the need to spend $9.7 billion nationwide between 1996 and 2016 (in 1995 dollars) to maintain the nation s current transit systems, $1.2 billion to retire a backlog of required asset rehabilitations and replacements, and an additional $3.3 billion dollars, or an additional 30.3 percent (3.3/10.9) increase in transit spending to improve actual system performance in terms of cost-effective increases in speed and service levels. Noticeably higher spending levels and accompanying changes in service levels appear to be required if significant shifts away from the automobile are to be induced.

Influence of Parking Infrastructure and Future Parking Policies. Parking control policies, through either higher parking rates or restrictions on spaces available, offer considerable leverage through which to alter travel patterns. A major obstacle to their adoption is their unpopularity with much of the traveling

26 See ITS America (1997), and Das, et al (1998) for example investment requirements.

public. To what extent these policies will be pursued in the future depends on the reasonableness, both economically and socially, of doing so. Recent survey data on nationwide parking practices, reported by Shoup and Breinholt (1997), found that some 95% of automobile commuters in the United States park free at work. They also found that over 97% of US firms who leased or owned parking space offered such parking free to their employees. This broke down into 31% of US firms leasing free paces for their workers, and an additional 47% allowing free employee parking in spaces owned by the company. In total, these firms were providing some 85 million parking spaces, of which 19.5 million are leased from other companies.

Since these free parking programs affect such a large percentage of travelers, who for the most part are traveling during periods of peak traffic congestion, they are an obvious target for policy consideration. As a result the 1990's has seen the idea of cashing out employee parking gain legislative momentum. California was the first state to try this in 1992, with some apparent success. A study of eight employers by Shoup (1997) found a 13% decline in automobile use in favor or carpooling, transit and walk/cycle alternatives, with an associated 12% reduction in vmt and an estimated savings of 807 pounds of CO2 per employee per year . At the same time the trading of tax-exempt parking for taxable cash wages increased federal tax paid per employee by $48 per year.

The federal government initiated its own lawmaking through the Taxpayer Relief Act of 1997[27]; and subsequently beefed up its legislation through Section 9010, Title IX of the 1998 TEA-21 (P.L. 105-178) transportation lawmaking. The result of this legislation, together with earlier legislation dealing with employer-provided transit (via The Energy Policy Act of 1992), is that employers may offer their workers a choice between untaxed free parking or extra taxable salary which they get for taking alternative modes of travel to work, including transit, carpooling and vanpooling. Employers are now also free to support these less energy intensive forms of commuting with money they had previously used to subsidize private vehicle parking.[28]

How successful such commuter benefits programs will be depends on both employer and employee willingness to participate. Results will likely vary across cities. Much will depend on the following factors:

- the capacity-to-demand ratio for available parking spaces,
- the percentage of publicly operated on-street spaces versus (for the most part) privately operated off-street lots (see Mildner, Stratham and Bianco, 1996),
- the number of spaces that are currently bundled with existing building leases (and therefore difficult to apply cash out or similar policies to).
- the size as well as number of firms participating in the regional economy, and
- the willingness of companies to consider parking cash out or other forms of commuter support programs whenever they change or add new office or factory locations.

The most likely participants will be companies in downtown and suburban center locations where parking has become scarce or expensive. Within many US cities parking construction and maintenance costs have risen quite steeply over the past three decades, creating an incentive to consider alterative solutions (Apogee Research, Inc, 1997).

A recent US EPA funded examination of the potential environmental impacts of a nationwide parking cash out program produced estimates ranging from a 0.8% to a 4.2% annual reduction in vmt by 2007 (i.e.

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27 See Apogee Research, Inc.(1997) for a description of the law as it pertains to commuter benefits.

28 For example, if Parking Cash Out is offered by an employer under these new commuter benefit laws an employee can choose $150 cash and pay income and payroll taxes on the full amount. Alternatively, he/she might choose a $65 tax free transit pass and receive $85 in taxable salary.

ten years into the program) based respectively on 10% and 50% rates of cash out adoption by potential adopter firms (Hagler Bailly, 1999) [29]. These estimates were calculated to imply annual reductions in CO2 emissions of roughly 1 million and 5 million metric tons of carbon, respectively. As the authors of the study note, however, these results are quite sensitive to company and employee adopter rates as well as to the travel cost elasticity parameter they employ in the computations.

A significant beneficiary of an effective parking policy instrument might be urban transit in large cities. Mildner, Stratham and Bianco (1996) looked at this parking-transit connection and found evidence from national data sources that higher transit ridership figures are most likely to be found in cities that have a high probability that travelers will pay to park, have high parking prices, and have limited parking supply. What is lacking currently is a proper understanding of the causal mechanisms connecting these various attributes of so-called transit-accommodating cities.

Considerable potential to affect vmt through parking cash out and similar policies clearly exists.
However, success rests on travelers collective response to the perceived costs of commuting and on their willingness to forego well established, if not always efficient, methods of travel. To have significant impacts on nationwide vmt, small as well as large companies will need to get involved in such programs (Shoup and Breinholt, 1997). A suitable public agency response to the problem would be to derive the full costs of travel under different parking fee policies *in conjunction with* future, and *regionwide* parking construction permitting policies. Commuters, at least the vast majority of them, should not be allowed to end up worse off as a result.

7. Conclusions.

This paper has examined the potential for significant vehicle miles of travel reductions through land use impacting public policy instruments. The examination was carried out in the context of the Clean Energy Futures-National Energy Modeling System forecasts presented in Chapter 6 of this report. As described in Section 4 of the paper all three of the CEF-NEMS vmt forecasts (Baseline, Moderate and Advanced) imply noticeably slower annual rates of vmt increase from 2010 through 2020 than other recent projections. Given the range of vmt forecasts currently in use caution is suggested in accepting any single model s forecasts of vmt reductions, including those produced by the existing CEF-NEMS scenarios. Given the complex nature of land use-transportation interactions described in Section 3 of this paper it is also problematic to suggest rigorously quantified adjustments to the NEMS vmt forecasts as currently modeled, or to other recent vmt forecasts, on the basis of specific land use policies.

Other reasons for caution in assigning vmt reductions to land use policies are provided in Sections 5 and 6 of the paper. In Section 5 a review of the evidence for forecasting land use change and the impacts of such changes on aggregate vmt highlights both the complexity of causality and the comparative lack of definitive empirical data. Estimating percentage decreases in nationwide vmt and greenhouse gas emissions as a result of proposed land use and infrastructure investment policies is at best a speculative business. Given the economic and social capital already invested in the current ways of planning and developing land, it does seem clear that bringing about significant vmt reducing changes in urban land use is likely to be no small task. In particular, the success of smart urban growth management strategies in producing a sustained vmt reduction will require local as well as Statewide decision-making bodies to adopt a multi-jurisdictional, regionwide focus.

The eventual outcome of current debates over urban sprawl and its associated traffic problems may well rest on how the growing public debate over environmentally sensible economic development plays out. As the existing empirical literature on the topic shows, uncoordinated actions to increase residential or commercial densities, to promote intra-jurisdictional housing-jobs balance, or to limit mixed use land development and auto-efficient urban designs to single neighborhoods are all unlikely to have much of an

29 Companies with under 10 employees were assumed not to participate.

impact on aggregate travel volumes. To have significant impacts on total vmt through urban restructuring will require some deep rooted changes in the way people choose to live and do business, and in turn choose to move between locations within entire urban systems.

To encourage such changes in a suitably democratic manner, a Moderate land use-based vmt reduction scenario might involve limited forms of State intervention into land use control, such as

- prioritization of vmt-reducing land development projects,
- placing limitations on expansions into the agriculturally productive rural peripheries of current urbanized areas , and
- encouragement of brownfield development projects geared to inner-city rejuvenation.

A more Advanced scenario might include more aggressive statewide legislation to control, and most importantly *to coordinate*, urban area expansions with each State and metropolitan region.

In Section 6 of the paper the focus is on travel reductions through more direct control over transportation infrastructure supply. The major policy levers apply to the permitting and investment of public monies in the construction of highways and the permitting of private vehicle parking lots. Recent empirical studies indicate that adding capacity to high volume highways will often induce significant volumes of additional traffic, in both urban and rural areas. As local and regional governments find it increasingly difficult to maintain as well as expand their current road networks other options to continued growth in traffic congestion are likely to receive greater consideration. For the most part this congestion is found in the nation s largest cities, with the vast majority of highway vmt occurring within or between cities with over half a million residents. While bus and rail transit offer more energy efficient modes of travel, increased support for these modes can be expected only if significant shifts away from the automobile can be demonstrated to be worthwhile to individual travelers. While the likelihood of significant modal shifts taking place seems small within the next 10 to 15 years, under current pricing policies and current attitudes towards personal mobility, changes in tripmaking behavior over the longer term may find a role for these more energy efficient modes within the context of re-designed urban environments. With time for longer term land use changes to manifest themselves the America of 2050 may be much different from that of 2020. While it is difficult to predict what the urban systems of 2050 or beyond will be, an accurate backcasting model of 1950's America would show major changes in the patterns as well as volumes of both urban development and personal (as well as freight) travel.

Some of the major changes that have occurred in urban development over the past half century, such as the growth of suburban activity centers, seem to have been of a gradual nature although lack of reliable historical data on this hampers detailed analysis. Given the considerable diversity in our urban and regional geographies and forms of local government, individual States developed in different ways. Similarly, over the next half century each State will need to develop its own versions of publicly acceptable urban growth boundaries or other smart growth policies - albeit with the opportunity to learn from each other s efforts. Significant reductions in vmt and greenhouse gas emissions will result only if these regional growth policies noticeably shorten the distances traveled between frequently connected pairs of places and/or eliminate the need for a significant number of automobile trips by making walking, cycling and transit more lucrative. Most Americans have come to expect high levels of accessibility to the places they most often wish to visit: the workplace, shops and professional service centers, friends homes and recreational facilities. They have also grown accustomed to gaining this access through high levels of daily, automobile supported, personal mobility. More environmentally sound land developments will include those that find ways to offer less mobility-dependent accessibility.

Finally, a successful outcome to vmt reduction policies will require the ongoing, and increasing public debate over urban development to evolve from its currently bi-polar dialogue over more greenery versus more greenbacks into a dialogue supporting carefully evaluated regional and multi-modal transportation infrastructure expansion programs. These programs must deal effectively with local, inter-jurisdictional land use equity issues. Traffic growth is only one concern, albeit an important one, in such increasingly well informed quality of life debates.

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