Essay

Trends Shaping Transportation's Future

Robert L. Olson
Institute for Alternative Futures

Introduction

This white paper reports on trends and emerging developments that are relevant to transportation planning in Arizona. Many of the ideas presented here are future-oriented or are related to larger trends in technology and society, and so may not have previously come to the attention of the state's transportation planners.

Some of the trends and forecasts explored in this paper, such as future developments in intelligent transportation systems, are comparatively certain. It is possible to look at the research and testing underway today to see what is likely to be available tomorrow. Other topics, like the time frame in which global oil production will begin to decline, are inherently more uncertain and controversial. Still other topics, like the proliferation of Segways, a new kind of personal transportation device, are included as part of a deliberate look at "wildcards"—developments that may not be likely, but that would have very large consequences if they should occur. Exploring this whole range of emerging developments can help Arizona's transportation planners work with a broader understanding of the possibilities ahead. Your view of the future and its possibilities influences your actions today, and your actions today shape the future.

The paper explores trends and developments within six broad topic areas or themes:

New Ways of Thinking about the Future in Transportation Planning
- Understanding the larger context of decisions
- Clarifying aspirations for the future and setting goals

Energy-Related Developments
- Rising oil and gasoline prices
- High fuel efficiency IC vehicles and hybrids
- Potential evolution toward a hydrogen economy

Correspondence: 100 North Pitt Strect, Suite 235 Alexandiaa, VA 22314-3134
Email: BOlson@altfutures.com

- Implications for combined power-transportation infrastructure
- Implications for auto usage, congestion and air quality

Converging Developments Affecting Urbanization Patterns
- Examples of unanticipated problems
- Outlines of an emerging vision
- Communication-Related Developments
- Computer power and network capacity
- Communication substitutions for travel
- Communication inducements for travel
- Intelligent vehicles and transportation systems

Demographic and Social Trends
- Population
- Population and Water
- Aging and Health
- Boomer Retirement Lifestyle Preferences
- Demands for Transparency

Wildcards
- Near-term oil price increases
- Rapid rollout of the Segway
- Near term water shortages limit development
- A shift from SUVs to Hypercars

Theme 1: New Ways of Thinking about the Future in Transportation Planning

The most difficult public policy decisions are those that relate to strategic choices that have long-term impacts on society. Among all the strategic choices that a state like Arizona makes, capital budgeting decisions for transportation arguably have the most far-reaching impacts. They shape the direction and character of urban development and are literally "set in concrete," influencing the future for generations.

Transportation planning has often seemed more sophisticated than other areas of capital budgeting, with decision-making supported by computer-based demand projection models. Unfortunately, much of this apparent sophistication was illusory. A good case can be made that transportation planning was at its worst in decades past when planners were most confident of their quantitative methodologies. Now the problems they face are much more difficult, but the planning itself is improving

thanks to less quantitative but more comprehensive ways of thinking about the future.

These more comprehensive ways of thinking about the future, used in today's most sophisticated planning efforts in both corporations and government, involve: 1) striving to see the larger context of decisions, the driving forces of change, alternative possibilities, and the key uncertainties ahead; and 2) involving relevant stakeholders in clarifying their aspirations for the preferred future and setting goals for creating that future.[1] Both of these trends are already influencing transportation planning and are likely to affect it much more over the generation ahead.

Understanding the Larger Context of Decisions

Transportation planning has always projected trends into the future. What has been missing is not so much a long-range perspective as "peripheral vision"—a sustained effort to understand the larger context of what transportation decisions really affect.

This means, above all, striving to understand the connections between transportation choices and other concerns such as shaping land use and urban development patterns, reducing urban air pollution, avoiding unsustainable long-term costs of infrastructure maintenance, improving access to housing and jobs for lower income people and people living in poverty, minimizing the fragmentation of ecosystems and damage to environmentally sensitive areas, and maintaining or restoring the kind of human scale in the built environment that fosters a sense of local community. It also means looking at all forms of transportation, the intermodal connections between them, and other means of facilitating "access" such as mixed use development and pedestrian mobility.

The challenge is to keep working over time (not just the current planning cycle) to improve understanding of this larger context, to collaborate with people who have other kinds of expertise needed to build this understanding, and to be honest about uncertainties. Techniques like scenario development can be used to construct images of how this larger context could change over time and communicate them to the public and decision makers, highlighting rather than hiding the uncertainties and the alternative theories of how the future could unfold.[2]

Clarifying Aspirations for the Preferred Future and Setting Goals

Rather than being reactive—responding only to immediate pressures, or extrapolating trends and developing plans to accommodate them—

more sophisticated planning efforts operate from the perspective that the future is something we proactively create. This does not mean that existing trends and circumstances can be ignored and that anything is possible. It does mean that the future is more open to shaping than we often assume, and that we tend to underestimate what is possible, especially over years or decades of effort.

A more proactive approach to planning implies that we need to clarify our aspirations for the preferred future, the kind of future we want to create. There is no way to do this in the transportation field except to open the debates and negotiations that were once held only among a small circle of transportation experts to environmental activists, community leaders, appointed members of metropolitan planning organizations, and the general public, who bring in all kinds of conflicting views. The ISTEA process has helped open transportation planning to these kinds of inputs, but much more needs to be done to foster real dialogue and meaningful collective learning that allows participants to reach greater agreement about the character of the long-term preferred future.

This approach involves a fundamental change from traditional planning. Instead of moving incrementally from the present into the future, it calls for understanding the broad context of change, clarifying aspirations, and then positing a "best feasible" preferred future and working backward toward the present to develop goals, strategies and actions for creating that future.

Theme 2: Energy-related Developments

Transportation is based on energy consuming technologies, primarily technologies that use oil. Cars and light trucks are oil's main users and its dominant growth market. As a result, changes in the price and availability of oil could have major impacts on transportation. Conversely, improvements in transportation technology can improve energy productivity and reduce the effects of fossil fuel combustion on human health and the environment. Important changes in oil prices and availability and in transportation technology are likely over the next two decades.

Rising Oil and Gasoline Prices

The price of gasoline was at or near all-time lows during the 1990s. But the surge in energy prices during 2000 and most of 2001 has drawn attention once again to the availability and security of energy resources and the prospects for both supplies and prices.

The most influential work on forecasting the availability of oil was done by petroleum geologist M. King Hubbert at the Shell research lab in Houston.[3] In 1956, Hubbert calculated that U.S. oil production would follow a logistic curve, peaking in the early 1970s and then declining just as rapidly as it had grown. Most industry experts understandably rejected Hubbert's analysis, despite his highly respected status. It was news no one wanted to hear, and several forecasters had cried "wolf" before and been proved wrong. The controversy over Hubbert's analysis raged until 1970, when U.S. crude production peaked and began to fall, making the U.S. increasingly dependent on imports.

Beginning in 1995, several analysts began to apply Hubbert's methodology to world oil production, producing sobering estimates. The analysis that caused the greatest stir within the global oil industry was done by an organization known for its optimistic outlook, the influential, Paris-based International Energy Agency (IEA), and reported in the IEA's 1998 *World Energy Outlook*. The energy projections contained in previous editions of the *World Energy Outlook* had a time horizon of 2010. The 1998 edition extended the projection horizon from 2010 until 2020 and applied a Hubbert-type analysis using a generous United States Geological Service estimate of 2300 Bb for the world Ultimate. The analysis projected that non-OPEC conventional oil production will peak in the early '00s and that total world production will peak during the period 2010-2020. This was a startling conclusion at the time and was published only after months of recalculation and internal debate.[4]

Nearing the top of the so-called "global Hubbert's peak" does not mean the world is running out of oil. But it does mean that prices will inevitably go up. This price rise is likely to begin during the 00s' as non-OPEC production peaks and then declines, giving growing leverage over prices to nations in the Persian Gulf where two-thirds of the world's petroleum reserves are located. Third World economic development will continue to drive the growth of demand. Once the global production peak is passed, both developed and developing nations will be bidding against each other for the dwindling oil supply, driving prices higher until substitutes are sufficiently developed to reduce oil demand.

High Fuel Efficiency IC Vehicles and Hybrids

Recent transportation projections for OECD regions conclude that, absent major price increases or policy actions, further strong increases in transportation energy demand and CO2 emissions can be expected out to 2010. After 2010 a stabilization and then eventually a reduction in trans-

portation energy demand is possible as more energy-efficient transportation technologies take an increasing market share.[5] Three transportation modes account for the vast majority of energy consumption: cars, trucks and aviation. Modal shifts toward more energy-intensive modes for freight, including a projected tripling of air freight volume by 2020, mean that the largest opportunities for reducing oil consumption and CO2 emissions are through technical improvements in cars and light trucks.

There is considerable room for improvement: new American cars average only 24 mpg, a 20-year low. In Europe, where gasoline prices are higher and smaller cars dominate the market, many models with conventional internal combustion engines get in the vicinity of 40 mpg. Volkswagen has recently begun selling Europeans a 78-mpg, four-seat non-hybrid subcompact and plans an ultra-light two-seat city car for 2003 that will get 235 mpg (not a typo).

In the U.S., where small cars have a small market, fuel-electric hybrid technology will be the key to reducing oil consumption. The 48 mpg Toyota Prius, the 64- mpg Honda Insight, and the new Honda Civic hybrid are proving highly popular. Ford, Daimler-Chrysler, and General Motors all plan to begin selling Hybrid SUVs in 2003, and all three are already testing mid-sized family sedans in the range of 60 mpg to 80 mpg. Ford's chairman estimates that up to 20 percent of cars on the road by 2010 could be hybrid fuel-electric.

Potential Evolution toward a Hydrogen Economy

The most important emerging development in road vehicle technology is the dramatic progress underway in the design and manufacturing of fuel cells. Fuel cells convert hydrogen into electricity by an electrochemical process that is highly efficient and totally nonpolluting. They can run on any hydrocarbon fuel, using a reformer to extract the hydrogen. Progress in fuel cell technology is occurring much faster than anticipated a few years ago because automobile manufacturers, under continuing pressure to lower emissions, and anticipating the coming global decline in oil production, have collectively poured over $2 billion into fuel cell research and development. It appears likely, therefore, that fuel-electric hybrids will be a transitional technology on the road to electric drive vehicles powered by fuel cells.

As per current plans, BMW, Daimler-Chrysler, Ford, GM, Toyota and Honda will all introduce fuel cell-powered cars by 2004-2005, but these initial vehicles will still be too expensive to be popular. Meanwhile, fuel cell growth is expected to occur much faster in the distributed power

generation market. Every doubling of cumulative production volume is anticipated to make fuel cells 10-30 percent cheaper, so they are likely to gain substantial market share in buildings of all kinds over the decade ahead. As production volume grows, falling prices will make widespread fuel cell use in vehicles affordable. Like other states, Arizona will need to consider steps it could take, such as fleet purchasing and partnerships with businesses, to help accelerate the shift to fuel cells. How fast this shift can occur is not yet fully clear. General Motors has announced the aim of having 10 percent of its new cars fuel cell-powered by 2010.

Because of fuel cell progress, the concept of a "hydrogen economy" has recently caught the imagination of many industrial leaders. Top management at Royal Dutch Shell and BP say they are committed to bringing a hydrogen economy into existence. William Ford wants to preside over Ford's complete transition from internal combustion engines to electric drives powered by hydrogen fuel cells. The Bush administration has launched the Freedom Car initiative to support industry's development of fuel cell vehicles and increased the DOE budget for hydrogen and fuel cells. The November 2001 issue of Fortune magazine ran a feature article on "The Coming Hydrogen Economy"—a sure sign that the concept is entering the mainstream.

Not that a hydrogen economy is a sure thing. There are major questions and challenges ahead about the how best to produce hydrogen, how to make it available to consumers, and what pathways of infrastructure investment could take us to a hydrogen economy most quickly, safely and efficiently. Most hydrogen will initially be produced by steam reforming of natural gas, but there are many other options including extracting hydrogen from coal with carbon sequestration and thermal cracking or electrolysis to extract hydrogen from water using nuclear energy. The "holy grail" for many researchers in the field is a solar hydrogen economy based on biological hydrogen production, wind, photovoltaics, and other renewable sources. A major problem of solar electric technologies is their intermittency—they only produce power when the sun is shining. Conversion to hydrogen as a storage medium and energy carrier offers a solution.

Implications for Combined Power-Transportation Infrastructure

Some experts believe that the interaction between fuel cell-based power generation and vehicle markets could be the key to moving toward a hydrogen economy much more quickly than anyone thought possible a few years ago. Here is one example of how it might happen:

As production volume increases and costs come down, fuel cells will become more common in buildings of all kinds, including homes. At least a dozen North American companies are racing to create a new market for residential fuel cells that run on hydrogen extracted from natural gas. General Motors itself has announced plans to bring out a fuel cell power-generation product; Ballard in Canada, which has been heavily supported by Daimler-Chrysler, is working to bring out units for residential use; and Plug Power in Latham, NY has partnered with General Electric and will begin shipping the GE HomeGen 7000 in 2003. It might be possible, therefore, for some people to begin using hydrogen even before a hydrogen refueling infrastructure has been developed by "gassing up" their fuel cell cars at home, getting hydrogen from the natural gas reformers that feed their home fuel cells.

As national standards for connecting micropower technologies to the electric grid come into place, people could also begin to use their fuel cell cars as generators. Each new fuel cell-powered car will in effect be a ~20+kWe power plant on wheels. The average American car is parked about 96 percent of the time, usually in habitual places. Imagine driving your car to work and leaving it in a parking structure where you plug it in to the electric grid—not to recharge, as battery powered electric cars require, but to serve as a generating asset. While you work, your car is part of the "virtual power plant" feeding electricity back into the grid, and you are being credited for this electricity production at the real-time price, which is highest in the daytime. While you go about your life, your car is busy repaying a significant part of its own purchase price or lease fee by selling power to the grid. This arrangement would make fuel cell cars a great deal, causing sales to boom and creating the demand that can justify rapid construction of a major hydrogen infrastructure in which hydrogen is produced and delivered in many other ways.[6]

Implications for Auto Usage, Congestion and Air Quality

The implications of these energy-related developments are difficult to assess. On the one hand, the prospect of rising prices means that over the generation ahead we may come within sight of inflection points in important transportation trends such as rising transportation energy consumption, constant growth in vehicle miles traveled, and the shift toward larger cars, SUVs and light trucks. If the energy costs of transportation go high enough, they could put economic constraints on low-density development.

On the other hand, hybrid fuel-electric vehicles with high fuel efficiency might blunt the impact of gasoline price increases, allowing VMT to continue rising, and allowing Americans to maintain their love affair with big cars without incurring big costs. Fuel cell powered vehicles may allow us to maintain our high levels of auto use despite a drop in world oil production. Even if higher energy prices drive a shift to smaller "green cars," we may find ourselves suffering through worsening "green traffic jams." What actually happens will depend greatly on the timing of price changes and technology developments. The most disruptive impacts would occur if significant price increases occur before the end of the '00s, before hybrid vehicles have taken a significant market share.

One certainty is that the technical changes we can see coming today will make possible major improvements in air quality. The Toyota Prius hybrid cuts fuel consumption by nearly 50 percent from the similarly sized Corolla, but it cuts emissions by 90 percent. Fuel cells will cut emissions still further. Fuel cells running directly on hydrogen will have no emissions at all accept for water vapor. By mid-century, one of the transportation-related complaints in Phoenix and Tucson may be that cars are increasing the humidity, worsening the temperature-humidity index.

Theme 3: Converging Developments Affecting Urbanization Patterns

Since World War II, our nation's urban development has been guided by a dominant vision of how metropolitan areas should grow. It is commonly described as suburbanization, low-density development, or urban sprawl. This urbanization pattern made an attractive way of life available for millions of people. It offered home ownership, modern schools, responsive local government, and an uncrowded environment of clean air and green lawns. It offered unprecedented mobility based on widespread automobile ownership and a rapidly expanding system of interstate highways and urban expressways. There is no question that this post-war development pattern contributed to an unprecedented surge of economic growth that brought the majority of our nation's population into the middle class. It literally became a part of the "American dream."

However, pursuing this development pattern over the past fifty years has given rise to unanticipated problems. At first they seemed to be manageable "side effects" of growth, but now they loom as serious threats to our nation's long-term well being. At the same time, new visions of how metropolitan areas should grow are emerging.

Examples of Unanticipated Problems

Infrastructure Maintenance Costs: Costs for maintaining the far-flung highway, water, and sewage infrastructure systems needed to support low-density development are soaring in many parts of the country, making it increasingly difficult to finance new construction. This problem will continue to escalate as the infrastructures age. While infrastructure to support new development on urban fringes is becoming more expensive to build and maintain over the long run, we continue to leave under-utilized infrastructure behind and build on the fringe because the short-term costs of doing so are low for both businesses and home buyers. Short-term incentive structures are leading us into a future where our children and grandchildren could face potentially crippling costs.

Congestion: Peak hour traffic congestion is worsening, especially in the suburbs, exacting an economic toll in lost time and worker productivity. Each year, Americans lose 2 billion hours to gridlock, and road jams are responsible for business losses of $40 billion. Longer commutes make it more difficult for people to get to where new jobs are, leading to higher labor costs. Congestion effects economic development by making areas less desirable for potential employees and customers.

Housing: Areas of low-density development provide little low- or even moderate-income housing. As a result, low-income people are often concentrated in the cheapest, most deteriorating housing within urban areas. Often they are without automobiles or adequate transit links to reach the areas where new jobs are being created. This concentration of poverty and isolation from jobs is a major contributor to unemployment, crime, school breakdown and other social problems.

Environment: A recent study within the U.S. Environmental Protection Agency highlighted the problem that current development patterns are fragmenting ecosystems into patches too small and isolated to maintain species diversity. Low-density development is also encroaching on environmentally sensitive areas, eliminating open space and causing a permanent loss of prime agricultural land. Travel in single occupancy vehicles is the greatest contributor to urban air pollution and the single largest factor in the buildup of greenhouse gases in the atmosphere.

Security: High oil consumption, over half of which is used by automobiles, makes the U.S. vulnerable to cutoffs by foreign suppliers and makes oil imports the biggest item in our foreign trade deficit.

Community: Our society is going through a profound disintegration of local community life. One of the important developments weakening our sense of community is the loss of human scale in the physical envi-

ronment as development is geared more toward automobiles, roads and parking than toward walkable communities where neighbors can meet and interact.

Outlines of an Emerging Vision

A new vision of how metropolitan areas should grow is emerging. Its outlines are visible in the heavy overlap between emerging movements of thought and policy such as smart growth, the new urbanism, transit-oriented development, traditional neighborhood development, livable communities, and community sustainability. Ideas being promoted by these movements are becoming increasingly influential, but it is not at all clear whether these ideas provide a workable alternative direction or whether they will become sufficiently accepted and influential to overturn public policies favoring the interests that benefit from current growth patterns.

These overlapping movements of thought all see the examples of unanticipated problems listed above not as separate, individual problems but rather as a "syndrome" of interconnected problems all generated simultaneously by our pursuit of low-density development. In this view, the only way to solve these interconnected problems is to invent new patterns of urban development superior to urban sprawl.

The general character of the new approach being proposed is a deliberate shift away from today's sprawl development pattern toward more compact, clustered, community—centered development patterns. Automobiles would still be the dominant means of transportation for a long period of time as this new development pattern evolved, and would always remain important, but eventually people would become less dependent on them. Expanded transit systems would connect centers of development with each other and with the older urban area. These centers of development would have many features of the traditional neighborhood designs that make older European cities and America's small towns so appealing. Many jobs and stores and a substantial amount of housing would be located within walking distance of transit stops. Neighborhoods would be designed to maximize the ease of pedestrian and bicycle movement. There would be wider choices of housing types, densities and costs than in conventional suburbs, with affordable housing in relatively close proximity to lower- and middle-income jobs. Public plazas, squares, and greens would be designed to encourage the presence of people throughout the day and evening. Natural features like creeks and streams would be restored where feasible, with the most dramatic features highlighted in public settings. All development clusters would have well-defined centers with

public buildings and distinctive architectural features to create a unique "sense of place." Each cluster of communities would have a defined edge such as a wildlife corridor or agricultural greenbelt permanently protected from development. [7]

Not surprisingly, people with this kind of vision of the preferred future tend to share a harsh critique of much of transportation policy and planning, which they see as a principal driver of the urban sprawl that is the opposite of what they want.

Induced Traffic and Latent Demand: Their basic critique is that building more highways and widening roads to ease traffic congestion always acts to spur more development and induce more traffic. Increasing road capacity makes longer commutes easier, so people are willing to live farther and farther from their places of work. But as growing numbers of people choose to live further out, the longer commutes grow as congested as the shorter commutes used to be and commuting times grow ever longer. Then additional lanes or highways are added to relieve congestion and the cycle of induced traffic repeats itself, with low-density development spreading over more and more of the landscape. If there is always more latent demand than can be met, then we will never be able to build our way out of traffic congestion, and the real constraint on driving is always going to be traffic. In this view, a fundamental reconsideration of transportation planning theory is called for that focuses on the broader question of "what do we want our urban areas to be like?" and is open to the radical notion of actually using congestion as a force for limiting automobile trips.[8]

Automobile Subsidies: A related argument is that people have been willing to sit for longer and longer periods of time in bumper-to-bumper traffic largely because automobile use is to a significant extent what economists call a "free good," and demand always goes through the roof for free goods. Government subsidies for highways and parking alone have been estimated to amount to between 8 and 10 percent of the U.S. GNP. Local government services to motorists and truckers-traffic engineering, traffic control, police traffic patrolling, street repair and maintenance are also all free goods. Each year on U.S. roads, 6 million crashes occur; 41, 000 people are killed and more than 3 million injured—this at the cost of $150 billion. "Softer" costs such as the health costs of urban air pollution could also be added. Everyone, not just drivers, pays these costs.[9]

Urban Design: The fundamental question of "what do we want our urban areas to be like?" is the touchstone to which proponents of "smart growth," the "new urbanism" and related movements always return. They

believe transportation planning has consistently led us in wrong directions. For example, the architects Andres Duany and Elizabeth Plater-Zybek argue that Norman Bel Geddes, the visionary behind the U.S. Interstate system, was right when he declared in 1939 that "Motorways must not be allowed to infringe upon the city." Bel Geddes wanted the kind of highway development that has occurred more commonly in Western Europe, where roadside development is not permitted on highways passing through the countryside, and where highways providing access to urban areas must take on the low-speed geometries of avenues and boulevards. In the U.S., the exact opposite has become more common. Highways are typically lined with commercial strips and have often been routed through the centers of cities, splitting downtowns and cutting neighborhoods into pieces. Duany and Plater-Zyberk argue that nearly every aspect of urban design that supports a thriving pedestrian life, safer streets, a strong sense of community, aesthetic beauty, and easy access to nature has been shut out by a preoccupation with engineering criteria for achieving unimpeded flows of traffic.[10]

The emerging vision of a potentially superior pattern of urban development is certainly attractive in some respects, but many questions remain about its social, economic and political desirability and feasibility. In any case, a change in this direction cannot be quick or easy. Today's dominant vision of low-density development is deeply embedded in our mindsets, institutional arrangements, policies, regulations, and investments in existing infrastructure.

Nevertheless, if the unanticipated problems reviewed above continue to worsen, and if this emerging vision continues to be refined and to gain adherents, then over the coming generation transportation agencies will go through the greatest change since the post-war development of modern transportation planning.

Theme 4: Communication-related Developments

Computer Power and Network Capacity

Computers and communications are increasingly central to the future of transportation. To use European terms, progress in "telematics" will influence transportation demand and "informatize" all transportation-related technologies. The rate of progress in telematics will therefore emerge as an important factor in transportation planning.

At the level of basic capabilities, progress in information technology is almost certain to continue for over a decade at rates far greater than

people expect. Moore's Law, the observation of Intel co-founder Gordon Moore that the processing power of integrated circuit chips doubles roughly every 18 months, is expected to continue for at least a decade until the limits of the optical lithography used in manufacturing chips begin to be approached. Developments in molecular computing or quantum computing might keep Moore's Law going into the foreseeable future, but that is not yet a sure bet. What is sure, however, is that a doubling of processing power every 18 months will take us to barely imaginable levels of computing power within a decade. When chips were evolving from containing 10 transistors to 20 to 40 to 80, and so on, the impacts of doublings were modest. But the most advanced chip designs today contain nearly 10 million transistors. Before the limits of optical lithography are reached it should be possible to put over a billion transistors on a chip.

The rates at which information can be sent over a single strand of optical fiber have increased even faster than Moore's Law. The rate of progress toward both fixed and wireless high capacity broadband networks is limited far more by investment levels and uncertainties about future demand than by technology. It seems reasonable to say, therefore, that there is probably no telematics application in transportation that will be blocked over the next 20 years by lack of computing or communication capacities.

Communication Substitutions for Travel

Facing frightening forecasts of worsening congestion, transportation planners are understandably interested in the possibility that telecommunication can substitute for travel. Areas where this kind of substitution seems feasible include:

- Telecommuting, using telecommunications to replace commuting between home and work
- Online shopping, banking, entertainment, and health services that allow consumers to obtain the services they desire without leaving home
- Distance learning and other interactive educational services that make formal learning possible from home or work
- Web portals for obtaining government services and carrying out routine activities like licensing and income tax filing
- Just-in-time manufacturing systems that avoid wasteful shipping and reduce dependence on large inventories
- Broadcasting of a wider variety of live events, combined with the

spread of wide screen high resolution television, so that more people watch the events from home

- Dedicated telecommunications applications that expand traveler ridesharing or that save trips by consolidating freight loads

Substitutions such as these clearly have had some effect already and will have more effect in the future, but unfortunately there is no evidence to date that the effect is very significant.

Communication Inducements for Travel

The evidence of the last few decades suggests, to the contrary, that telecommunications and travel grow together, feeding on each other.[11] Due to latent demand, other travelers quickly take any road space vacated by telecommuters and others utilizing communications instead of travel. At the same time, telecommunications appear to induce travel through a variety of casual routes:[12]

- Telecommunication spurs productivity improvements and income growth, and people with more income tend to travel more
- Improvements in communication expand the number and geographic scope of the business and social relationships in which people engage
- Telecommunication supports the geographical decentralization of organizational functions and residential settlement, which tends to move trip origins and destinations further apart
- The use of wireless mobile phones, Palm Pilots, Blackberries and similar devices is reducing reluctance to travel by making travel time more productive
- Telecommunication is supporting population growth and economic activity in rural communities, causing growth in rural travel
- Telecommunication is enabling the rise of businesses that specialize in customized vehicle trips, from home pizza delivery and overnight package delivery to temporary employment services

The spread of higher bandwidth, more interactive communications will allow easier and more effective substitutions of communications for travel, but it will also increase all the inducements for travel listed above. As a result, there is no reason to anticipate that telecommunications will have any significant impact on reducing congestion over the generation ahead. However, if an oil crisis should occur, or if a significant rise in energy prices causes major increases in transportation costs, we might be surprised as a society by how much our rapidly evolving telecommunications systems can substitute for travel, when needed.

Intelligent Vehicles and Transportation Systems

At the same time that fuel-electric hybrids and fuel cell vehicles begin coming into the marketplace in large numbers later in this decade, a wide range of intelligent vehicle technologies will also be appearing. These two lines of development are likely to synergize, creating a public perception that a new era of high tech is emerging in transportation. Several of the expected developments are listed below. A few of these have already begun to appear as expensive options on Lexus, Mercedes-Benz and Infiniti models.

- 42-volt power systems
- X-by-wire technology replacing all the hydraulic and mechanical systems in the vehicle with electronic sensors and motors
- Vehicle self-diagnostic systems that analyze the status of the vehicle and communicate results to the driver; more advanced systems will communicate status information to a control center when appropriate, which can analyze the data, predict malfunctions in real time, inform the driver, and schedule the service required
- Radar-based collision warning systems that gauge the speed and distance of oncoming traffic, alert drivers to danger, and induce braking in emergencies
- Emergency alert systems that alert the driver when a car drifts from its lane; more advanced systems will track driver's eyelid movements and sound an alarm if a driver is becoming too sleepy to drive safely
- Vision-enhancement screens on the windshield to reduce glare from the halo effect of approaching lights; more advanced systems will offer fighter-jet-style night-vision-equipped windshields
- Built-in mobile communications technology for wireless voice and data communication and serving as a basis for other telematic applications
- Global Positioning System (GPS) technology for navigation, vehicle location in the event of breakdowns or accidents, or locating a stolen vehicle
- Navigation technology based on GPS and detailed digital map databases
- Real time traffic congestion information as a value-added component to the digital mapping and navigation service
- Further into the future, "Intelligent Windshields" will display context-aware information and services, highlighting signs related

to the driver's chosen route, highlighting obstacles ahead or pedestrians to watch for, and alerting drivers to points of interest. When parked, the windshield can serve as a kiosk presenting information about its surroundings or upcoming events, or as a movie/video display screen (possible by 2020)
- Still further in the future, vehicles may continuously talk to each other electronically to provide real-time, fully accurate traffic information
- This kind of inter-vehicle communication is likely to be the basis for automatic highway systems with computer controlled vehicles running in high-speed, close-spaced platoons-if this vision of the future is ever realized. The paradigm of centralized computer control of vehicles is likely to be replaced by a distributed paradigm that integrates fast computers and high performance networks through novel computer algorithms. This vision of the future may not materialize, however, due to the extraordinary demands it places on vehicle reliability and the potential for massive accident liability.

Most of these emerging capabilities will become available in the marketplace, but there is considerable uncertainty about what features will eventually become "standard" and what consumers will be willing to pay for. Higher accident rates among today's cell phone users highlights a potential problem of drivers being distracted by in-vehicle telematic systems. A growing area of "human factors" research is emerging to study this problem and find ways to avoid it.

Intelligent Transportation Systems (ITS) are a broader set of applications that include intelligent vehicle capabilities but also include a larger infrastructure of diverse technologies for information processing, communications, and control. ITS may become much more important than is currently appreciated, because it appears to be developing in the direction of a "super infrastructure." Existing infrastructures for information, security, banking, medical systems and other areas are generally stand-alone systems that work independently of each other. ITS systems are driving toward an integrating infrastructure that will allow these different functions to interact. A "super infrastructure" will make new integrated services possible and cut costs by eliminating duplicated functions, but it could also increase vulnerability.

To see how ITS may spur infrastructure integration, imagine an advanced truck passing through a highway ETC gate 25 years from now.

By wireless communication, the toll gate identifies the truck, identifies the bank the trucking firm uses, accesses the bank computer, and draws the toll fee from the appropriate bank account. The toll gate also reports the truck's location to the company that is waiting for its contents to be delivered, estimating arrival time based on current and projected traffic conditions. It performs a security check to insure that the electronic seals on the truck's cargo have not been broken. If the truck's biomonitoring system indicates that the driver has become dangerously sleepy, the toll gate will shunt the driver to a temporary rest area.

Many ITS applications are already coming into place. Applications likely to be adopted or become more widespread over the generation ahead include the following:

Advanced Traffic Management Systems (ATMS)
- Traffic signal coordination
- Freeway ramp meter signals for access management
- Changeable message signs to warn drivers of upcoming road closures, accidents, and other hazards
- Congestion detection systems evolving from closed circuit TV to GIS applications to intercommunicating vehicles as traffic probes
- Route diversion systems

Advanced Traveler Information Systems (ATIS)
- 511 systems that consolidate and expand phone access to travel information
- Traveler information via public kiosks, Internet web sites, radio broadcast, cable TV, etc.
- Dynamic message signs
- Smart call boxes
- In-vehicle navigation and information systems
- Weather information systems

Advanced Public Transportation Systems
- Electronic payment (VISA/MC/debt cards) of transit fares
- Automatic vehicle location (AVL) technology to track buses, provide up to the minute information on transit schedule and arrival times, reroute buses to avoid congestion, route paratransit flexibly and efficiently, and improve response time in case of accident
- Traveler information kiosks with real time information on transit schedules, arrival times, and intermodal connections

Advanced Rural Transportation Systems (ARTS)

- Hazardous weather warnings
- Animal warning systems
- Motorist emergency services including in vehicle Mayday devices
- Statewide software architectures that integrate operations and maintenance functions with information on road closings, weather, tourism and traffic

Commercial Vehicle Operation (CVO)

- Commercial vehicle applications of all intelligent vehicle systems
- Electronic credential checking
- Weigh-in-motion
- In vehicle self-inspection systems to assess cargo stability and security
- Smart inspections, such as performance-based brake testing devices
- E-seals and other electronic cargo security systems
- Smart gateways to automate vehicle, driver and cargo identification and clearance at port and terminal gates
- Smart truckways to optimize truck routing to reduce conflict with passenger traffic and manage truck travel through congested or high-risk areas
- Onboard office work via wireless Internet access, voice recognition, and other tools
- Virtual road signs to alert drivers to upcoming hazards, low-clearance bridges, curved ramps, steep downgrades, intersections with limited turning radii, etc.
- Load matching systems to optimize truck utilization, minimize empty haulbacks
- Intermodal hazmat management systems to track the flow of hazmat containers and cargo across modes, improve the routing of vehicles carrying hazardous materials, and facilitate rapid emergency response

Theme 5: Demographic and Social Trends

Population

Population growth, population aging, and the growth of minorities are the most important demographic trends in Arizona that need to be considered in transportation planning. Arizona's population grew by 40% between 1990 and 2000, reaching a total population of over 5 million.

The state's population is projected to continue growing rapidly, reaching over 7 million by 2020, 10 million by 2040 and nearly 12 million by mid-century. However the possibility of worsening water scarcity may begin to slow growth during the latter part of this period (see below).

Despite its reputation as a retirement haven, Arizona's current population is actually slightly younger than the national average. But the most rapidly growing age cohort in Arizona is the 85 and over population, which grew by 82 percent over the past decade. The other, much larger, age cohort that grew most rapidly was people aged 45 to 54 (up 80 percent). That larger cohort will become the elderly population in 2020.

Arizona's other most distinctive demographic trait is the growth of minorities. Between 1990 and 2000, the state's Hispanic population increased by 57 percent to over 1 million, accounting for 22.7 percent of the total population. Arizona now has the sixth largest Hispanic population among all the states. American Indians are the state's second largest minority group, with a 1999 estimate of approximately 261,000. Arizona has the third largest number of American Indians among all 50 states, and since 1990 has led the nation in the numerical growth of its Native American population. Asians account for only a little over 2 percent of Arizona's population, but they are the fastest growing minority, up over 75 percent since 1990. Arizona's relatively small Black population grew by over 50 percent to about 175,000. Minorities now compose 36.2 percent of Arizona's total population. If current demographic trends continue, by mid-century Arizona could have a "minority majority."

Population and Water

Settlement patterns depend more than anything else on transportation patterns, but in Arizona and other parts of the West there is a possibility that water will become the ultimate determinant of development as urban areas outrun their water supplies. The limits of water availability are already being reached in smaller Arizona towns like Pine and Strawberry. Throughout rural parts of the state, where it is too costly to build more canals to bring in water from the Colorado River, more and more people are tapping into smaller and smaller supplies of groundwater. Wells are going deeper, and then going dry, forcing people to truck water in.

The state's biggest cities, Phoenix and Tucson, have abundant water supplies thanks to the 2.8 million acre feet of Colorado River water annually allocated to Arizona and transported via the Central Arizona Project. However continuing development is projected to fully tap the Central Arizona Project's water by 2030. Further growth would depend on ex-

pensive and speculative undertakings such as desalinizing seawater. After 2030, therefore, water scarcity may emerge as a significant constraint on growth.

Aging and Health

By 2030, more than one in five Arizonan's will be over 65. As the state's population lives longer and the proportion of the population over 65 grows, the number of people who will be limited by chronic conditions and disabilities will also grow. This will place increasing demands on state governments, especially on medical and social services, but also on transportation systems. Losing the independence and mobility that the automobile makes possible is one of the most heart-breaking stages of old age. Flexible and affordable transportation services that can come to people's homes and take them to their destinations will be in growing demand. Unlike younger people who need to travel quickly and on schedule, older people can often tolerate slower service and more restricted service times. What matters most is simply that they retain the ability to travel.

One of the most important conclusions to emerge strongly from recent research on aging is that healthy lifestyles are more influential than genetic factors in helping older people avoid the physical deterioration traditionally associated with aging. People who maintain a proper weight, eat a healthy diet, remain physically active, do not use tobacco, and practice other healthy behaviors have half the rate of disability of those who do not practice healthy behaviors. Over the decades ahead, a growing proportion of the elderly population is likely to practice healthy aging, staying active and mobile longer than has been common in the past.

This healthy aging population will make growing demands for sidewalks and street arrangements that are safe for walking and bicycling. They will continue driving longer and can benefit from conscious efforts to improve the visibility of signage, road edges, and lane separations. "Intelligent vehicle" technologies such as emergency alert systems, collision warning systems and vision-enhancing windshield screens can do much to help elderly people drive safely.

A simple change that can help avoid fatal collisions involving older drivers is to Improve vision screening tests for driver's license renewal. Elderly deaths from car crashes are 12 percent higher in states that do not require vision screening tests, according to a study by Dr. Melvin Shipp, a professor at the University of Alabama's School of Optometry.[13] Dr. Shipp studied traffic fatality records from 1989 to 1991 in 48 states. Night

vision declines steadily with age, and peripheral vision is reduced, affecting the ability to see other vehicles and pedestrians approaching from the side. State mandated vision tests prompt older drivers to visit their eye doctors to update the prescriptions on their corrective lenses prior to renewing their license. A thorough eye exam can identify the small number of older drivers whose vision has reached a stage where they are likely to be a hazard to themselves and others.

Boomer Retirement Lifestyle Preferences

The individualistic, idealistic, demanding Baby Boom generation has continually transformed institutions and expectations as this large population group has moved through elementary school, college, birthing and parenthood, and midlife careers. Now the oldest Boomers are beginning to prepare for retirement, and it looks like they will remain true to form, transforming the life stage of retirement. Phyllis Moen, a professor of sociology at Cornell, is conducting the largest study to date of Boomer retirement lifestyle preferences.[14] The study's preliminary findings suggest that there is a fundamental shift in how Baby Boomers view retirement. Moen says that "Communities, workplaces and society will have to accommodate to aging Baby Boomers who will move into retirement healthier, better educated and more energetic than any previous generation and who don't want their father's retirement."

About one-third of the Boomers surveyed are planning to keep on working. Others are looking for ways to cut back significantly on work while still continuing, part-time, to do the work they like best. About a third are considering more formal education. Two-thirds consider traveling and volunteering as important. Many view retirement as a chance to do things more in keeping with their ideas and ideals than they were able to do in full time jobs. Moen concludes that, "Many workers of this generation do not view retirement as the end of work but rather as a change in work and lifestyle, a time to do what you like and consider important rather than what you have to do."

The healthy, educated, active Boomer retirees of the generation ahead seem likely to generate many more trips than the more relaxed retirees of the generation just passed. They are less likely to be satisfied living in Sun City-type environments or suburbs distant from centers of activity. As driving becomes more difficult for many of them, they are likely to become strong advocates for improving transit services. The kind of neighborhoods advocated by proponents of the New Urbanism-traditional neighborhood designs centered on transit stations that connect out to the

larger urban area-is likely to be one of the kinds of living arrangements most appealing to aging, empty nest Boomers.

Demands for Transparency

Transportation agencies, like other government operations and business activities, are likely to face growing pressures for greater transparency-for operating in an open and accountable manner and providing the public with information it can use to evaluate an organization's performance. Today's headlines are filled with stories that reflect this growing pressure, from Enron and Arthur Anderson to the FBI.

The growing demands for transparency are broad-ranging. The strongest demands are for information related to the bottom line-economic performance. The pressure for greater transparency comes primarily from the marketplace itself. Financial markets can only function well when investors have the information they need to make judgments about who will most productively make use of their capital. The more the economy is in flux due to rapid technological change, globalization and other forces, the more investors need good information. The greatest nightmare for investors is that corporations they are invested in may be hiding losses or covering up activities that if revealed could cause a major drop in stock value.

Demands for transparency are also increasing for the "new bottom lines" of environmental and social responsibility. Home Depot, the world's largest lumber company, recently committed itself to stop purchasing lumber from endangered forests. The decision was largely the result of an e-mail, Internet, and mass media campaign that involved Internet coordination among hundreds of environmental organizations and grassroots groups around the world. In the late 1990s, when information circulated on the Internet showing that Nike produced some of its athletic shoes under unhealthy and exploitive working conditions, first CNN and then media outlets around the world picked up the story. The company quickly instituted sweeping reforms to protect its brand value from permanent damage.

As the pressure for external transparency grows, organizations will inevitably be pushed to be more transparent internally. Secrecy and distrust within bureaucracies sabotage efforts to motivate and empower employees and have them operate with a common purpose.

Transportation agencies influence the allocation of large amounts of money. They deal with a topic that really matters to citizens. Their decisions have major impacts not just on mobility but on the larger character

of urban development. They have close relationships to political leaders and to private sector contractors. All of these conditions will make them increasingly vulnerable to criticism as pressures for greater transparency continue to build in our society. The best protection is to take the initiative internally to operate in an increasingly open and accountable manner.

Theme 6: Wildcards

"Wildcards" are developments that are not currently viewed as likely, but that would have very large consequences if they should occur. Several of the potential developments listed below are actually highly likely in the long run, but would be surprising if they occurred in the decade ahead.

Near Term Oil Price Increases

Two potential developments could lead to large energy price increases in the '00s, with highly disruptive effects on transportation. The first is a significant cutback of oil available from the Middle East as a result of war, coordinated efforts to use the "oil weapon" to influence U.S. policy toward Israel, terrorism, or other disruptions. The probability of such developments is impossible to estimate, but it is clearly not zero.

The second development is a sooner-than-expected peaking and decline of global crude production. Several recent analysis have estimated that the peak year for world oil production could be as soon as 2004 to 2008, after which oil availability would begin to decline and prices would rapidly rise. These analyses are controversial, but they have been published in major peer-reviewed sources such as *Nature*, *Science* and *Scientific American*.[15] None of our political leaders have paid attention to these forecasts, so there has been no acceleration of the kind of actions that might mitigate the impacts.

A peaking of global production this early would be a truly disruptive wildcard. While energy efficiency and alternative energy sources could allow a smooth transition away from oil over the decades ahead, there is no way they could be brought into place fast enough to deal with a global production decline beginning in the '00s. The result would be rapidly raising oil prices with global economic disarray and particularly severe impacts on mobility and agriculture.

Rapid Rollout of the Segway

During 2001 the media gave a huge advertising boost to the thing called "It" being developed by Dean Kamen, a multimillionaire engineering legend with more than 150 patents. Amazon's Jeff Bezos and other

high tech industry leaders invested in It and touted it as a more important development than the personal computer or the Internet. As the time for revealing what It is grew near, some insiders got more specific and said it was the most revolutionary transportation invention since the automobile.

When It, now called the "Segway," was unveiled at the start of 2002, it turned out to be a two-wheeled personal transportation device about the size of a lawn mower, powered by a battery and stabilized by gyroscopes and 10 computers that keep it balanced. The rider stands on a platform over its single axel and holds on to handlebars that steer the device, leaning forward to accelerate up to 12.5 mph and leaning back to brake.

Segways are not on the market yet, but are being tested by the military, the Postal Service, the Atlanta police force, and General Electric-and winning enthusiastic fans. Most observers see the Segway as a high tech toy that will never have more than a small niche market. Kamen believes it's a wildcard that will happen, revolutionizing urban transportation.

Kamen has already spent nearly a million dollars lobbying legislatures, and 20 states have passed laws approving the use of Segways on public sidewalks. Nineteen other states are scheduled to consider the issue before the end of 2002. The Senate Committee on Environment and Public Works has approved on a voice vote a measure that allows the Segway to be used on all sidewalks and bike paths built with federal funds, as long as local authorities agree.

Segways would be most likely to become popular in states like Arizona where bad weather would seldom inhibit their use. They might be especially popular with aging baby boomers and retirees who could regain youthful mobility through the use of these "Human Transporters" (the other more formal name for the device). It is worthwhile considering what would happen if Segways catch on.

They weigh 69 to 95 pounds, depending on the model, and can carry up to 325 pounds (rider plus cargo). With that much mass, and traveling at 12 mph, some of the collisions that occur on sidewalks are sure to cause serious injuries. As more injuries occur, citizens and consumer groups will increasingly challenge the use of Segways on sidewalks, arguing that if bicycles, motor scooters, and rollerblades are not permitted on sidewalks in many cities, Segways should be banned as well. This might create unprecedented pressures for changes in urban design and transportation engineering toward more construction of bikeways and road lanes reserved for bicycles and Segways. In some areas, widespread Segway use might actually reduce traffic congestion.

Near Term Water Shortages Limit Development

Water issues are nothing new in Arizona, but there are a number of wildcard possibilities that could bring water limits on development into play earlier than expected. Water shortages in adjoining states might lead to renewed water conflicts that unhinge existing allocation agreements. The "death of the Gulf" might emerge as a major political and environmental issue as the lack of fresh water inflow and overfishing devastate the ecology of the Gulf of California. El Nino-driven drought and growing impacts of global warming might reduce water flows in the Colorado.

Developments like these may not be likely, but they are possible. In any case, it may not be too soon to think about what more "water-efficient settlement patterns" may need to be like, and to consider whether current transportation planning is encouraging or discouraging such patterns.

A Shift From SUVs to Hypercars
Americans love their big cars

Over half of passenger car sales last year were for gas-guzzling SUVs, minivans, and light trucks. Barring dramatic gas price increases, it seems highly unlikely that small economy cars will make a comeback. But there is a wildcard possibility that by the end of the decade the new rage will be big cars that get 70-100 miles per gallon. There is no doubt that vehicles like this are possible. They are a wildcard because a wide range of engineering improvements would need to be made by an industry not known for rapid innovation.

In 2000, Hypercar Incorporated, a firm spun off from the Rocky Mountain Institute in Colorado, designed a super-efficient cost-competitive, midsize-SUV concept car able to get the equivalent of 99 mpg. It can drive 330 miles on 7.5 pounds of compressed hydrogen. The car's body is made of ultralight carbon-fiber composite, which can absorb up to five times more crash energy per pound than steel. The body is mounted on a chassis platform that contains fuel cells, hydrogen tanks, the brake system, and a score of computers and auxiliary electronics. Electricity from the fuel cells drives electric motors mounted within all four wheels. Moving at 55 mph, the Hypercar uses no more power than a normal SUV needs just for its air conditioner.

GM's new AUTOnomy fuel cell-electric concept car draws on many of the ideas pioneered by Hypercar. A chassis platform GM's designers refer to as the "skateboard" is made of advanced composite material and houses all the drivetrain essentials and electronics. odies of various kinds,

from 2-seater sports cars to SUVs, can be mated to the skateboard. The mating is both physical-with mechanical locks-and electronic, with the upper body connecting to the platform much like a laptop docks into a docking station. Like the Hypercar design, the AUTOnomy combines steering, acceleration and braking in a drive-by-wire system with a vertical handle that the driver grips.

AUTOnomy represents GM's vision of how automobiles will be designed and built in 2020, so it would be surprising-but not impossible-to see vehicles like this on the road in the '00s. When they do appear, and reach a competitive price point, they are likely to be extremely popular.

Conclusion

There are four quite different lines of thinking that can be used to explore the policy implications the developments reviewed here may have for Arizona.

The first approach, which applies to comparatively likely developments, is to ask "How do we need to respond?" For example, it is virtually certain that Arizona's population will continue to grow older and that older people will drive more than they did in the past. Appropriate responses include measures such as improving the visibility of signage, road edges and lane separations and mandating better vision screening tests for drivers license renewal.

A second approach, which applies to areas of greater uncertainty, is to ask "What are the most "robust" policies or actions that make sense across a variety of future conditions?" For example, taking full advantage of emerging Advanced Traffic Management Systems and Advanced Public Transportation Systems will be essential if future traffic congestion is on the high side of the range of forecasts. But these actions make sense under almost any foreseeable conditions.

A third approach, which often applies in the areas of greatest controversy, is to ask "Do we need to seriously question our basic assumptions about this issue?" This is always difficult to do, impossible for some people who have been involved in a field for a long time. The critique of conventional transportation planning being put forward by smart growth advocates, the New Urbanism and others poses this question in a striking way. For Phoenix, in particular, it may be important to reexamine traditional assumptions and draw on ideas from the emerging alternative vision of how metropolitan areas should grow and how transporta-

tion choices can steer growth into new patterns.

The fourth approach is to focus on the preferred future and ask "What do we want the future to be like and how do we create it?" And then act to drive change rather than adapt to it. The recent actions of the California legislature to require cuts in the tailpipe emissions of greenhouse gases by cars and light trucks is a dramatic example of this approach, where California is literally challenging the federal government for the lead in setting environmental and transportation policy in the United States. If the California action holds against court challenges, it will accelerate the shifts described here to hybrid fuel-electric and then fuel cell-electric vehicles.

Applying these four questions to the developments reviewed here, as well as other topics, is an excellent methodology for making transportation strategies more creative and responsive. This kind of thinking can be done individually, but often works best in interactive facilitated workshop settings.

Adopting new ways of thinking about the future can help take transportation planning to a higher level where decisions are made with an understanding of their larger context, a wider range of possible futures are examined, and transportation choices are made with greater attention to their role in shaping a desirable future.

Notes

This paper was written for Cambridge Systematics and the Arizona Department of Transportation(ADOT), but it reflects only the views of the author. It is NOT an official ADOT publication and there is no implication that ADOT has adopted its conclusions. It is one of several papers ADOT commissioned from outsiders to help stimulate their thinking as they develop a statewide long range transportation plan.

1. Institute for Alternative Futures. 2002. "Environmental Scanning Methods," presentation to the seminar on Government Foresight at the Brookings Institution.
2. Thomas W. Bonnett and Robert L. Olson. 2000. "How Scenarios Enrich Public Policy Decisions" in *Learning From the Future*, Liam Fahey and Robert M. Randall, eds. (New York: John Wiley & Sons. Pp. 308-324.
3. Kenneth S. Deffeyes. 2001. *Hubbert's Peak*. Princeton, NJ: Princeton Univer-

sity Press.
4. International Energy Agency. 1998. *World Energy Outlook 1998* (Paris: IEA).
5. Michael Landwehr and Celine Marie-Lilliu. 2002. "Transportation Projections in OECD Regions - Detailed Report" (Paris: IEA).
6. Amory B. Lovins. 1999. "A Strategy for the Hydrogen Transition." paper for the 10th Annual Meeting of the U.S. Hydrogen Association, Vienna, Virginia, (Snowmass, Colorado: Rocky Mountain Institute).
7. Mobility for the 21st Century Task Force. 1996. *Mobility for the 21st Century: A Blueprint for the Future.* (Washington: American Public Transit Association).
8. Andres Duany, Elizabeth Plater-Zyberk, and Jeff Speck. 2000. "Suburban Nation: The Rise of Sprawl and the Decline of the American Dream." Chapter 5. *The American Transportation Mess.* New York: North Point Press. Pp. 88-93.
9. Stanley Hart and Alvin Spivak. 1993. *The Elephant in the Bedroom: Automobile Dependence and Denial; Impacts on the Economy and Environment.* Pasadena, Calif.: New Paradigm Books.
10. Andres Duany, Elizabeth Plater-Zyberk, and Jeff Speck. *Suburban Nation.* Pp. 62-87.
11. John S. Niles. 1994. *Beyond Telecommuting: A New Paradigm for the Effect of Telecommunications on Travel.* Berkeley: DOE Lawrence Berkeley Laboratory.
12. Ibid., p. 5.
13. "Older Drivers, Seeing is Believing." news story reported at <www.demko.com/m980302.htm>
14. Cornell University Newswise. 2001. "A Third of Baby Boomers Plan to Work Beyond Retirement" available online at<www.newswise.com/articles/2001/10/BOOMWORK.CNS.html>
15. C. B. Hatfield. 1977. "Oil Back on the Global Agenda." *Nature* 387:121. R. A. Kerr. 1998. "The Next Oil Crisis Looms Large-And Perhaps Close" *Science* 282:1128-31 C.A. Campbell and J. H. Laherrere. 1998. "The End of Cheap Oil." *Scientific American.* Pp. 78-83.