Current Mobility Trends – Implications for Sustainability 02

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This chapter investigates current mobility trends and their implications for sustainability. It discusses factors that affect transport demands (the amount and type of travel that people would choose in a particular situation) and how demographic and economic trends affect these demands. During most of the last century, motor vehicle travel grew steadily in most developed countries. During this period, it made sense to invest significant resources in expanding roads and parking facilities, so this became the focus of transport planning. However, per capita vehicle travel has peaked in most developed countries because of demographic and economic trends, including aging population, rising fuel prices, increasing urbanization and associated traffic and parking congestion, improving transport options, increasing health and environmental concerns and changing consumer preferences.

Motor vehicle travel imposes significant economic, social and environmental costs. An optimal transport system provides diverse mobility options and incentives to use the most efficient option for each trip, taking into account all benefits and costs. This implies that in many situations, it makes sense to shift resources currently devoted to accommodating automobile travel to improving alternative modes, in order to respond to changing consumer demands and to reduce problems that result from excessive automobile dependency. This chapter explores the implications of these changing demands and priorities on transport policy and planning decisions. It discusses ways to evaluate various transport benefits and costs, and the degree that these are considered in conventional planning. This analysis indicates that current planning is biased in various ways that favour mobility over accessibility and automobile travel over other modes. It discusses potential policy and planning reforms needed to better respond to user demands and help achieve sustainability goals.

1. Introduction

During the 20th century, motor vehicle travel grew steadily in most developed (industrialized) countries. During this period, it made sense to invest significant resources to accommodate this growth. However, travel demands (the amount and type of travel that people would choose in a particular situation) are changing. Per capita vehicle travel has peaked in most developed countries, and there is growing awareness of the problems that can result from excessive automobile dependency. It is time to reconsider some basic assumptions (Asian Development Bank, 2009). A *paradigm shift* (a change in the way problems are defined and potential solutions are evaluated) is occurring in the transport planning field, as summarized in Table 1. It is important that people involved in transport policy and planning activities understand this shift.

	Old paradigm	New paradigm
Definition of transportation	*Mobility:* movement of people and goods	*Accessibility:* ability to access goods, services and activities
Planning objectives	Maximize mobility, minimize time and monetary costs	Maximize accessibility, cost efficiency and user options. Respond to consumer demands
Impacts considered	Travel time, vehicle operating costs, risk, and some pollution emissions	Various external, indirect and non-market impacts, including negative effects of vehicle traffic on non-motorized travel, land use impacts, health and social equity objectives
Options considered	Primarily road and parking facility improvements, and major transit improvements on some urban corridors	Multiple modes (walking, cycling, ride-sharing, automobile, public transit, and telework) and demand management strategies (road space prioritization, pricing reforms, smart growth land use policies)
Consideration of travel demands	Focuses primarily on automobile travel demand. Seldom applies transportation demand management	Considers demand for all modes, including latent demands. Often considers transportation demand management solutions
Performance indicators	Vehicle travel speeds, vehicle operating cost per person-mile, roadway level-of-service	*Accessibility:* number of opportunities people can reach within a given time and money budget. Service quality of various modes
Favored improvements	Projects that increase motor vehicle travel speeds	Policies and projects that increase transport system efficiency and diversity

Table 1. Comparing transport planning paradigms (Litman 1999).
This table compares the old and new transport planning paradigms. The new paradigm is sometimes considered sustainable transport planning.

The old paradigm defines *transport* based primarily on *mobility* (physical travel), which assumes that society's goal is to increase travel speed and distance. However, mobility is seldom an end in itself; the ultimate goal of most transport is *accessibility* (or *just access*), which refers to people's ability to reach desired goods, services and activities (together called *opportunities*) (Chapman & Weir, 2008; Litman, 2003). Many factors affect accessibility including the quality of mobility options available (the ease of walking, cycling, automobile travel, public transit and taxi services), the location of destinations (the distance between homes, worksites, schools, shops and parks), path and roadway connectivity and the quality of mobility substitutes such as telecommunications and delivery services.

Planning decisions often involve trade-offs between different types of access. For example, roadway expansions tend to improve automobile access but reduce access by non-motorized modes. Bus-lane and bike-lane development often requires reducing traffic or parking lanes. Land use patterns that maximize automobile access, with activities located along major roadways and abundant parking supply, are generally difficult to access by other modes. It is important that decision-makers understand the full impacts of such decisions, including the negative impacts that unintentionally result from efforts intended to improve motor vehicle travel.

An efficient and equitable transport system is diverse, so travellers can choose the best accessibility option for each type of trip. This means, for example, that walking and cycling are convenient and safe for local errands, high-quality public transit is available for efficient travel on major travel corridors, and automobiles can be used to reach dispersed destinations or carry loads. To the degree that current planning practices favour mobility over accessibility and automobile travel over other modes, they result in excessively automobile-dependent communities, forcing people to drive more than overall optimal.

The current planning process is biased in many, often subtle ways. For example, transport system performance is often evaluated primarily on the basis of roadway level-of-service, which reflects automobile travel speed and affordability. This justifies roadway expansion to improve motor vehicle accessibility, but ignores the negative impacts this can have on other accessibility factors. By evaluating only impacts on motor vehicle accessibility while ignoring many of the negative impacts that result from wider roadways, this type of performance evaluation often results in economically excessive roadway expansion and inadequate investment in alternative modes. Similarly, generous minimum parking requirements, and traffic impact analysis that impose higher costs on compact, infill development, create more sprawled, less walkable and transit-oriented communities than would otherwise occur. More optimal planning requires more comprehensive and multi-modal analysis. For example, project and policy analysis should account for the increased transport costs that result if wider roads and increased motor vehicle traffic force residents to drive for local trips that could otherwise be made by non-motorized modes, and the reduction in accessibility that would result from sprawled land use development.

The old transport planning paradigm tends to reflect an engineering perspective: It optimizes for one primary objective, mobility. The new paradigm tends to reflect an economic perspective: It recognizes that planning should consider diverse objectives, impacts and options.

By applying accessibility-based planning, the new paradigm greatly expands the variety of solutions that can be applied to transport problems, which can increase cost efficiency and total benefits. For example, with the old paradigm, the only solution to traffic and parking congestion problems is to expand road and parking facilities, which is costly, and by increasing total vehicle travel tends to exacerbate other traffic problems. The new paradigm allows consideration of other solutions, including improvements to alternative modes, incentives to use alternatives, and smart growth land use policies that reduce the amount of vehicle travel generated in a community. These solutions are often more cost effective and beneficial overall.

The new planning paradigm requires comprehensive understanding of transport demands to determine the types of facilities and services users want, and how they would respond to transport system changes. For example, the new planning paradigm recognizes the possibility of latent demand for alternative modes, that is, people would sometimes prefer to drive less and rely more on walking, cycling and public transport, if given suitable options. This information can be used to design effective demand management strategies, such as improvements to alternative modes, efficient transport pricing, and smart growth land use policies, in order to achieve planning objectives such as congestion reduction, cost savings, improved public safety and health and environmental protection. The following section discusses this issue.

2. Factors Affecting Transportation Demands

Various factors affect transport demands, as summarized in Table 2. These factors can help predict how demographic and economic trends will affect future travel demands, and they can be used to better respond to user needs and to develop demand management programmes that increase system efficiency.

Demographics	Economics	Prices	Transport options	Service quality	Land use
Number of people (residents, employees and visitors) Incomes Age/lifecycle Lifestyles Preferences	Number of jobs Incomes Business activity Freight transport Tourist activity	Fuel prices and taxes Vehicle taxes & fees Road tolls Parking fees Vehicle insurance Public transport fares	Walking Cycling Public transit Ridesharing Automobile Taxi services Telework Delivery services	Relative speed and delay Reliability Comfort Safety and security Waiting conditions Parking conditions User information Social status	Density Mix Walkability Connectivity Transit service proximity Roadway design

Table 2. Factors that affect transport demand (Litman 2008).
This table indicates various factors that affect transport demand, which should be considered in transport planning and modeling, and can be used to manage demand.

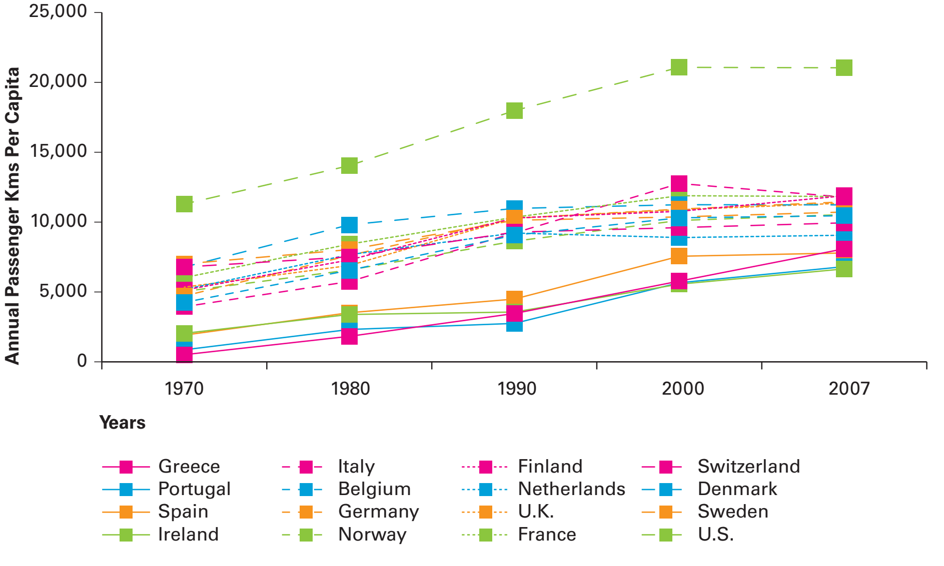

Figure 1. International Vehicle Travel Trends (EC 2007; FHWA, Various Years).
Per capita vehicle travel grew rapidly between 1970 and 1990, but has since leveled off and is much lower in European countries than in the U.S.

This is important and timely because current demographic and economic trends are significantly changing travel demands (Goodwin, 2011; Litman, 2006; Metz, 2010; Millard-Ball & Schipper, 2010). Per capita motor vehicle travel grew rapidly during most of the 20th century but recently peaked and declined slightly in most developed (industrialized) countries, as illustrated in Figure 1. The level at which vehicle travel peaks varies, depending on transport and land use policies; low fuel prices, abundant highway expansion and low-density land use development result in two to three times as much per capita vehicle travel in the United States as in other wealthy countries. This indicates that our transport policies and planning practices will need to change in order to respond to future needs and preferences, and demand management strategies can help achieve strategic planning objectives, such as reducing traffic congestion, accidents, energy consumption and pollution emissions.

Several specific factors have contributed to the peaking of vehicle travel:

Motor vehicle saturation. Motor vehicle ownership and use grew steadily in most developed countries during the 20th century. In many areas, there is nearly one motor vehicle for every licensed driver and most travel is by automobiles. In those situations, people have little reason to own more vehicles and little opportunity to drive more annual kilometres.

Wealth effect. As households become wealthier, their vehicle ownership tends to increase, but at a declining rate (Dargay, Gately & Sommer, 2007). International data indicate that below about $10,000 annual income per capita (2002 U.S. dollars), automobile ownership and annual kilometre rates tend to increase about twice as fast as income growth, but at higher incomes growth rates level off and eventually saturate (Millard-Ball & Schipper, 2010). Karlaftis and Golias (2002) find that households' purchase of their first vehicles depends primarily on socioeconomic factors (employment and income), but additional vehicles depend on the quality of access options available, making multiple household vehicle ownership rates responsive to transport and land use planning decisions.

Aging population. People tend to reduce their vehicle travel by 40-60% after they retire and by more as they age into their 70s, 80s and 90s.

Rising fuel prices. Higher fuel prices tend to reduce vehicle travel, particularly over the long run (long-term effects tend to be three times greater than short-term effects). Real (inflation-adjusted) fuel prices have increased during the last decade, and high prices are expected to continue into the future.

Increased urbanization. Urban area residents tend to drive 20-60% less than they would in automobile-oriented, suburban and rural locations. Urbanization has increased in most countries, both from migrations to urban areas and because many suburbs are becoming more urbanized. Current real estate trends tend to favour urbanization (Litman, 2010). Surveys indicate that an increasing portion of households would choose smaller-lot, urban home locations if they provide better travel options (better walking, cycling and public transit), more local services (nearby shops, schools and parks) and shorter commute distances (Myers & Ryu, 2008; Urban Land Institute, 2009).

Improving transport options and incentives. Many communities are improving walking and cycling conditions, rideshare and public transport service quality and telecommunications and delivery services, and are implementing various transportation demand management strategies to encourage use of efficient transport options. This is increasing use of alternative modes and mobility substitutes such as telecommuting and Internet shopping.

Changing consumer preferences. The younger generation appears to place less value on vehicle ownership and suburban living (Santos, McGuckin, Nakamoto, Gray, & Liss, 2011). Car ownership and travel declined, and use of other modes increased, among German and British 20- to 29-year-olds (Kuhnimhof, Buehler, & Dargay, 2011). Sivak and Schoettle (2011) find that, controlling for other factors, an increase in Internet use is associated with a decline in drivers' licence rates, suggesting that telecommunications substitutes for physical travel.

Increased health and environmental concerns. Although largely anecdotal, there is evidence that many people would prefer to drive less and rely more on alternative modes owing to health and environmental concerns. These issues also affect public policy, resulting in energy conservation and emission reduction, and active transport encouragement programmes in many jurisdictions.

As people become wealthier, they tend to be less price sensitive and more sensitive to service quality. In the past, this usually resulted in shifts from basic public transit (such as buses operated in mixed traffic) to personal automobile travel. However, it sometimes has other effects. For example, some households use additional wealth to purchase more accessible homes (in more central, walkable neighborhood) or to travel by high-quality public transport (such as express buses or trains). This implies that some travellers would shift to more efficient alternatives if their quality was improved. For example, it is possible that some relatively wealthy people could shift from driving to public transit if it had amenities such as comfortable seats, on-board Internet access and refreshment services.

Although impacts vary, there is now good evidence to indicate that in most developed countries total vehicle travel has peaked, and in many communities there is latent demand for alternatives: Many people would prefer to drive less and rely more on alternative modes, provided that they are convenient, comfortable, safe and affordable.

Existing transport demand models are poor at accounting for these factors. There is research on the effects that individual, demographic, income, price and land use factors have on travel activity, but many of these factors interact, making it difficult to predict future travel demands, particularly over the long run. For example, we can predict that people usually reduce their annual vehicle travel when they retire, and we can also predict that future generations of retirees will probably drive more annual kilometres than they did in the past. We can also predict that the amount that people reduce their driving will depend on the quality of alternatives, where they live, and future fuel prices. However, it is difficult to predict exactly how these various factors will interact.

It is also difficult to predict future freight travel demands. During the last several centuries, shipping costs declined steadily, stimulating increased freight volumes (Figure 2). Over time, the scale and efficiency of marine, rail and truck transport increased. Containerization, intermodalism, deregulation and various technical and logistical improvements continued to reduce shipping costs and to increase speeds, particularly for long-distance travel. Unit costs often declined by an order of magnitude during the last century. Although such improvements are likely to continue, particularly increased use of information technologies to automate and optimize flows, future cost reductions will probably be more modest and may be

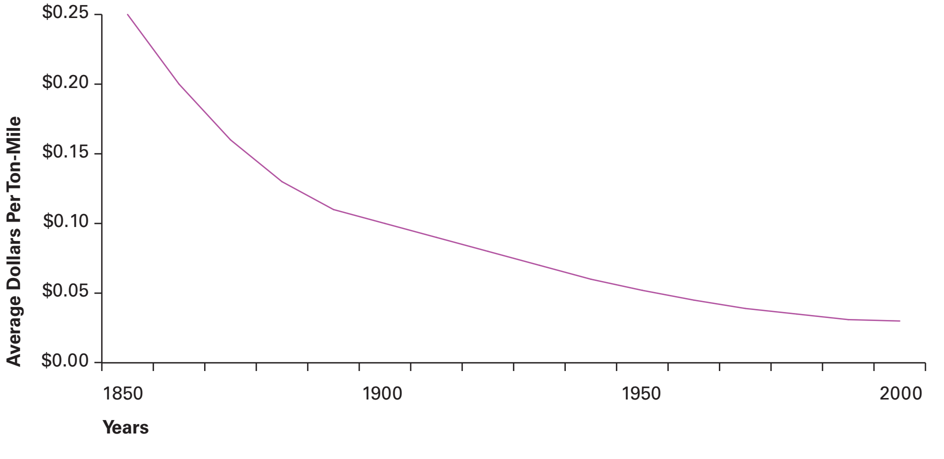

Figure 2. Railroad freight costs (Garrison & Levinson 2006, p. 290).
Shipping costs per ton-mile declined significantly during the last 150 years.

offset by increased fuel prices, particularly for truck transport. When transport costs are a major portion of total retail prices, transport cost reductions significantly increase sales and shipping volumes, but further cost reductions have less impact.

As a result, freight transport demand will probably continue to grow, particularly on high-volume routes, but the growth will probably be at a lower rate than during the last half century, particularly for intraregional shipping.

Similarly, long-distance travel, particularly personal air travel, tends to be sensitive to price and income (Dargay, 2010; InterVISTAS, 2007). As a result, total worldwide air travel demand is likely to continue growing in the future, particularly from developing countries, but the growth rate may decline if fuel prices continue to increase.

This suggests that both freight and long-distance air travel demand growth will result primarily from increased demand by developing countries and will be concentrated on major corridors where scale economies can maintain low prices despite rising fuel prices. For example, there may be further growth in freight and air travel volumes between Asia, the Americas and Europe, but less growth, and possibly declines, on many routes within Europe. Much of this growth will probably be met through increased efficiencies, such as larger jets and ships, and faster loading. Although some large airports and ports may continue to experience congestion, others may experience overcapacity. It will be important to identify appropriate niches on the basis of competitive advantages and strategic planning and to avoid overbuilding freight and airport capacity.

3. New Technologies

It is worth considering how future technological improvements are likely to affect transport demands. Past technological innovations (better vehicles, drive systems, roadway designs, logical management) improved motor vehicle performance (power, speed, safety, reliability and comfort), which reduced costs (money, time, discomfort and risk per kilometre of travel) and increased travel demand. Many newer transport innovations improve alternative modes or allow more efficient pricing. Table 3 categorizes technologies according to their vehicle travel impacts. More new technologies are likely to reduce rather than to increase vehicle travel. The mobility effects of specific new technologies are discussed on the next page.

Telework

Telework refers to the use of electronic communication to substitute for physical travel, including commuting, business activities and errands such as shopping and banking.

Increases motorized travel	Mixed mobility impacts	Reduces motorized travel
Increased fuel efficiency and cheaper alternative fuels Increased vehicle comfort Automated driving	Electronic vehicle navigation Improved traffic signal control	Telework (electronic communication that substitutes for physical travel) Improved road and parking pricing Improved transit user information Transit service improvements Improved rideshare matching Improved delivery services Improved carsharing services

Table 3. Travel impacts of new transport technologies (Litman 2006).
Some new technologies tend to increase vehicle travel, others tend to reduce it.

There is evidence that Internet shopping is replacing some physical trips (Santos et al., 2011). The Internet can also increase potential travel demand, for example, by helping people make and maintain long-distance friendships.

Intelligent Transportation Systems

Intelligent Transportation Systems (ITS) apply computers and electronic communication to improve transport services. Although ITS research initially focused on automated driving, which probably would increase vehicle travel, implementation of this strategy has been slow. So far, ITS successes have consisted primarily of driver information and navigation services, transit user information, transit priority systems and better road and parking pricing, which tend to reduce rather than to increase motor vehicle travel.

New Modes

Some new modes could develop during the next century, such as Personal Rapid Transit (PRT), Magnetic Levitation (Maglev) trains, flying cars, Segways and their variants. There may also be new transport services, such as commercial space travel and more underwater tunnels replacing ferry travel. Their overall impacts are likely to be modest since they serve only a small portion of trips. For example, even if Maglev technology is perfected, it is only suitable for medium-distance (50-500 km) trips on heavy traffic corridors. It may increase long-distance commuting in a few areas, but have little effect on other travel. Only if Maglev systems stimulate transit oriented development (compact communities designed around transit stations) is overall travel likely to change, and this will result from land use changes, not the technology itself.

Usually considered	Often overlooked
Financial costs to governments	Downstream congestion impacts
Travel speed (reduced congestion delays)	Traffic impacts on non-motorized travel
Vehicle operating costs (fuel, tolls, tyre wear)	Parking costs
Per-km crash risk	Vehicle ownership and mileage-based depreciation
Project construction environmental impacts	Indirect environmental impacts
Per-km air and noise emissions	Strategic land use impacts
	Transportation diversity value (*e.g.*, mobility for non-drivers)
	Equity impacts
	Impacts on physical activity and public health

Table 4.Scope of conventional planning analysis.
Conventional transportation planning tends to focus on a limited set of impacts.

Similarly, Segways are unlikely to affect overall travel unless implemented with urban design and traffic management changes to favour local, slower-speed modes over automobile traffic.

Alternative Fuels
Various alternatives may replace petroleum as the primary vehicle fuel, but virtually all currently being developed will be more expensive than what petroleum cost in the past, and most alternatives impose their own problems, such as the high carbon content of petroleum produced by tar sands and coal liquefication, and the economic and environmental costs of increasing electrical production to power electric vehicles. As a result, alternative fuels are unlikely to reduce future vehicle operating costs.

4. Comprehensive Evaluation

Conventional transportation planning tends to consider a relatively limited set of benefits and costs when evaluating transportation policies and projects, as summarized in Table 4. For example, conventional transport project economic evaluation models such as MicroBenCost and HDM4 were originally developed to evaluate specific highway projects, and so they only consider project costs and marginal changes in travel time, vehicle operating costs, accidents and sometimes pollution emissions. These models generally ignore parking costs, and therefore the parking cost savings to businesses if more of their employees and customers arrive by alternative modes, nor do they consider vehicle ownership costs and therefore the savings to households that result from improved mobility options. Most models ignore the induced vehicle travel that results from urban highway expansion and from fuel and parking subsidies, and the incremental congestion, accidents and pollution that results. Most evaluation models seem to assume that everybody (or at least, everybody model makers consider important) has the ability to drive and so assign no value to transport policies and programmes that improve accessibility for non-drivers.

Planning objective	Definition	Consideration in conventional planning
Increased user convenience and comfort	More convenient and comfortable conditions for transport system users, including better walking and cycling conditions, and better transit service	Although often recognized as desirable, not generally quantified or included in benefit-cost analysis
Congestion reduction	Reduced delays, and associated reductions in travel time, fuel costs and pollution emissions.	Motor vehicle congestion costs are widely recognized and quantified, but delays to non-motorized travel (called the "barrier effect") is generally ignored
Roadway cost savings	Reduced costs for building and main-taining roadways	Generally considered
Parking cost savings	Reduced costs for building and main-taining parking facilities	Generally ignored
Consumer cost savings	Reduced costs to users to own and operate vehicles, and for public transit fares.	Operating cost savings are generally recognized but vehicle ownership savings are generally ignored
Reduced traffic accidents	Reduced per capita traffic crashes and associated costs	Crash risk, measured per vehicle-mile, is often considered, but impacts of changes in vehicle mileage are gener-ally ignored
Improved mobility options	Improved quantity and quality of transport options, particularly afford-able modes that serve non-drivers	Sometimes recognized as a planning objective but seldom quantified or included in formal economic evaluation
Energy conservation	Reduced energy consumption, particularly petroleum products	Sometimes recognized
Pollution reduction	Reduced emissions of harmful air, noise and water pollution	Sometimes recognized. Generally measured per vehicle-km.
Physical fitness and health	Improved physical fitness and health, particularly more walking and cycling by otherwise sedentary people	Not usually considered in the past. Sometimes recognized now, but seldom quantified
Land use objectives	Support for various land use planning objectives	Sometimes recognized as a planning objective but seldom quantified or included in formal economic evaluation

Table 5. Comprehensive planning objectives (Litman 2011).
"Planning objectives" are desirable outcomes, the opposite of "problems". This table lists various transport planning objectives and the degree they are considered in conventional planning.

As a result, such models are unsuited to evaluating decisions that involve choosing between alternative modes or for evaluating demand management strategies. For example, if used to compare a highway expansion project, a transit improvement project and congestion pricing, they will fail to account for the parking cost savings to governments and businesses that result if commuters shift from driving to alternative modes, and the cost savings that can result if improved public transit service allows some households to reduce their vehicle ownership.

Planning objective	Roadway expansion	Fuel efficient vehicles	Improve transport options	Price reforms
User convenience and comfort	•		•	•
Congestion reduction	•		•	•
Improved pedestrian access			•	•
Roadway cost savings			•	•
Parking cost savings			•	•
Consumer cost savings		Mixed	•	Mixed
Reduced traffic accidents			•	•
Improved mobility options			•	•
Energy conservation		•	•	•
Pollution reduction		•	•	•
Physical fitness & health			•	•
Land use objectives			•	•

Table 6. Comparing strategies (Litman 2011).
(• = Achieve objectives.) Roadway expansion and more fuel efficient vehicles help achieve relatively few objectives. Improving transport options and transport pricing tend to achieve a broader range of objectives.

This is not to suggest that these additional objectives and impacts are totally overlooked in the planning process. They are sometimes considered qualitatively or during public comment. However, they are not generally considered in economic evaluation, when calculating net benefits, and so receive less weight. This biases planning towards mobility over accessibility and automobile improvements over alternatives. More comprehensive transport planning analysis considers a wider set of planning objectives and impacts. Table 5 identifies a set of planning objectives and discusses the degree to which they are considered in a conventional planning process.

Many transport improvement strategies can achieve only a few of these objectives. For example, expanding highways increases user comfort and reduces traffic congestion, and increasing vehicle fuel efficiency conserves energy and pollution emissions and provides fuel savings. Some strategies provide a broader range of benefits. Table 6 compares the range of planning objectives achieved by various strategies.

Some studies have quantified and monetized (measuring in monetary units) these impacts, as indicated in Figure 3. This allows the costs of various different vehicles, travel modes and travel activities to be compared. These impacts can be categorized in various ways. In general, impacts that are variable (they increase with the amount that a person travels) and internal (borne directly by users)

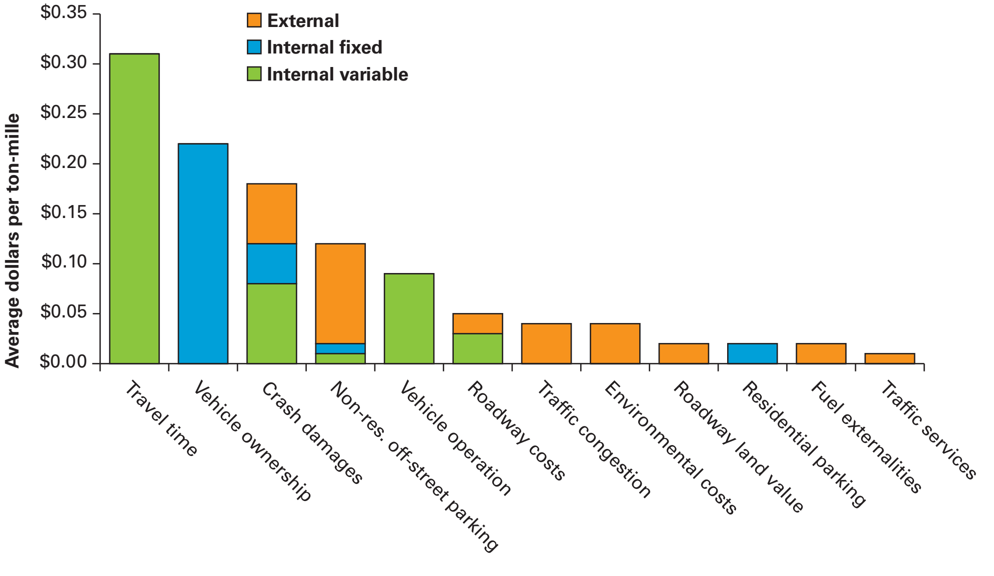

Figure 3. Per-mile costs of automobile use (Litman 2009).
This figure illustrates the estimated costs of motor vehicle ownership and use, averaged per vehicle-mile.

are most efficient and equitable. This analysis indicates that a major portion of automobile travel costs are inefficient and inequitable. Traffic congestion and air pollution, the costs that tend to receive the greatest consideration in transportation planning, are modest in magnitude overall. A policy or programme that reduces congestion or pollution but results in even modest increases in other costs, such as vehicle ownership, road and parking facility costs or crashes, is likely to harm society overall.

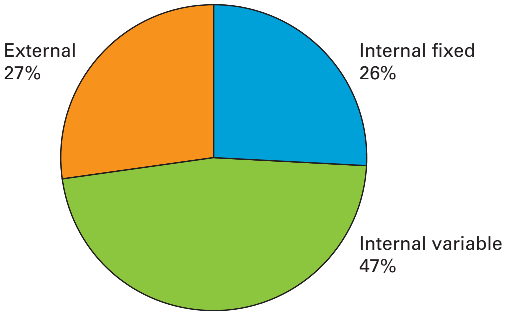

Figure 4. Average distribution of automobile costs (Litman 2009).
Less than half of the total costs of automobile use are internal-variable.

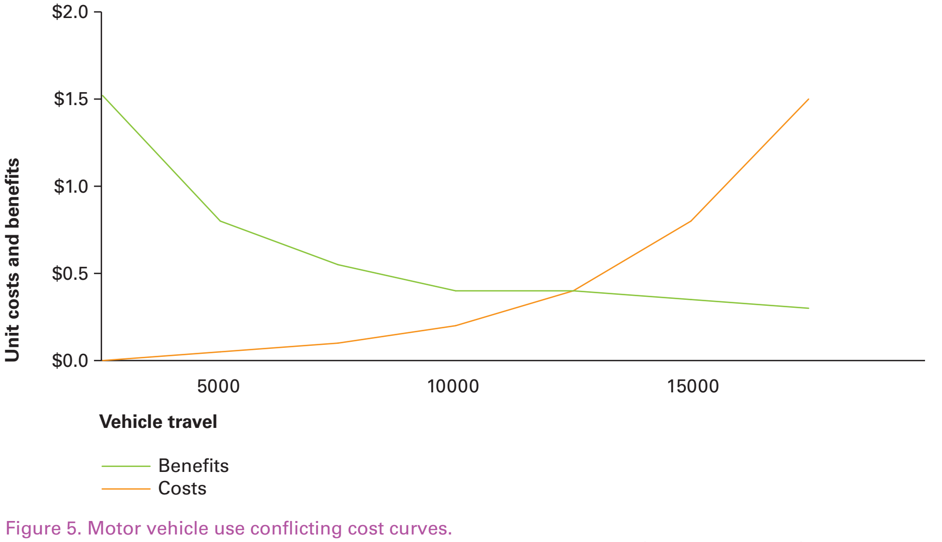

Figure 5. Motor vehicle use conflicting cost curves.
Although some vehicle trips have very large benefits, the benefit curve (or demand curve) declines with increased vehicle travel. Costs, however, increase, particularly as the system becomes congested. As a result, beyond a certain point, marginal costs exceed marginal benefits, so society is better off with reduced vehicle travel.

Name	Description	Transport Impacts
Least-Cost Planning	More comprehensive and neutral planning and investment practices	Increases support for alternative modes and mobility management
Mobility Management Programs	Local and regional programs that support and courage use of alternative modes	Increases use of alternative modes
Commute Trip Reduction (CTR)	Programs by employers to encourage alternative commute options	Reduces automobile commute travel
Commuter Financial Incentives	Offers commuters financial incentives for using alternative modes	Encourages use of alternative commute modes
Fuel Taxes - Tax Shifting	Higher fuel and vehicle taxes	Reduces fuel consumption and vehicle travel
Pay-As-You-Drive Pricing	Converts fixed vehicle charges into mileage-based fees	Reduces vehicle mileage
Efficient Road Pricing	Charges users directly for road use, with rates that reflect costs imposed	Reduces vehicle mileage, particularly under congested conditions
Parking Management	Various strategies that result in more efficient use of parking facilities	Reduces parking demand and facility costs, and encourages use of alternative modes
Parking Pricing	Charges users directly for parking facility use, often with variable rates	Reduces parking demand and facility costs, and encourages use of alternative modes
Transit and Rideshare Improvements	Improves transit and rideshare services	Increases transit use, vanpooling and carpooling
HOV Priority	Improves transit and rideshare speed and convenience	Increases transit and rideshare use, particularly in congested conditions
Walking and Cycling Improvements	Improves walking and cycling conditions	Encourages use of nonmotorized modes, and supports transit and smart growth
Smart Growth Policies	More accessible, multi-modal land use development patterns	Reduces automobile use and trip distances, and increases use of alternative modes
Location Efficient Housing and Mortgages	Encourage businesses and households to choose more accessible locations	Reduces automobile use and trip distances, and increases use of alternative modes
Mobility Management Marketing	Improved information and encouragement for transport options	Encourages shifts to alternative modes
Freight Transport Management	Encourage businesses to use more efficient transportation options	Reduces truck transport
School and Campus Trip Management	Encourage parents and students to use alternative modes for school commutes	Reduces driving and increases use of alternative modes by parents and children
Regulatory Reforms	Reduced barriers to transport innovations	Improves travel options
Carsharing	Vehicle rental services that substitute for private automobile ownership	Reduces automobile ownership and use
Traffic Calming and Traffic Management	Roadway designs that reduce vehicle traffic volumes and speeds	Reduces driving, improved walking and cycling conditions

Table 7. Win-win strategies (IGES 2011; Litman 2011).
There are various Win-win strategies, which encourage more efficient transportation.

On the other hand, a congestion or pollution reduction strategy becomes far more valuable to society if it also reduces these other costs. This emphasizes the importance of finding solutions that provide multiple benefits.

Figure 3 presents these costs measured per vehicle mile. Figure 4 summarizes the total of these costs, indicating that approximately a quarter of all automobile costs are external, and another quarter are external-fixed (users must pay them regardless of how much they drive).

The motor vehicle transport provides significant benefits, but like most goods, benefits diminish marginally because consumers are rational enough to choose more benefit travel before less beneficial travel. For example, if some vehicle trips are very beneficial, consumers will choose them even if prices are high, but will forego vehicle trips that provide little benefit or have good substitutes. Costs, however, tend to increase, particularly once a system becomes congested, as illustrated in Figure 5. As a result, beyond a certain level, increased vehicle travel imposes more costs than benefits. At that point, society benefits from demand management strategies that reduce lower value while allowing higher value vehicle travel.

5. Strategies for More Sustainable Transport

Several "win-win" policy and planning reforms, summarized in Table 7, can help create more efficient transport systems by improving resource-efficient transport options and giving travellers incentives to choose the most efficient option for each trip. They tend to reflect market principles, including comprehensive evaluation, consumer sovereignty and efficient pricing.

6. Performance Evaluation

Performance evaluation refers to a monitoring and analysis process to determine how well policies, programmes and projects perform with regard to their intended goals and objectives. *Performance indicators* (also called *measures of effectiveness*) are specific measurable outcomes used to evaluate progress towards established goals and objectives (Dhinghi, 2011; Joumard & Gudmundsson, 2010). More comprehensive transport planning requires multi-modal performance indicators, such as those listed in Table 8.

It will be useful for international transportation professional organizations to develop more consistent data collection practices to support more comprehensive and multi-modal performance evaluation (Bongardt, Schmid, Huizenga, & Litman, 2011; Litman 2007; Global Transport Intelligence Initiative; Sustainable Transportation Indicators, 2008).

Mode	Service quality	Outcomes	Cost efficiency
Walking	Sidewalk/path supply Pedestrian LOS Crosswalk conditions	Pedestrian mode split Avg. annual walk distance Pedestrian crash rates	Cost per sidewalk-km Cost per walk-km Cost per capita
Cycling	Bike path and lane supply Cycling LOS Path conditions	Bicycle mode split Avg. annual cycle distance Cyclist crash rates	Cost per path-km Cost per cycle-km Cost per capita
Automobile	Roadway supply Roadway pavement condition Roadway LOS Parking availability	Avg. auto trip travel time Vehicle energy consumption and pollution emissions Motor vehicle crash rates	Cost per lane-km Cost per vehicle-km User cost per capita External cost per capita
Public transit	Transit supply Transit LOS Transit stop and station quality Fare affordability	Transit mode split Per capita transit travel Avg. transit trip travel time Transit crash and assault rates	User cost per pass.-km User cost per capita Subsidy per capita
Taxi	Taxi supply Average response time	Taxi use Taxi crash and assault rates	Cost per taxi-trip External costs
Multi-modal	Transport system integration Accessibility from homes to common destinations User survey results	Total transportation costs Total average commute time Total crash casualty rates	Total cost passenger-km Total cost per capita External cost per capita
Aviation	Airport supply Air travel service frequency Air travel reliability	Air travel use Air travel crash rates	Cost per trip External costs Airport subsidies
Rail	Rail line supply Rail service speed and reliability	Rail mode split Rail traffic volumes Rail crash rates	Cost per rail-km Cost per tonne-km External costs
Marine	Marine service supply Marine service speed and reliability	Marine mode split Marine traffic volumes Marine accident rates	Cost per tonne-km Subsidies External costs

Table 8. Multi-modal performance indicators.
This table illustrates various types of performance indicators.

7. Conclusions

The 20th century was the period of automobile ascendency. Between 1900 and 2000, automobile travel grew from almost nothing to becoming the dominant transport mode in most economically developed regions. During this time, it made sense to devote significant resources to accommodating increased vehicle travel demand. Much of our current transport policies and planning practices developed during that period. This analysis indicates that current transport policies and planning practices are biased in ways that favour mobility over accessibility and automobile travel over other modes. This has created automobile-dependent transportation systems and economically excessive motor vehicle travel, which exacerbates various economic, social and environmental costs. These existing policies and practices are unsuited to solve future problems.

A number of current trends are reducing demand for automobile travel and increasing demand for more alternatives. This is not to suggest that everybody wants to give up automobile travel completely, but this analysis indicates that at the margin – compared with their current transport patterns – many people would prefer to drive less and rely more on alternatives, provided they are convenient, comfortable, safe and affordable. Freight and air travel may continue to increase in the future, particularly on major corridors, provided that prices remain low, although how much is difficult to predict.

In the past, as people became wealthier, their motor vehicle travel tended to increase. This is no longer true. Most developed countries have reached vehicle saturation. The level at which automobile ownership and use peaks depends on transport and land use policies; automobile-oriented policies (such as generous roadway capacity, poor walking and cycling conditions, inferior public transit service, low fuel and parking prices and sprawled land use development) cause vehicle travel to peak at high levels (more than 20,000 annual kilometres per capita), but if policies are more multi-modal, the peaks will be much lower. Some cities have demonstrated that relatively wealthy people will walk, bicycle and use public transit, provided they are of high quality.

Although motor vehicle travel provides significant benefits, like most goods, these diminish marginally. Motor vehicle travel also imposes significant costs, including many that are external, indirect and non-market. A more efficient transport system offers travellers a diverse range of accessibility options, with incentives to use the most efficient option for each trip. A number of "win-win" transportation policy reforms can help correct existing market distortions, resulting in a more diverse and efficient transport system. These strategies ensure that higher value trips can be made conveniently and efficiently while preventing lower-value vehicle travel that imposes more costs than benefits.

These reforms are justified on market principles, including comprehensive evaluation, consumer sovereignty and efficient pricing. Because they provide multiple benefits they can gain broad support from diverse interest groups. It will be important to educate stakeholders about the principles of sustainable transport planning and the full potential benefits of win-win solutions.

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