



Sustento del uso justo
de Materiales Protegidos
derechos de autor para
fines educativos



UCI

Universidad para la
Cooperación Internacional

UCI
Sustento del uso justo de materiales protegidos por
derechos de autor para fines educativos

El siguiente material ha sido reproducido, con fines estrictamente didácticos e ilustrativos de los temas en cuestión, se utilizan en el campus virtual de la Universidad para la Cooperación Internacional – UCI – para ser usados exclusivamente para la función docente y el estudio privado de los estudiantes pertenecientes a los programas académicos.

La UCI desea dejar constancia de su estricto respeto a las legislaciones relacionadas con la propiedad intelectual. Todo material digital disponible para un curso y sus estudiantes tiene fines educativos y de investigación. No media en el uso de estos materiales fines de lucro, se entiende como casos especiales para fines educativos a distancia y en lugares donde no atenta contra la normal explotación de la obra y no afecta los intereses legítimos de ningún actor.

La UCI hace un USO JUSTO del material, sustentado en las excepciones a las leyes de derechos de autor establecidas en las siguientes normativas:

a- Legislación costarricense: Ley sobre Derechos de Autor y Derechos Conexos, No.6683 de 14 de octubre de 1982 - artículo 73, la Ley sobre Procedimientos de Observancia de los Derechos de Propiedad Intelectual, No. 8039 – artículo 58, permiten el copiado parcial de obras para la ilustración educativa.

b- Legislación Mexicana; Ley Federal de Derechos de Autor; artículo 147.

c- Legislación de Estados Unidos de América: En referencia al uso justo, menciona: "está consagrado en el artículo 106 de la ley de derecho de autor de los Estados Unidos (U.S, Copyright - Act) y establece un uso libre y gratuito de las obras para fines de crítica, comentarios y noticias, reportajes y docencia (lo que incluye la realización de copias para su uso en clase)."

d- Legislación Canadiense: Ley de derechos de autor C-11– Referidos a Excepciones para Educación a Distancia.

e- OMPI: En el marco de la legislación internacional, según la Organización Mundial de Propiedad Intelectual lo previsto por los tratados internacionales sobre esta materia. El artículo 10(2) del Convenio de Berna, permite a los países miembros establecer limitaciones o excepciones respecto a la posibilidad de utilizar lícitamente las obras literarias o artísticas a título de ilustración de la enseñanza, por medio de publicaciones, emisiones de radio o grabaciones sonoras o visuales.

Además y por indicación de la UCI, los estudiantes del campus virtual tienen el deber de cumplir con lo que establezca la legislación correspondiente en materia de derechos de autor, en su país de residencia.

Finalmente, reiteramos que en UCI no lucramos con las obras de terceros, somos estrictos con respecto al plagio, y no restringimos de ninguna manera el que nuestros estudiantes, académicos e investigadores accedan comercialmente o adquieran los documentos disponibles en el mercado editorial, sea directamente los documentos, o por medio de bases de datos científicas, pagando ellos mismos los costos asociados a dichos accesos.

Evaluating Complete Streets

The Value of Designing Roads For Diverse Modes, Users and Activities
24 August 2015

By
Todd Litman
Victoria Transport Policy Institute



Original four-lane arterial designed to maximize motor vehicle traffic speeds.

(Photo Source: City of Urbana, Illinois)



Complete street with center turn lane, bike lane and pedestrian refuge island at bus stop.

Summary

Complete streets refers to roads designed to accommodate diverse modes, users and activities including walking, cycling, public transit, automobile, nearby businesses and residents. Such street design helps create more multi-modal transport systems and more livable communities. This report discusses reasons to implement complete streets and how it relates to other planning innovations. Complete streets can provide many direct and indirect benefits including improved accessibility for non-drivers, user savings and affordability, energy conservation and emission reductions, improved community livability, improved public fitness and health, and support for strategic development objectives such as urban redevelopment and reduced sprawl. Net benefits depend on the latent demand for alternative modes and more compact development, and the degree that complete street projects integrate with other planning reforms such as smart growth, New Urbanism and transportation demand management.

A shorter version of this report is to be presented at the
Threadbo 14 Conference
September 2015, Santiago, Chile

Todd Litman © 2012-2015

You are welcome and encouraged to copy, distribute, share and excerpt this document and its ideas, provided the author is given attribution. Please send your corrections, comments and suggestions for improvement.

Preface

My city, Victoria, British Columbia, is a popular place to visit and live. We attract hundreds of tourists who spend more than a billion dollars annually. They often recommend Victoria to friends, and some return to live. When we ask visitors to describe the activities that made their Victoria visits so enjoyable, a common response is, “We walked around.”

Like many older cities, Victoria has relatively narrow arterials with low traffic speeds, good sidewalks, shops oriented to pedestrians, and relatively good public transit, making it easy to get around without a car, which provides independence for seniors and people with disabilities, plus financial savings, health benefits and enjoyment for all visitors and residents.

Figure 1 Victoria, Canada Arterial



Victoria, Canada is a popular place to visit and live due partly to its narrow arterials with low traffic speeds that provide good walking and cycling conditions and create livable neighborhoods.

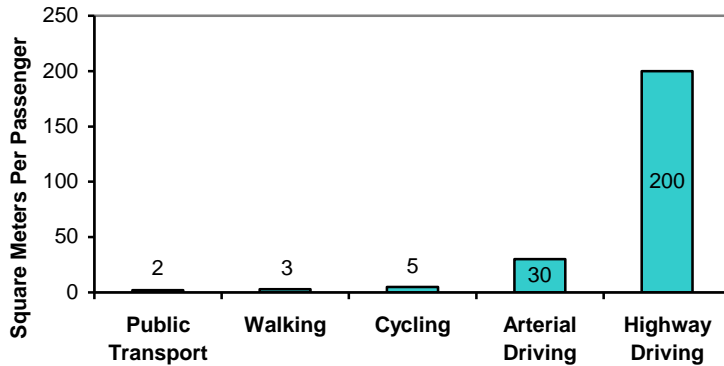
These are valuable features which make our city an attractive place to visit and live, and generates significant economic activity. Yet, these features exist *despite* rather than because of conventional planning practices. For many decades, transport planning assumed that *transportation* primarily means driving, so the most important goal is to increase automobile traffic speeds, often to the detriment of other modes, activities and objectives. This type of planning can have undesirable, unintended consequences; it degrades walking and cycling conditions, creates automobile dependent transport system and sprawled development patterns, increases total transportation costs, and creates unattractive roadways.

In response, communities increasingly apply a new transport planning paradigm which considers a wider range of objectives, impacts and options. This approach recognizes the need for more comprehensive and multi-modal analysis. This report applies this new paradigm to evaluating *complete streets*, a policy which commits communities to roadway designs that accommodate diverse modes, users and activities.

Introduction

Cities are places where numerous people and activities locate close together, which maximizes accessibility, that is, it minimizes transport costs. For cities to be efficient and livable urban transport systems must favor resource-efficient modes of travel such as walking, cycling and public transport (Loukaitou-Sideris and Ehreffeucht 2010). Although details vary from one city to another, once an area has about 100,000 residents or 30,000 jobs it is infeasible for most trips to be made by automobile. There is never enough road or parking space, and the heavy traffic increases infrastructure costs, accidents, pollution and ugliness.

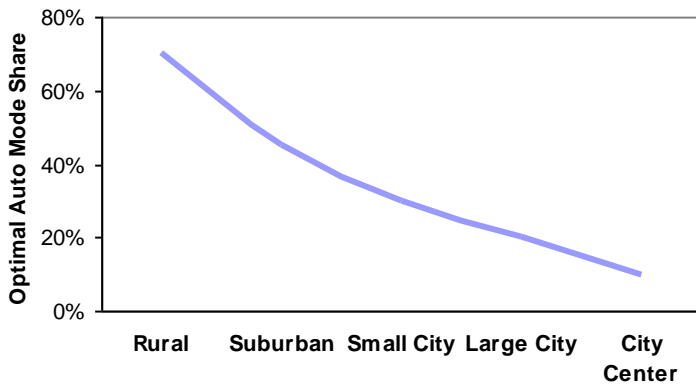
Figure 2 Road Space Required For Various Travel Modes



Road space requirements increase with vehicle size and speeds (faster vehicles require more “shy distance” between them and other objects), and declines with more passengers per vehicle. As a result, single-occupant automobile travel requires ten to one hundred times as much road space as walking, cycling and public transport.

As a result, a city’s economic productivity and livability increase if walking, cycling and public transport are so attractive that even affluent travelers will leave their cars at home and use these modes for many of their travel. Automobile travel is eliminated, but as cities become larger and denser, automobile mode share should decline, as illustrated in Figure 3.

Figure 3 Optimal Peak-Period Automobile Mode Share



As cities become larger and denser, their optimal automobile mode share declines and the optimal share of resource efficient modes (walking, cycling and public transit) increases, particularly on major corridors during peak periods. Otherwise, traffic problems become severe, reducing economic efficiency and community livability.

This requires integrated planning that makes travel *without* a car convenient, comfortable and affordable. This creates communities where households own fewer vehicles, drive less and rely on alternative modes. Such planning has several names. Regional planners call it *smart growth*, local planners call it *transit-oriented development* or *new urbanism*, and transport planners and engineers call it *complete streets*. The following section discusses this concept in more detail.

Complete Streets

Complete streets refers to roadways designed to safely accommodate diverse modes, users and activities including walking, cycling, driving, public transport, people with disabilities, plus adjacent businesses and residents (AARP 2009; Burden and Litman 2011; LaPlante and McCann 2008; Seskin and Gordon-Koven 2013). Complete streets planning recognizes that roadways serve diverse functions including mobility, commerce, recreation and community, and that road users range from freight trucks to pedestrians with impairments.

Typical Complete Streets Features

- Wider and better sidewalks
- Universal design features (curbcuts and ramps)
- Crosswalks with pedestrian refuge islands
- Bike lanes and paths
- Bus lanes and shelters
- Center left turn lanes
- Lower traffic speeds
- Landscaping

Typical complete streets projects redesign roadways to include better sidewalks and crosswalks, pedestrian refuge islands (so pedestrians need only cross half the street at a time), bike lanes, and center turn lanes, as illustrated in Figure 4. It sometimes involves reducing traffic and parking lanes, traffic calming, and replacing traffic signals with roundabouts. It can also include improved enforcement of traffic speed and sidewalk encroachment regulations. This tends to reduce maximum traffic speeds but smoothes flow and increases use of alternative modes.

Figure 4 Typical Complete Streets Design (NYCDOT)



Complete street projects typically add or improve sidewalk, crosswalks, bike lanes and center turn lanes.

This reflects the new transport planning paradigm which emphasizes accessibility and multi-modalism, as summarized in Table 1. Complete streets integrate with other planning innovations including sustainable development, smart growth, New Urbanism, context oriented planning, traffic calming and transportation demand management. It is a practical way to create more diverse transport systems and more livable communities.

Table 1 Conventional Versus Multi-Modal Transport Planning (Litman 2013)

	Conventional (Old Paradigm)	Multi-Modal (New Paradigm)
Definition of <i>transportation</i>	<i>Mobility</i> – physical travel (primarily motor vehicle travel)	<i>Accessibility</i> – peoples’ ability to reach desired services and activities
Planning goals	Maximize travel speeds	Maximize overall accessibility
Transport system performance indicators	Roadway level-of-service (LOS), average traffic speed, congestion delay	Multi-modal LOS, time and money required by various people to access services and activities
Roadway design priority	Maximize vehicle traffic speeds and volumes	Accommodate multiple modes and activities
Typical design speed	30-50 miles (50-80 kilometers) per hour	20-30 miles (30-40 kilometers) per hour
Roadway network type	Hierarchical with low connectivity	Highly connected roads and sidewalks
Design vehicle	Heavy trucks (fire truck or moving van)	Heavy trucks for roads, impaired sidewalk user

Conventional planning favors roadway design that maximizes vehicle traffic speeds. Multi-modal planning considers other modes important and so favors complete streets designs.

The new planning paradigm recognizes that motor vehicle travel is seldom an end in itself; the ultimate goal of most transport activity is *accessibility* (people’s ability to reach desired services and activities) and that various factors affect accessibility including mobility, the quality of transport options, transport network connectivity and the distances between activities (CTS 2010; Litman 2003). Conflicts often exist between different forms of access, for example, wider roads and increased vehicle traffic create barriers to non-motorized access (called the *barrier effect*), hierarchical road systems and one-way streets reduce road network connectivity, and locations that are most accessible by automobile are often difficult to access by other modes. Complete streets planning recognizes these trade-offs and so can optimize accessibility overall.

Table 2 Consideration of Accessibility Factors In Transport Planning Evaluation

Factor	Conventional Planning	Comprehensive Planning
<i>Motor vehicle travel conditions</i> – traffic speed, congestion delays, vehicle operating costs and safety	Usually considered using indicators such as roadway level-of-service, average traffic speeds and congestion costs and crash rates.	Impacts should be considered per capita (per capita vehicle costs and crash casualties) to take into account the amount that people travel.
<i>Quality of walking, cycling, ridesharing, public transport, and delivery services</i>	Considers public transit speed but not comfort. Non-motorized modes ignored.	Multi-modal performance indicators that account for convenience, comfort, safety, affordability and integration
<i>Transport network connectivity</i> – density of connections between paths, roads and modes, and therefore the directness of travel between destinations	Most traffic models consider major regional road and transit networks. They often ignore local streets, sidewalks and paths, and connections between modes.	Fine-grained analysis of sidewalk, path and road network connectivity, and consideration of the connections between modes, such as the ease of walking and biking to public transit terminals.
<i>Land use accessibility</i> – distances that people must travel between common destinations	Often ignored. Some integrated models consider some land use factors.	Fine-grained analysis of how land use factors affect accessibility by various modes.

Conventional planning evaluates transport system performance based primarily on motor vehicle travel speed and operating costs. New methods are needed for more comprehensive accessibility evaluation.

The old planning paradigm evaluates transport system performance based primarily on vehicle traffic speeds and so favors wider roads with higher design speeds. The new paradigm recognizes the important roles that walking, cycling and public transport play in an efficient and equitable transport system and so supports multi-modal planning. The old paradigm does not completely ignore alternative modes but often treats them as luxuries to be accommodated where convenient, for example, if wider sidewalks and bike lanes can easily fit into available road rights-of-way and project budgets. Where conflicts exist between motorized and non-motorized travel the old paradigm considers it acceptable to block pedestrian and bike access and require those modes to make significant detours. The new paradigm considers non-motorized access an essential design objective. It reverses conventional planning priorities, as illustrated in Table 3.

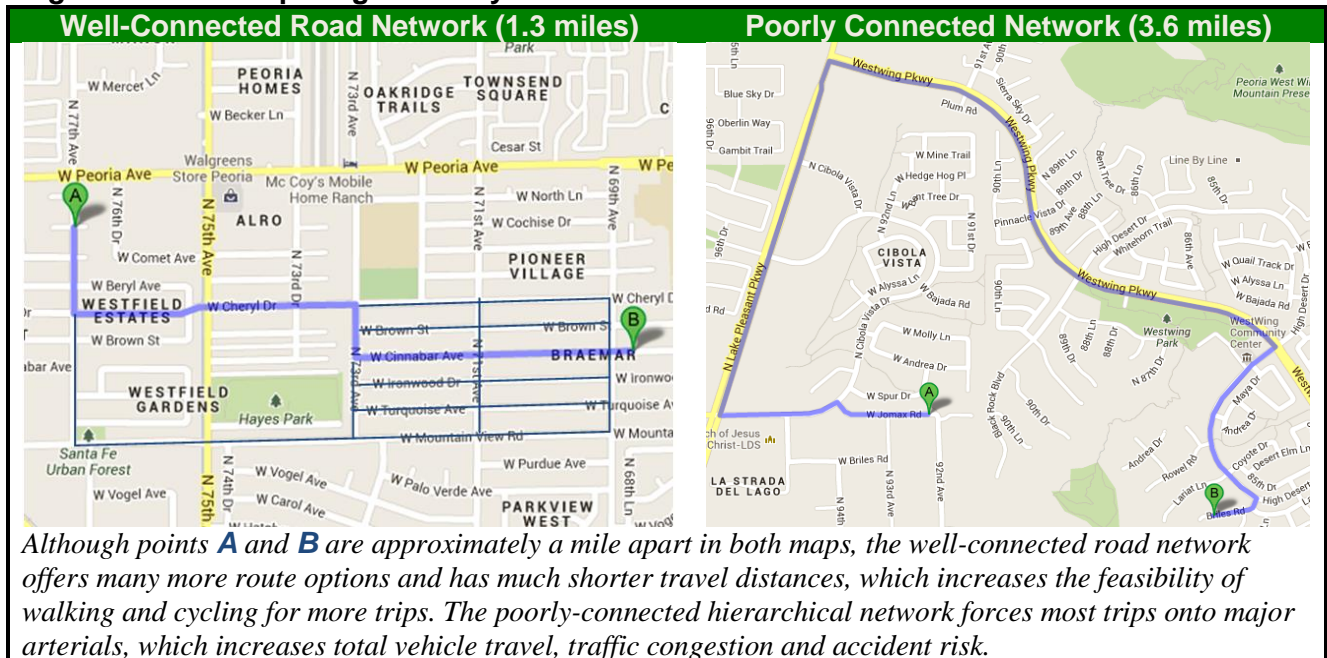
Table 3 Conventional Versus Complete Streets Planning Priorities

Conventional Planning	Complete Streets Planning
1. Automobile traffic	1. Pedestrian
2. Freight/service vehicle	2. Bicycle
3. Automobile parking	3. Bus
4. Bus	4. Freight/service vehicle
5. Bicycle	5. Automobile traffic
6. Pedestrian	6. Automobile parking

Conventional planning favors faster travel and therefore motorized modes over slower travel and therefore non-motorized modes. Complete streets planning reverses this to favor sustainable modes.

Conventional planning favors hierarchical road networks that channel traffic from smaller, local streets onto wider, higher-speed arterials, as opposed to well-connected road networks (FHWA 1989), as illustrated in Figure 5.

Figure 5 Comparing Roadway Networks



Although a hierarchical road network allows higher arterial design speeds, it increases travel distances, concentrates traffic on fewer streets which increases congestion, increases accident severity, and creates barriers to walking and cycling (Gayah and Daganzo 2012; Handy, Tal and Boarnet 2010). Table 4 compares hierarchical and well-connected road networks.

Table 4 Comparing Road Network Designs

Advantages of Hierarchical Road Network	Advantages of Well-Connected Roads
Allows higher travel speeds when arterials are uncongested. Reduces through traffic on local streets.	Provides more route options, which tends to allow more direct and shorter trips. Tends to reduce traffic congestion because less traffic is concentrated on major arterials. Tends to reduce traffic crash severity, due to lower traffic speeds. Tends to improve walking and cycling conditions, and encourage active transport, by providing more direct route options and reducing traffic volumes on major roadways.

Hierarchical and well-connected road networks each have advantages. Increasing roadway connectivity tends to reduce the distances that must be traveled to reach destinations and improve walking and cycling conditions, which reduces per capita vehicle travel, traffic congestion and accidents.

A number of studies have quantified roadway connectivity impacts on travel activity. Ewing and Cervero (2010) conclude that the elasticity of vehicle travel with respect to connectivity is -0.12, so a 10% increase in intersection or street density reduces vehicle travel 1.2%. Based on detailed reviews of available research Handy, Tal and Boarnet (2010) conclude that increased street intersection density reduces VMT, and increases walking and public transit travel. They find elasticity values from reliable studies ranging from -0.06 up to -0.59.

Analyzing four U.S. urban regions, Zhang, et al. (2012) found that reducing city block length, an indicator of roadway connectivity, had a major effect in reducing per capita VMT, particularly in smaller, less dense, automobile-oriented urban areas (Norfolk-Virginia Beach). The LUTAQH (Land Use, Transportation, Air Quality and Health) research project also found that a 10% increase in intersections per square mile reduces average household VMT by about 0.5% (Larry Frank & Company 2005). Traffic modeling by Alba and Beimborn (2005) finds that improved local street connectivity can reduce traffic volumes and therefore congestion on major arterials.

Frank and Hawkins (2007 and 2008) divided neighborhoods into four categories:

1. Low permeability for cars, high permeability for pedestrians and cyclists.
2. Low permeability for pedestrians and cyclists, high permeability for cars.
3. High permeability for both.
4. Low permeability for both.

The analysis indicates that the first option significantly increases walking and cycling mode share compared with the others. They estimate that in a typical urban neighborhood, a change from a pure small-block grid to a *Fused Grid* (pedestrian and cycling travel is allowed, but automobile traffic is blocked at a significant portion of intersections) that increases the relative

connectivity for pedestrians 10% typically increases home-based walking trips by 11.3%, increase the odds a person will meet the recommended level of physical activity through walking in their local travel by 26%, and decrease vehicles miles of local travel by 23%.

By favoring narrower, slower, more connected roadway design, complete streets policies tend to reduce maximum traffic speeds but allow more direct travel and improved access by other modes, which tends to improve overall accessibility (Table 5).

Table 5 Impacts on Accessibility

Accessibility Factors	Automobile-Oriented Streets	Complete Streets
Maximum traffic speeds	Higher maximum (peak) traffic speeds	Optimal (often reduced) traffic speeds
Traffic capacity	Higher design speeds and lack of left turn lanes can reduce peak traffic capacity	Center turn and bike lanes, and lower design speeds increase peak capacity
Vehicle travel efficiency (directness to destinations)	Hierarchy road systems reduce connectivity, increasing travel distances	More connected roadway networks reduce travel distances
Parking convenience	High priority. On-street parking and driveways wherever possible	Moderate priority. On-street parking provided after sidewalks, bike and bus lanes
Non-motorized access	Wider roads and increased traffic tend to create barriers to non-motorized access	Significantly improves walking and cycling access
Public transport access	Since most transit trips include non-motorized links, auto-oriented streets can reduce transit access	Improves walking and cycling access, and may include bus lanes and other transit support features
Transport affordability (quality of affordable modes)	May reduce vehicle operating costs but reduces access by affordable modes	Significantly improves walking and cycling access, and may improve transit access
Land use accessibility (distances between activities)	Tends to stimulate more dispersed, urban-fringe development (sprawl)	Encourages more compact, accessible land use development

Complete streets tend to reduce vehicle traffic speeds but increase other accessibility factors including non-motorized access, transit access, road network connectivity, and land use accessibility.

Travel and Land Use Impacts

Complete streets tend to have various transport and community development impacts:

- *Lower motor vehicle traffic speeds.* Complete streets often reduce maximum traffic speeds, typically from 30-50 miles (50-80 kms.) down to 20-30 miles (30-40 kms.) per hour. This reduces *mobility*, the distances motorists can travel in a given time period.
- *Increased safety* - Lower traffic speeds tend to reduce traffic collision rates and severity, and therefore crash costs, particularly injury risk for pedestrians and cyclists (HSIS 2010).
- *Improved non-motorized conditions* - Complete streets generally include wider sidewalks, better crosswalks, bike lanes and reduced traffic speeds, which improve walking and cycling convenience, comfort and safety.
- *Improved public transit service* - Complete streets often include improved bus stops and pedestrian access, and sometimes bus-lanes which increase public transit speed, reliability, comfort and efficiency.
- *Mode shifts* - By improving walking, cycling and public transit, and reducing maximum vehicle traffic speeds, complete streets encourage shifts from automobile to alternative modes, reducing total vehicle travel.
- *Reduced local air and noise pollution* - By reducing traffic speeds and total motor vehicle travel, and improving bus flow, complete streets tend to reduce local air and noise pollution.
- *Improved aesthetics* – Complete streets often include landscaping and other design changes that tend to be more attractive.
- *Improved livability* - By improving walkability, accessibility and aesthetics, and reducing pollution, complete streets tend to improve livability (local environmental quality and affordability).
- *Increase economic activity and local property values* – By improving livability, complete streets can increase local business activity and property values.

Not every complete streets project has all of these impacts but most have several. These impacts provide benefits and impose costs to different road user types, as summarized below. Motorists have reduced mobility, but benefit from reduced stress, increased safety and improved livability.

Table 6 Impacts Distribution

Better Off	Worse Off
Motorists who prefer slower traffic speeds and improved roadway aesthetics	Motorists who want to drive faster
Motorists from reduced crash risk	Urban fringe residents and property owners
Pedestrians, cyclists and transit users	Local merchants who rely on on-street parking
Anybody who benefits from reduced automobile traffic	
Local residents and businesses	
Local property owners	

Complete streets directly benefit some people and can make others worse off. Motorists benefit in some ways and are worse off in others.

Evaluating Complete Streets Benefits and Costs

Table 7 summarizes various complete streets impacts (benefits and costs). Some result from roadway design changes, others from changes in travel activity or land development patterns.

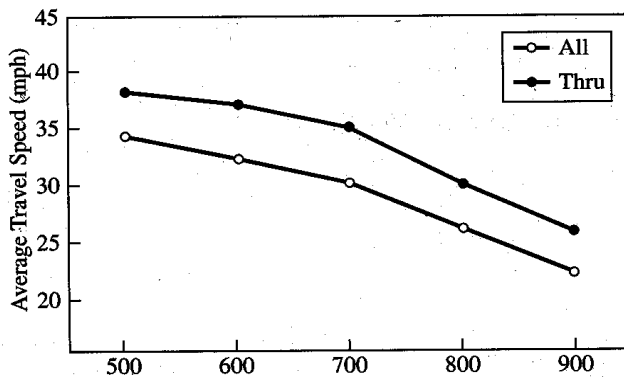
Table 7 Complete Streets Benefits and Costs (Litman 2010)

	Improved Transport Options	Increased Use of Alternative Modes	Reduced Automobile Travel	Smart Growth Development
Potential Benefits	<ul style="list-style-type: none"> Improved user convenience and comfort Improved accessibility, particularly for non-drivers, which supports equity objectives Option value (the value people place on having an option that they do not currently use) Increased local property values 	<ul style="list-style-type: none"> User enjoyment Improved public fitness and health Increased community cohesion (positive interactions among neighbors due to more walking on local streets) which tends to increase security 	<ul style="list-style-type: none"> Reduced congestion Road and parking savings Consumer savings Reduced traffic crashes Reduced chauffeuring burdens Energy conservation Reduced air and noise pollution 	<ul style="list-style-type: none"> Improved land use accessibility Transport cost savings Infrastructure savings Openspace preservation Improved aesthetics Urban redevelopment Support for local businesses
Potential Costs	<ul style="list-style-type: none"> Planning and implementation Lower traffic speeds 	<ul style="list-style-type: none"> Additional user costs (shoes, bikes, fares, etc.) 	<ul style="list-style-type: none"> Reduced travel speeds from mode shifts Reduced parking convenience 	<ul style="list-style-type: none"> Increases in some development costs Transition costs

Complete streets involve various benefits and costs.

A key issue is the degree that total travel speeds actually decline. Complete streets projects often reduce traffic lanes, such as converting *four-traffic-lanes* into *two-traffic-lanes-plus-bike-lanes-and-a-center-turn-lane*, but such conversions do not necessarily reduce traffic capacity because they eliminate delays caused by left-turning vehicles and slower bicycles (CTRE 2004). Three lane roads can operate efficiently roads up to 20,000 daily vehicles (HSIS 2010). Reducing traffic speeds from 40 to 30 miles per hour tends to *increase* roadway capacity (Figure 6), because lower speeds reduce *shy distances* (space required between vehicles) so traffic is smoother and less congested. Off-peak traffic is slower but peak-period traffic is faster.

Figure 6 Travel Speed Versus Traffic Volumes (Roess, Prassas and McShane 1998)



As traffic speeds increase, so does the distances required between vehicles, which reduces roadway capacity. Reducing traffic speeds from approximately 40 to 30 miles per hour tends to increase arterial roadway traffic capacity from approximately 500 to 900 vehicles per hour.

Vehicles Per Hour Per Lane

Reducing traffic speeds can increase in other types of access, including improvements to alternative modes, improved roadway connectivity, and support for more compact land use development. Conventional planning often ignores these impacts.

Roadway expansion advocates often claim that roadway expansions will reduce accidents, fuel consumption and pollution emissions, which implies that roadway narrowing exacerbates these problems, but this is often untrue (Litman 2012). Roadway expansion sometimes reduces fuel consumption and emission rates per-mile, but this is generally offset over the long run by induced travel (Noland and Quddus 2006).

Complete streets designs can provide significant safety benefits (Dumbaugh 2005; Petritsch 2007). Research by the U.S. Highway Safety Research System (HSIS 2010) concludes that *road diets* typically reduce crash rates by 47% on major highways through small urban areas, by 19% on corridors in larger city suburban areas, and 29% overall. The New York City Department of Transportation found that total crash rates (pedestrians, cyclists and motorists) decline 40-50% after bike lanes are installed on the city's arterials (NYCDOT 2011). Narrower streets with lower design speeds tend to have fewer and less severe accidents (Frith 2012), and per capita traffic accident rates tend to decline in communities with more connected streets, more multi-modal transportation systems, and more accessible land use development (Wei and Lovegrove 2010). Marshall and Garrick (2011) conclude that more connected, multi-modal street design can significantly reduce traffic injury and fatality rates in U.S. cities. Stout, et al (2006) found that conversion of four-lane undivided roadways to three-lane cross-sections in typical Iowa towns reduced crash frequency by 25% and crash injuries by 34%. To the degree that complete streets improve pedestrian and cycling conditions, shift travel to alternative modes, smooth traffic or reduce sprawl they tend to reduce crash risk, conserve fuel and reduce emissions overall.

In some cases, complete streets projects reduce on-street parking supply in order to widen sidewalks or add bus or bike lanes. On-street parking is convenient and efficient: a typical arterial on-street space serves many destinations and so substitutes for several off-street spaces, and on-street parking can provide a barrier between traffic and sidewalks. However, merchants often exaggerate the value of on-street parking, they assume that eliminating a space will eliminate all business generated by the customers who used that space, ignoring the possibility that some customers could park elsewhere or shift modes, and they underestimate the importance of other forms of customer access (Clifton, et al. 2012; Sztabinski 2009).

Conventional transport economic evaluation tends to overlook or undervalue many of these impacts. It generally only monetizes (measure in monetary values) project costs, travel time and vehicle operating savings, and sometimes changes in accident and emission rates. Conventional planning tends to ignore the tendency of wider roads to reduce accessibility by creating barriers to non-motorized travel and stimulating sprawl. It generally assigns no value to improved non-drivers accessibility, comfort and enjoyment; option or equity values; reduced chauffeuring burdens; improved public fitness and health; parking cost savings; vehicle savings; energy conservation; reduced noise; improved aesthetics; or reduced sprawl. As a result, conventional evaluation tends to overvalue roadway expansion and undervalue complete streets.

Methods exist for quantifying and monetizing (measuring in monetary units) many often-overlooked complete streets benefits. For example, the costs of pedestrian delays caused by wider roads and increased motor vehicle traffic, called the *barrier effect*, can be monetized using methods similar to those currently used to monetize delays to motorists caused by traffic congestion. Guidance on these methods is available from various research organizations and transport agencies, including the U.K. Department for Transport (DfT 2006) and the New Zealand Transport Agency (NZTA 2011). Table 8 summarizes some of these methods.

Table 8 Quantification and Monetization Methods (DfT 2006; Litman 2009; NZTA 2011)

Often Overlooked Impact	Quantification Methods
<i>Direct user benefits</i> – improved convenience, comfort and enjoyment from improved walking, cycling and public transit, and reduced driver stress	Survey travelers to determine their preferences. Adjust travel time unit costs downward as travel conditions improve.
<i>Reduced barrier effects</i> – reduced pedestrian and cyclist delay	Quantify and monetize the incremental delays and shifts from active to motorized modes
<i>Vehicle cost savings</i> – reduced vehicle ownership and operating costs if residents own fewer vehicles and drive less	Use vehicle ownership surveys to determine whether residents tend to own fewer vehicles and drive less in areas with more multi-modal transport systems
<i>Parking savings</i> – reduced parking problems and subsidy costs if travelers shift mode	Estimate parking cost savings from reduced vehicle ownership and use in areas with multi-modal transport
<i>Safety benefits</i> – reduced traffic crashes due to slower traffic speeds, improved facilities for alternative modes and reduced vehicle travel	Estimate crash cost reductions from reduced traffic speeds and reduced total vehicle travel
<i>Improved public health</i> – increased public fitness and health from more walking and cycling.	Estimate increases in walking and cycling activity and assign monetary values as indicated by NZTA (2011)
<i>Energy conservation and emission reductions</i> – from lower traffic speeds and reduced total vehicle travel.	Estimate energy conservation and emission reductions and assign dollar values
<i>Supports more efficient land use (reduced sprawl)</i> – encourages more compact, multi-modal development	Estimate the community savings and benefits from more compact development and reduced sprawl. Assign monetary values to each household that locates in existing urban areas and avoids urban expansion.
<i>Supports social equity objectives</i> – improves affordable modes and access for disadvantaged people	Weigh savings and benefits in favor of physically, economically and socially disadvantaged people (e.g., an hour saved by a person with an impairment, or a dollar saved by a lower-income household is worth several times more than the same savings by able and wealthy people)
<i>More livable communities</i> – improved local environmental quality	Measure increases in residential and commercial property values along complete streets

Methods exist for quantifying and monetizing many complete streets benefits that are not currently considered in transport economic evaluation.

The following can affect complete streets benefit evaluation:

Evaluation Perspective – Automobile Oriented or Multi-Modal

Conventional planning evaluates transport system performance using roadway level-of-service (LOS), which measures motor vehicle delays. This approach makes traffic congestion the primary planning problem and assumes that road roadway widening is an *improvement*, that is, it is inherently desirable. Complete streets planning requires multi-modal evaluation which recognizes the trade-offs that exist between different forms of transport and the negative impacts that wider streets and increased vehicle traffic can have on access and community livability (Dowling Associates 2010; Litman 2012).

Demand

Complete streets benefits depend on future demands for alternative modes and for homes and businesses in compact, multi-modal urban neighborhoods. There is significant latent demand for these options in many communities: walking, cycling and public transport travel increase after their facilities and services are improved (ELTIS; VTPI 2012), and current demographic and economic trends (aging population, rising fuel prices, increasing health and environmental concerns, changing consumer preferences, etc.) are increasing such demand (Contrino and McGuckin 2009; Litman 2006; OECD 2012). This suggests that the justification for complete streets will probably increase in the future.

Integration

Complete streets support and are supported by other transport and land use planning reforms, listed below. The effectiveness of complete streets programs therefore depends on the degree to which these reforms are implemented and integrated.

Planning Reforms That Complement Complete Streets

- *Sustainable development.* Development that balances economic, social and environmental objectives, including long-term and indirect impacts.
- *Smart growth/New Urbanism/transit-oriented development.* More compact, mixed development integrated with alternative modes.
- *New transport planning paradigm/multi-modalism.* Accessibility- rather than mobility-based transport planning which considers diverse modes and impacts.
- *Context oriented planning.* Roadway planning that is flexible and sensitive to community values.
- *Traffic calming and road diets.* Roadway design and management that limits traffic speeds.
- *Transportation demand management.* Various strategies that encourage use of efficient transport options.
- *Parking management.* Various strategies that result in more efficient use of existing parking resources.
- *Urban redevelopment.* Efforts to redevelop existing urban neighborhoods and commercial areas.

Social Equity Perspective

Social equity (also called *justice* and *fairness*) refers to whether the distribution of impacts (benefits and costs) is fair and appropriate (Litman 2002). Transport equity generally includes:

- *Horizontal equity* concerns the distribution of impacts between people considered similar in ability and need. It assumes that equal individuals and groups should receive equal shares of public resources, bear equal costs, and in other ways be treated the same. It implies that road rights-of-way should be allocated equality per road user.
- *Vertical equity with regard to income* is concerned with the distribution of impacts between different income classes. It assumes that policies should favor lower disadvantaged people, which are called *progressive*, while those that burden disadvantaged people are called *regressive*. This definition supports improvements to affordable modes such as walking, cycling and public transit.
- *Vertical equity with regard to transport ability* is concerned with the degree that a transport system meets the needs of travelers with special needs such as mobility impairments. This definition supports improvements to modes commonly used by physically and socially disadvantaged people, such as walking, cycling and public transit, and *universal design* so transport facilities accommodate all users, including those with special needs.

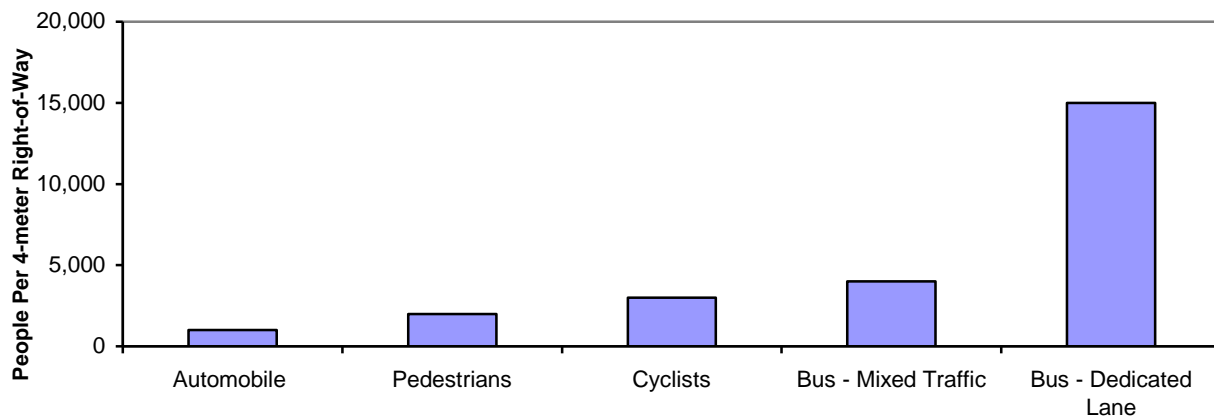
Planning practices that favor mobility over accessibility and automobiles over other modes tend to be unfair and regressive, since they reduce the transport options available to non-drivers. In a typical community, 20-40% of residents cannot or should not drive due to physical impairment, poverty or age. In automobile dependent communities non-drivers tend to have significantly less accessibility, and therefore reduced economic and social opportunity, than motorists. Complete streets help achieve equity objectives by giving non-drivers a fair share of road space, by reducing risks motor vehicles impose on pedestrians and cyclists, and by improving mobility and accessibility options for non-drivers. The conceptual test for the fair allocation of resources between automobiles and other modes is the mode share that would occur if transport planning gave walking, cycling and public transport as much priority as automobile transport.

Road Space Analysis

Since automobiles are relatively large and fast, automobile travel requires more road space per unit of travel than most other modes (Figure 7). It is therefore equitable to shift road rights-of-way from general traffic lanes to sidewalks, bike lanes and bus lanes if, after the changes are complete, these uses will carry more people than a general traffic lane. For example, a general traffic lane should be converted to a bus lane if during peak periods the bus lane would carry more than 20 buses with 50 average passengers, since the bus lane would carry more people.

There is even greater justification to convert parking lanes into setbacks that protect pedestrians from vehicle traffic, wider sidewalks, bike lanes or bus lanes, since personal mobility is generally considered a more important public good than vehicle parking, and motorists usually have alternative parking options available if they pay or walk a few blocks. In some situations the reduced vehicle parking supply is offset by reduced parking demand if automobile travel shifts to alternative modes. For example, if converting a parking lane that serves 100 vehicles into a bike or bus lane causes an average of 100 commuters to shift from driving to alternative modes there would be no net increase in parking congestion.

Figure 7 Maximum Passengers Per Hour on Lane By Urban Mode



The number of passengers carried by 4 meters of urban road right-of-way varies by mode, travel speed and load factor (passengers per vehicle). Automobiles are generally least space-efficient: an urban street lane can typically accommodate up to 800 vehicles with about 1,000 passengers per hour.

Risk Analysis

Motor vehicle traffic imposes risk and delay on non-motorized modes (“Barrier Effects,” Litman 2009). Even if pedestrians and cyclists are not actually injured these risks reduce their comfort and require accommodation, forcing them to use less direct routes, or shifts from non-motorized to motorized modes. Roadway design factors such as road and lane widths; the presence and quality of sidewalks, paths and crosswalks; traffic signal cycles (such as whether they allow sufficient time for even slower walkers to cross streets); and traffic speeds often involve trade-offs between motor vehicle mobility and non-motorized safety.

Local Impact Analysis

Wider roads and increased motor vehicle traffic speed and volumes impose noise and air pollution, and accident risks on the neighborhoods through which they pass. These external costs (uncompensated costs that one person imposes on others) are unfair and inefficient. By favoring wider roads and faster motor vehicle travel, conventional planning favors through motorists over people who live and work in impacted neighborhoods, and tends to increase urban fringe property values at the expense of urban neighborhood property values. Complete streets tend to improve local access, safety, environmental quality and property values in existing urban areas, which tends to increase economic efficiency and social equity.

Facility Funding Analysis

Many people assume that roadways are funded primarily by fuel taxes and other special motor vehicle-related fees, giving motorists ownership and design priority.¹ Actually, motor vehicle user fees finance less than half of total roadway expenditures and an even smaller portion of the local roads and streets that are usually candidates for complete streets policies (Henchman 2013; Subsidy Scope 2009). Local streets are primarily funded through general property and sales taxes that all residents pay regardless of how they travel. Since motor vehicle travel imposes more

¹ This reflects horizontal equity which implies that consumers should, “get what they pay for and pay for what they get” unless subsidies are specifically justified (Litman 2002).

roadway costs (it requires more space and imposes more wear per mile or kilometer of travel) and imposes other external costs (congestion, accident risk, pollution damages and parking subsidies), residents who drive less than average tend to subsidize the roadway costs of their neighbors who drive more than average, and bear an excessive share of external costs. As a result, complete streets help achieve horizontal equity objectives by giving non-drivers a greater share of the public roadways they help finance. This also tends to be progressive with respect to income since lower-income people tend to rely on alternative modes and drive less than average.

Parking Lane Analysis

Complete streets projects often involve converting parking lanes into wider sidewalks, more landscaping, bike- and bus lanes. Residents and businesses often oppose such conversions. On-street parking is visible and serves multiple destinations, making it convenient and efficient.

However, there is less justification to devote public right-of-way to parking than to mobility. Alternative parking options are usually available nearby so the actual cost of reducing arterial on-street parking is often small. If walking, cycling, public transit and landscaping improvements attract additional customers, cause some motorists to shift to alternative modes, or expand the range of parking options that serve the area (for example, if shoppers can more conveniently walk a few blocks from parked cars to shops) these change can more than compensate for the loss of on-street parking. For example, a loss of 100 on-street spaces could be offset if walking, cycling and public transit improvements caused a similar number of commuters and customers to shift from driving to alternative modes, freeing up that number of parking spaces in the area.

Local merchants tend to overestimate the portion of their customers who arrive by automobile and overlook the economic benefits of improved pedestrian, bicycle and public transit access, and more attractive streetscapes (Tolley 2011). Shoppers who arrive walking, cycling or public transport tend to spend less per trip but make more trips per month and so spend more in total than automobile shoppers (Clifton, et al. 2012). A survey of more than 1,000 drivers and pedestrians traveling to a New York city commercial district found that most area shoppers do not drive, and that shifting street space from vehicle parking to pedestrians would increase the number of shoppers and the amount of business activity in the area (Schaller 2006). The survey found that shoppers who prefer wider sidewalks over parking spent about five times as much money in the aggregate as those who prefer parking.

A particular set of on-street parking spaces tends to benefit a relatively small group of motorists and businesses. In many situations, improved management can significantly reduce the number of parking spaces needed in a particular area, allowing land currently devoted to parking to be converted to more productive uses without reducing access overall (Litman 2008; Shoup 2005). Walking, cycling and public transit improvements tend to benefit a wide range of people, including direct benefits to users of those modes, improved mobility for non-drivers, and indirect benefits from reduced traffic congestion, accident risk and pollution.

This suggests that there are often both efficiency and equity justifications to convert on-street parking lanes into wider sidewalk, bike- and bus-lanes, and landscaping improvements, provided that there is sufficient demand for these other uses and alternative parking options are available nearby. This reflects the new planning paradigm which values alternative modes and ranks automobile parking at the bottom of public road design priorities, as indicated in Table 1.

Redefining Roadway Efficiency

Efficiency refers to the ratio of benefits (outputs) to costs (inputs). This is often measured using benefit/cost ratios, net benefits, or return on investment; higher values indicate that an option is more efficient and therefore better. How roadway efficiency is defined and measured can significantly affect planning decisions.

- *Conventional transport planning* evaluates roadway efficiency based primarily on vehicle traffic speeds. From this perspective bigger and faster roads are always more efficient.
- *Traffic network analysis* evaluates roadway efficiency based on both vehicle travel speeds and trip distances. This can favor lower-speed but more connected road networks over high-speed but less connected hierarchical networks if the increased speed is offset by longer trip distances.
- *Multi-modal transport planning* recognizes that travel demands are diverse: Not everybody can drive, and alternative modes (walking, cycling and public transport) are sometimes more efficient than driving. For example, it is inefficient if, due to inadequate transport options, parents must chauffeur children who prefer to walk or bicycle, or commuters are forced to drive if public transit is overall cheaper. From this perspective roads are most efficient if they accommodate multiple modes and favor resource-efficient modes so users can choose the most efficient option for each trip. This justifies bike and bus lanes where there is sufficient demand, since this improves transport diversity and encourages use of resource-efficient modes.
- *Accessibility-based transport planning* recognizes that the ultimate goal of most transport is access to services and activities. Several factors can affect accessibility including mobility (travel speed and affordability), the quality of transport options, transport network connectivity, land use accessibility, and mobility substitutes such as telecommunications and delivery services. From this perspective, roads are most efficient if they support diverse modes, connectivity, and land use accessibility. This justifies integrated, multi-modal transport and land use planning.
- *Economic efficiency* refers to the degree that economic systems maximize the value of goods and services. From this perspective roads are most efficient if managed or priced to favor higher-value trips and more resource-efficient modes over lower-value trips and less efficient modes. This can justify truck lanes (they tend to have high value) and public transit or high occupant vehicle lanes (they tend to be space efficient), where there is sufficient demand, or even better, congestion pricing (road tolls that are higher during peak periods), which allows higher value trips and more efficient modes to outbid lower-value trips and more space-intensive modes.
- *Planning efficiency* refers to the degree that planning activities are comprehensive and integrated, so that individual, short-term decisions support strategic, long-term goals. This is functional way to develop more accessible and economically efficient roadway systems. From this perspective roads are most efficient if planned and managed to support strategic objectives. For example, efficient strategic planning may justify congestion pricing to improve freight transport efficiency, bus lanes and pedestrian improvements that support more compact development, streetscaping that supports local commercial district redevelopment, and constraints on urban fringe roadway expansion, if these support a region's development objectives.

People involved in transport planning should understand how these different definitions can affect planning decisions. Conventional planning applies a narrow definition: it evaluates transport system efficiency based primarily on vehicle travel speeds and so favors roadway designs that increase vehicle traffic capacity and speed, which can contradict other transport efficiency factors. For example, it favors hierarchical road networks with wide, higher speed, limited access arterials that create barriers to non-motorized travel, reduce roadway connectivity,

and stimulate sprawled development, which reduces transport options, reduces traffic efficiency, and increase travel distances. In these ways, conventional efficiency analysis tends to bias planning decisions to favor mobility over accessibility and automobile travel over other modes.

Many terms commonly used in transport planning terms are unintentionally biased. For example, projects that increase road or parking capacity are often called “improvements,” although by creating barriers to walking and cycling access, and increasing noise and air pollution they may degrade neighborhood livability. Calling such changes “improvements” indicates a bias in favor of automobile travel over other modes and through traffic over other activities. Objective language uses more specific and neutral terms, such as “added capacity,” “additional lanes,” “modifications,” or “changes.” Roadway level-of-service (LOS) is a commonly used way to measure travel conditions on a roadway. Currently, most roadway LOS analysis only reflects motor vehicle traffic conditions. Multi-modal LOS indicators are now available (Dowling 2010). These should be applied if possible, and if only motor vehicle LOS is reported this should be indicated.

Below are examples of biased and more objective terms:

Biased Terms

Traffic or trips
Improve, enhance, upgrade
Efficient
Level of service

Objective Terms

Motor vehicle traffic, pedestrian/bike traffic, motor vehicle trips, person trips
Change, modify, expand, widen, increase traffic speeds
Faster, increased vehicle traffic capacity
Level of service for...

Advocates tend to justify automobile-oriented planning by citing statistics which indicate that most travel (often reported as more than 90%) is by automobile, implying that other modes are unimportant and so deserve little consideration in roadway design. However, such statistics tend to be biased: Conventional travel surveys tend to overlook or undercount short trips, non-commute and off-peak travel, travel by children, and non-motorized trips (Forsyth, Krizek and Agrawal 2010; Litman 2010). The non-motorized links of trips that include motorized travel are often ignored, so a bike-transit-walk trips is coded simply as a transit trip, and pedestrian trips from parked cars to destinations are often not counted even if they involve walking several blocks on public sidewalks. More comprehensive surveys indicate that walking, cycling and public transit typically represent 15-25% of total urban trips, and more where there is suitable support, such as complete streets, indicating that there is often latent demand for such travel. More comprehensive analysis of travel demands, including more complete travel statistics and analysis of latent demand for alternative modes, can help support complete streets planning.

The conceptual test for determining the efficient and equitable allocation of resources is the mode share that would occur if transport planning gave walking, cycling and public transport as much priority as automobile transport, modified to account for other planning objectives, such as equity (which justifies additional support for affordable and universally accessible modes), public fitness and health (which justifies additional support for non-motorized travel), and environmental objectives (which justifies additional support for resource efficient and less polluting modes).

Can Cities Function With Reduced Automobile Traffic Capacity and Speeds?

Complete streets projects often face skepticism from people concerned that reducing roadway capacity will cause severe traffic congestion and reduced travel speeds. However, complete streets projects that reduce traffic lanes but add center turn lanes and bike lanes generally maintain *vehicle* capacity by removing left-turning vehicles and bicycles from through traffic, and they can maintain or increase *person* capacity by encouraging shifts from automobile to alternative modes. Mode shifting is particularly effective if complete street policies are part of integrated programs that also include improvements to alternative modes, transportation demand management programs, smart growth land use policies and urban redevelopment.

In recent years several major urban highways have been converted into lower-speed boulevards or totally removed. Evaluations indicates that such projects can achieve various planning objectives including improved urban accessibility and reduced traffic risk without increasing vehicle traffic congestion (Cairns, Atkins and Goodwin 2002). For example (ITDP 2012; NYCDOT 2012; SDOT 2008):

- San Francisco's Embarcadero Freeway was demolished shortly after it was severely damaged in the 1989 Loma Prieta earthquake, and replaced with a six-lane, palm-lined "complete street" boulevard. Subsequently, vehicle traffic volumes declined from about 50,000 to 25,000 average daily vehicles, while pedestrian, bicycle and transit traffic increased, and nearby neighborhoods experienced significant economic development.
- New York City has implemented several roadway redesign projects that include pedestrian improvements, bike lanes, bus lanes, and more efficient parking management. These changes reduced congestion delays, increased bus operating speeds and efficiency, increased transit ridership, increased cycling activity, reduced traffic collisions, and increased business activity.
- Seoul, South Korea's Cheonggye Expressway was demolished in 2005, the river was restored and made into a linear park, and nearby surface streets were redeveloped with bus rapid transit lanes. Prior to demolition, the Expressway carried 168,000 average vehicles per day. The number of vehicles passing through downtown decreased 9% after implementation of the bus rapid transit system and other transportation demand management measures. The park attracts approximately 90,000 daily visitors. A adjacent land values increased by an average of 30% and summer temperatures in the park average 7 degrees lower than at locations a quarter mile away.

The feasibility and benefits of road space reallocation are likely to increase in the future. As mentioned previously, in most developed countries, demographic and economic trends are causing motor vehicle travel to peak and demand for alternative modes to increase. Aging population, rising fuel prices, increasing health and environmental concerns, and changing consumer preferences are motivating more people in North American, Europe and affluent Asian cities to want to rely more on walking, cycling and public transit, provided they are convenient, comfortable and affordable. In addition, transport professionals have better understanding of how to implement roadway design changes, and how to integrate them with other planning reforms to minimize costs and maximize overall benefits.

Complete Streets Evaluation Examples

These examples illustrate how more comprehensive and multi-modal evaluation supports complete streets policies and design. Also see CATSIP, McCann and Rynne (2010), and Seskin and Gordon-Koven (2013).

Active Mode (Pedestrian and Cycling) Improvements

Conventional planning, which evaluates transport system based on travel speeds, considers walking and cycling inefficient. For example, conventional traffic models can measure the increased traffic speeds that result from wider roads with higher traffic speeds, but ignore the delay this imposes on active modes (called the *barrier effect*). More comprehensive evaluation recognizes the unique and important roles active modes play in an efficient and equitable transport system, including mobility to non-drivers (which reduces the need for drivers to chauffeur non-drivers), public transit access, and support for more compact development. This supports roadway designs that include more sidewalks, paths, crosswalks and bike lanes, traffic calming and speed reductions, and policies to prevent sidewalk encroachment.

Bus Priority Lanes (Wikipedia: Public Transit Networks)

Conventional planning evaluates transport system performance based primarily on vehicle capacity and speeds using indicators such as traffic speed, congestion delay and roadway level-of-service. With this approach, bus lanes are only justified if they reduce per-vehicle delay. For example, a typical urban arterial can carry up to 800 vehicles per hour, so a six-lane arterial with 2,250 automobiles with 1.1 average occupants and 50 buses with 40 average passengers carries 2,475 automobile occupants and 2,000 bus occupants. If evaluated using conventional indicators, a bus lane is only justified if it would cause more than a third of motorists to shift to bus travel, so the reduction in vehicle capacity is fully offset by reduce automobile demand, so few bus lanes are justified.

More comprehensive and multi-modal analysis evaluates transport performance based on *people* rather than *vehicle* travel. This recognizes, for example, that a minute saved by a 40-passenger bus is worth about 36 times as much as a minute saved by a 1.1 occupant car. This can justify bus lanes even if they slightly increase automobile traffic delay, and so justifies bus lanes on most urban arterials with 24 or more peak-hour buses, since those buses carry more passengers than general traffic lanes. Comprehensive analysis also recognizes that a transport system becomes overall more efficient if it favors resource-efficient modes. Walking, cycling and public transit require one or two orders of magnitude less road and parking space as automobile travel, impose less risk on other road users, consume less energy, and produce less pollution. If converting a general traffic lane into a bus lane causes a few hundred commuters to shift from driving to transit, downstream traffic congestion, parking demand, accident risk and pollution emissions are all reduced. This perspective increases the justification for bus lanes and other demand management strategies that encourage travelers to use resource-efficient modes.

Complete Streets Outputs and Outcomes (Ranahan, Lenker and Maisel 2014)

The report, *Evaluating the Impact of Complete Streets Initiatives* describes a framework for evaluating various *outputs* (e.g., miles of on-street bicycle routes, number of crosswalk enhancements, installed curb ramps) and *outcomes* (e.g., level of service, crash and injury data, mode share, perceived safety, citizen satisfaction) resulting from complete streets projects. Starting with a universe of more than 800 indicators, the study consolidated them into seven major categories of impact: citizen input; economic; environmental; health; safety; multi-modal

level of service; and bicycle/pedestrian. Each of the seven categories is described in a section that includes: (a) a definition of the category and its importance; (b) common measurement approaches for that category; (c) novel and innovative measurement tools; and (d) strategies for measurement. The measurement tools were selected based on their potential importance, frequency of use, availability, and cost.

Other Road Uses

Conventional transport planning assumes that roads primary function is the movement of vehicles. More comprehensive evaluation recognizes other important functions of streets:

- Commercial activities (shops and street vendors).
- Recreation and socializing (people and pets walking for exercise and enjoyment, people standing and sitting in sidewalk right-of-ways)
- Community cohesion (opportunities for neighbors to meet and interact in positive ways, which primarily results from walking and local services).
- Aesthetics (attractiveness to people walking, cycling and driving along the street, and to residents living on the street).
- Live and work (quality of the environment for people who live and work in buildings on a street).

Complete streets planning tends to recognize significant value form these non-mobility functions of urban streets, which justifies more pedestrian improvements (wider sidewalks, better crosswalks, pedestrian refuges, etc.), bike lanes, traffic calming and speed reductions, more compact and mixed development, streetscaping, higher building and landscaping design standards, more efficient parking management, neighborhood parks, and efforts to create neighborhood identity. At a regional level it supports more transportation demand management and smart growth in order to reduce total motor vehicle traffic on local streets. An example is the New York City Department of Transportation’s guidebook, *Measuring the Street: New Metrics for 21st Century Streets* identifies various performance indicators (*metrics*) that can be used for complete streets evaluation, as summarized in Table 9.

Table 9 Complete Street Evaluation (NYCDOT 2012)

Goals	Strategies	Metrics
<ul style="list-style-type: none"> • Safety • Serve all users. • Create great public spaces. 	<ul style="list-style-type: none"> • Design safer streets. • Provide safe and attractive options for all street users. • Build great public spaces for economic value and neighborhood vitality. • Improve bus service. • Reduce delay and speed to allow for faster and safer travel. • More efficient parking and loading to improve access to businesses and neighborhoods. 	<ul style="list-style-type: none"> • Pedestrians, cyclists and motorist crash rates. • Vehicles, bus passengers, bicycle riders, and other street user volumes. • Optimal traffic speeds. • Economic vitality, including retail activity growth. • User satisfaction. • Environmental and public health impacts.

Complete streets evaluation requires comprehensive and multi-modal performance indicators.

Conclusions

Urban streets are a scarce and valuable resource. How they are designed and management represents an allocation of public resources that should balance various objectives:

- Cost effective mobility
- Overall accessibility
- Fairness for non-drivers
- User convenience and comfort
- Safety and security
- Local economic development

Streets have many users whose interests should be balanced in planning decisions.

- Motorists who drive or park on the street
- People who currently walk and bicycle, and people who would use these modes if they were more convenient and attractive
- People standing and sitting near the street
- Users of goods and services shipped by road
- Motorists who must chauffeur non-drivers in automobile-dependent communities
- Businesses located near roads
- Residents living near roads
- People impacted by external impacts of roads, such as noise and air pollution

Complete streets policies insure that roadway planning, design and operations serve multiple modes, users and activities. This reflects a major change. Conventional transport planning assumes that streets' primary users are motorists. It evaluates transport system performance based primarily on motor vehicle traffic speeds, which favors wider streets with higher design speeds. It overlooks ways these design features can reduce accessibility by reducing roadway connectivity, creating barriers to active modes, and stimulating more dispersed development. Complete streets planning recognizes a wider range of modes, users and activities and therefore more trade-offs to consider in roadway design. It supports lower traffic speeds, alternative mode improvements, more connected networks, and more compact, accessible land use development. This tends to reduce maximum traffic speeds but improves accessibility in other ways.

Conventional planning tends to assume that urban arterials should be designed for 30-50 miles (50-80 kilometers) per hour, allowing 15-25 mile (25-40 km) average distances in 20-minute commute. The new planning paradigm recognizes that high traffic speeds are inappropriate in urban areas and so favors 20-30 mile per hour (30-50 km/hr) design speeds, which reduce average commutes to 8-12 miles (12-20 km). By reducing traffic speeds, improving transport options and supporting compact development, complete streets planning helps achieve various objectives including improved accessibility for non-drivers, road and parking facility savings, consumer savings and affordability, improved public fitness and health, energy conservation, noise and air pollution emission reductions, reduced sprawl, and more attractive streetscapes. It also helps achieve social equity objectives: they insure that public roads serve all community members, reduces risks that motor vehicles impose on non-motorized travelers, and improves accessibility for physically, economically and socially disadvantaged people.

The main long-term cost of these policies is a reduction in arterial traffic speeds. Can cities function efficiently with slower arterials? Yes, many of the world's most economically successful and livable cities operate with such speeds because lower automobile access is more than offset by improved transport options and more accessible land use patterns.

Conventional transport evaluation tends to exaggerate roadway expansion benefits and undervalue complete streets. More comprehensive analysis that considers more objectives, impacts and options can help identify truly optimal urban street designs. Methods exist for quantifying and monetizing many currently overlooked complete streets benefits.

Complete streets policies are a practical way to create more multi-modal transport systems and more livable communities. Transport planning should reflect future travel demands and strategic planning objectives, such as improving accessibility, safety, economic development, and basic mobility. Current demographic and economic trends are increasing demand for alternative modes and more accessible, livable communities. Complete streets design features such as wider sidewalks, better crosswalks, lower traffic speeds, bike- and bus-lanes should be evaluated based on the levels of walking, cycling and public transit travel that would occur on those roadways *after* reforms are implemented.

Complete streets benefits can be further increased by integrating complete streets with other planning reforms including multi-modal transport planning, smart growth and New Urbanism, context-oriented planning, and transportation demand management. This is not to suggest that in an optimal system automobile travel would disappear - but it would probably be significantly less than what occurs in most cities.

References and Information Resources

AARP (2009), *Planning Complete Streets for an Aging America*, American Association for Retired Persons Public Policy Institute (www.aarp.org/ppi); at <http://bit.ly/1BRJSqr>.

AARP (2015), *Evaluating Complete Streets Projects: A Guide for Practitioners*, National Complete Streets Coalition and Smart Growth America (www.smartgrowthamerica.org); at <http://bit.ly/1D7vQvK>.

ADB (2012), *Solutions for Urban Transport*, Asian Development Bank (www.adb.org); at http://farm8.staticflickr.com/7228/7399658942_267b1ba9fc_b.jpg.

Carlos A. Alba and Edward Beimborn (2005), *Analysis Of The Effects Of Local Street Connectivity On Arterial Traffic*, Transportation Research Board Annual Meeting (www.trb.org); at <http://bit.ly/1efkmQS>.

Geoff Anderson, et al. (2015), "Safer Streets, Stronger Economies Complete Streets Project Outcomes From Across The United States," *ITE Journal*, Vol. 85, No. 6, pp. 29-36; also see <http://bit.ly/1bqGAOW>.

Dan Burden and Todd Litman (2011), "America Needs Complete Streets," *ITE Journal* (www.ite.org), Vol. 81, No. 4, April, pp. 36-43; at www.vtpi.org/ITE_comp_st.pdf.

Sally Cairns, Stephen Atkins and Phil Goodwin (2002), "Disappearing Traffic? The Story So Far," *Municipal Engineer*, Vol. 151, Issue 1, March, pp. 13-22; at <http://bit.ly/1SZ3o90>.

CATSIP (California Active Transportation Safety Information Pages), *Case Studies: Complete Streets* (<http://catsip.berkeley.edu/walkbikesafer/Complete%20Streets>).

Kelly J. Clifton, et al. (2012), *Consumer Behavior And Travel Mode Choices*, Oregon Transportation Research and Education Consortium (www.otrec.us); at <http://bit.ly/1efk5xl>.

CNU (2003), *Civilizing Downtown Highways: Putting New Urbanism To Work On California's Highways*, Congress for the New Urbanism (www.cnu.org).

Complete Streets (www.completestreets.org).

Complete Streets for Canada (<http://completestreetsforcanada.ca/backgrounders>)

Heather Contrino and Nancy Mcguckin (2009), "Travel Demand in the Context of Growing Diversity: Considerations for Policy, Planning, and Forecasting," *TR News*, Transportation Research Board (www.trb.org), September-October, pp. 4-9; at <http://bit.ly/1U1LXpF>.

CTRE (2012), *Four-Lane to Three-Lane Conversion*, Iowa State University Center for Transportation Research and Education (www.ctre.iastate.edu); at www.ctre.iastate.edu/research/4laneto3lane.htm.

CTS (2010), *Measuring What Matters: Access to Destinations*, Center for Transportation Studies, University of Minnesota (www.cts.umn.edu); at <http://bit.ly/1GVS5Ja>.

Camille Delepierre (2008), *Decreasing Car Speed In Cities – Pro's And Cons - In Theory And Practice: With Lund, Malmö (Sweden) And Lille (France) Examples*, Masters Thesis, Lund University; at www.lumes.lu.se/database/alumni/06.08/thesis/Camille_Delepierre.pdf.

DfT (2006), *Transport Analysis Guidance*, Integrated Transport Economics and Appraisal, Department for Transport (www.dft.gov.uk/webtag).

Dowling Associates (2010), *CompleteStreetsLOS: Multi-Modal Level-of-Service Toolkit*, Dowling Associates (www.dowlinginc.com/completestreetslos.php).

Eric Dumbaugh (2005), "Safe Streets, Livable Streets," *Journal of the American Planning Association* (www.planning.org), Vol. 71, No. 3, pp. 283-300; at <http://bit.ly/1R0fmS7>.

ELTIS (www.eltis.org), European Local Transport Network Information Service provides information on various transportation demand management programs.

Reid Ewing and Robert Cervero (2010), "Travel and the Built Environment: A Meta-Analysis," *Journal of the American Planning Association*, Vol. 76, No. 3, Summer, pp. 265-294; at <http://bit.ly/1FLv9bB>.

FHWA (1989), *Functional Classification Guidelines*, U.S. Federal Highway Administration (www.fhwa.dot.gov); at <http://1.usa.gov/1Hu84BF>.

Ann Forsyth, Kevin J. Krizek and Asha Weinstein Agrawal (2010), *Measuring Walking and Cycling Using the PABS (Pedestrian and Bicycling Survey) Approach: A Low-Cost Survey Method for Local Communities*, Mineta Transportation Institute, San Jose State University (www.transweb.sjsu.edu); at www.transweb.sjsu.edu/project/2907.html.

Lawrence Frank and Chris Hawkins (2007), *Fused Grid Assessment: Travel And Environmental Impacts Of Contrasting Pedestrian And Vehicular Connectivity*, Canada Mortgage and Housing Corporation (www.cmhc-schl.gc.ca).

Bill Frith (2012), *Economic Evaluation Of The Impact Of Safe Speeds: Literature Review*, Report 505, New Zealand Transportation Agency (www.nzta.govt.nz); at <http://bit.ly/1FLvevY>.

Vikash V. Gayah and Carlos F. Daganzo (2012), "Analytical Capacity Comparison of One-Way and Two-Way Signalized Street Networks," *Transportation Research Record 2301*, Transportation Research Board (www.trb.org), pp. 76-85; summarized in "Two-Way Street Networks: More Efficient than Previously Thought?" *Access 41*, Fall, pp. 10-15; at www.uctc.net/access/41/access41.pdf.

Susan Handy, Gil Tal and Marlon G. Boarnet (2010), *Draft Policy Brief on the Impacts of Network Connectivity Based on a Review of the Empirical Literature*, for Research on Impacts of Transportation and Land Use-Related Policies, California Air Resources Board (<http://arb.ca.gov/cc/sb375/policies/policies.htm>).

Joseph Henchman (2013), *Gasoline Taxes and Tolls Pay for Only a Third of State & Local Road Spending*, The Tax Foundation (www.taxfoundation.org); at <http://bit.ly/1IF17tL>.

HSIS (2010), *Evaluation of Lane Reduction "Road Diet" Measures on Crashes Summary Report Research, Development, and Technology*, Highway Safety Information System (www.hsisinfo.org); summary www.fhwa.dot.gov/publications/research/safety/10053/10053.pdf.

ITDP (2011), *Better Street, Better Cities: A Guide To Street Design In Urban India*, Institute for Transport and Development Policy and Environmental Planning Collective (www.itdp.org/betterstreets).

ITDP (2012), *The Life and Death of Urban Highways*, Institute for Transport and Development Policy and Environmental Planning Collective (www.itdp.org); at <http://bit.ly/1R0geGg>.

ITF (2012), *Pedestrian Safety, Urban Space and Health*, International Transport Forum for the OECD (www.oecdbookshop.org); at <http://www.oecd.org/bookshop?9789282103654>.

ITE (2010), *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, Recommended Practice, Institute of Transportation Engineers (www.ite.org); at www.ite.org/css.

John LaPlante and Barbara McCann (2008), "Complete Streets: We Can Get There From Here," *ITE Journal*, Vol. 78, No. 5 (www.ite.org), pp. 24-28; at <http://bit.ly/1BRJhou>.

Larry Frank & Company (2005), *A Study of Land Use, Transportation, Air Quality and Health in King County, WA*, King County; at <http://1.usa.gov/1LRr5f3>.

Todd Litman (2002), "Evaluating Transportation Equity," *World Transport Policy & Practice* (http://ecoplan.org/wtpp/wt_index.htm), Vol. 8, No. 2, Summer, pp. 50-65; at www.vtpi.org/equity.pdf.

Todd Litman (2003), "Measuring Transportation: Traffic, Mobility and Accessibility," *ITE Journal* (www.ite.org), Vol. 73, No. 10, October, pp. 28-32; at www.vtpi.org/measure.pdf. Also see *Evaluating Accessibility for Transportation Planning*, at www.vtpi.org/access.pdf.

Todd Litman (2006), "Changing Travel Demand: Implications for Transport Planning," *ITE Journal*, Vol. 76, No. 9, (www.ite.org), September, pp. 27-33; at www.vtpi.org/future.pdf.

Todd Litman (2008), *Parking Management: Strategies, Evaluation and Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/park_man.pdf.

Todd Litman (2009), *Transportation Cost and Benefit Analysis*, Victoria Transport Policy Institute (www.vtpi.org/tca).

Todd Litman (2010), *Evaluating Active Transport Benefits and Costs*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/nmt-tdm.pdf.

Todd Litman (2012), *Toward More Comprehensive and Multi-modal Transport Evaluation*, VTPI (www.vtpi.org); at www.vtpi.org/comp_evaluation.pdf.

Todd Litman (2012), *Smart Congestion Relief: Comprehensive Analysis Of Traffic Congestion Costs and Congestion Reduction Benefits*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/cong_relief.pdf.

Todd Litman (2013), "The New Transportation Planning Paradigm," *ITE Journal* (www.ite.org), Vo. 83, No. 6, pp. 20-28; at www.vtpi.org/paradigm.pdf.

Anastasia Loukaitou-Sideris And Renia Ehrefoecht (2010), "Vibrant Sidewalks in the United States: Re-integrating Walking and a Quintessential Social Realm," *Access 36* (www.uctc.net/access); Spring 2010, pp. 22-29; at www.uctc.net/access/36/access-36vibrantsidewalks.pdf.

Wesley E. Marshall and Norman W. Garrick (2011), "Evidence on Why Bike-Friendly Cities Are Safer for All Road Users," *Environmental Practice*, Vol 13/1, March; at <http://files.meetup.com/1468133/Evidence%20on%20Why%20Bike-Friendly.pdf>.

Barbara McCann (2013), *Completing Our Streets: The Transition to Safe and Inclusive Transportation Networks*, Island Press (www.islandpress.org); at <http://islandpress.org/ip/books/book/islandpress/C/bo9115674.html>.

Barbara McCann and Suzanne Rynne (2010), *Complete Streets: Best Policy and Implementation Practices*, Planning Advisory Service Report Number 559, American Planning Association (www.planning.org); at www.planning.org/pas/brochure/pdf/report.pdf.

NACTO (2011), *Urban Bikeway Design Guide*, National Association of City Transportation Officials (www.nacto.org); at <http://nacto.org/cities-for-cycling/design-guide>.

NACTO (2012), *The Urban Street Design Guide*, National Association of City Transportation Officials (www.nacto.org); at <http://nacto.org/urbanstreetdesignguide-overview>.

National Complete Streets Coalition (www.completestreets.org) promotes adoption of policies to ensure communities effectively accommodate multiple modes and support local planning objectives in all transportation projects. It maintains an extensive collection of resources on its webpage.

NCSC (2010), *Complete Streets Fact Sheets*, National Complete Streets Coalition (www.completestreets.org); at www.completestreets.org/complete-streets-fundamentals/factsheets.

NCSC (2011), *Costs of Complete Streets: What We Are Learning from State and Local Governments*, National Complete Streets Coalition (www.completestreets.org); at www.smartgrowthamerica.org/documents/cs/factsheets/cs-costs-2.pdf.

Nelson\Nygaard (2009), *Abu Dhabi Urban Street Design Manual*, Abu Dhabi Urban Planning Council (www.upc.gov.ae/en/Home.aspx); at <http://bit.ly/1R0fBfW>.

NJDOT (2012a), *A Guide To Creating A Complete Streets Implementation Plan*, New Jersey Department Of Transportation (www.state.nj.us); at <http://bit.ly/1GLvFYp>.

NJDOT (2012b), *Making Complete Streets A Reality: A Guide to Policy Development*, New Jersey Department Of Transportation (www.state.nj.us); at <http://bit.ly/1LyFMpl>.

Robert Noland and Mohammed A. Quddus (2006), "Flow Improvements and Vehicle Emissions: Effects of Trip Generation and Emission Control Technology," *Transportation Research D*, Vol. 11 (www.elsevier.com/locate/trd), pp. 1-14; also see <http://bit.ly/1R0fEIG>.

NZTA (2010), *Economic Evaluation Manual*, Volumes 1 and 2, New Zealand Transport Agency (www.nzta.govt.nz); at www.nzta.govt.nz/resources/economic-evaluation-manual/volume-1/index.html and www.nzta.govt.nz/resources/economic-evaluation-manual/volume-2/docs/eem2-july-2010.pdf.

NYCDOT (2009), *New York City Street Design Manual*, New York City Department of Transportation (www.nyc.gov/html/dot) at www.nyc.gov/html/dot/html/about/streetdesignmanual.shtml.

NYCDOT (2011), *Bike Lanes: Memorandum*, New York City Department of Transportation (www.nyc.gov/html/dot); at www.nyc.gov/html/om/pdf/bike_lanes_memo.pdf.

NYCDOT (2012), *Measuring the Street: New Metrics for 21st Century Streets*, New York City Department of Transportation (www.nyc.gov/html/dot); at <http://on.nyc.gov/1pRKn8P>.

OECD (2012), *Long-run Trends in Travel Demand*, International Transport Forum and OECD Roundtable (www.oecd.org); at <http://internationaltransportforum.org/jtrc/RoundTables/2012-Long-run-Trends/index.html>.

Theodore A. Petritsch (2009), *The Truth About Lane Widths*, Pedestrian and Bicycle Information Center (www.walkinginfo.org); at www.walkinginfo.org/library/details.cfm?id=4348.

PPS (2008), *Streets As Places: Using Streets To Rebuild Communities*, Project for Public Spaces (www.pps.org); at www.pps.org/pdf/bookstore/Using_Streets_to_Rebuild_Communities.pdf.

PPS (2008), *The Quiet Revolution in Transportation Planning: How Great Corridors Make Great Communities*, Project for Public Spaces (www.pps.org); at <http://bit.ly/1Hr4lmv>.

PPS (2012), *Rightsizing Streets*, Project for Public Spaces (www.pps.org); at www.pps.org/reference/rightsizing.

Molly E. Ranahan, James A. Lenker and Jordana L. Maisel (2014), *Evaluating the Impact of Complete Streets Initiatives*, Center for Inclusive Design & Environmental Access, University at Buffalo School of Architecture and Planning (www.idea.ap.buffalo.edu); at <http://bit.ly/1efjQ5w>.

Roger P. Roess, Elena S. Prassas and William R. McShane (1998), *Traffic Engineering*, Prentice Hall.

SACOG (2011), *Complete Streets Resource Toolkit*, Sacramento Area Council of Governments (www.sacog.org); at www.sacog.org/complete-streets/toolkit/START.html.

Schaller Consulting (2006), *Curbing Cars: Shopping, Parking and Pedestrian Space in SoHo*, Transportation Alternatives (www.transalt.org); at <http://bit.ly/1LyFOgZ>.

Marc Schlossberg, John Rowell, Dave Amos and Kelly Sanford (2013), *Rethinking Streets: An Evidence-Based Guide to 25 Complete Street Transformations*, University of Oregon's Sustainable Cities Initiative (<http://sci.uoregon.edu>); at www.rethinkingstreets.com.

SDOT (2008), *Case Studies in Urban Freeway Removal*, Seattle Urban Mobility Plan, Seattle Department of Transportation (www.cityofseattle.net); at <http://bit.ly/1Hu7x2s>.

Stefanie Seskin and Lily Gordon-Koven (2013), *Best Complete Streets Policies of 2012*, National Complete Streets Coalition (www.completestreets.org) and Smart Growth America (www.smartgrowthamerica.org); at <http://bit.ly/1JtzOXp>.

Donald Shoup (2005), *The High Cost of Free Parking*, Planners Press (www.planning.org).

Streetmix (www.StreetMix.net) is an easy-to-use web-based street section builder which illustrates various configurations of sidewalks, bike-, bus-, parking- and general traffic lanes for a particular street.

Subsidy Scope (2009), *Analysis Finds Shifting Trends in Highway Funding*, Subsidy Scope (www.subsidyscope.com); at www.subsidyscope.com/transportation/highways/funding.

Fred Sztabinski (2009), *Bike Lanes, On-Street Parking and Business A Study of Bloor Street in Toronto's Annex Neighbourhood*, The Clean Air Partnership (www.cleanairpartnership.org); at www.cleanairpartnership.org/pdf/bike-lanes-parking.pdf.

Carol H. Tan (2011), "Going On A Road Diet: Lane Reduction Can Increase Safety For Pedestrians, Bicyclists, And Motorists While Improving The Quality Of Life In Downtowns Across The Country," *Public Roads*, U.S. Federal Highway Administration (www.fhwa.dot.gov); at <http://1.usa.gov/1NuCPET>.

Rodney Tolley (2011), *Good For Busine\$\$ - The Benefits Of Making Streets More Walking And Cycling Friendly*, Heart Foundation South Australia (www.heartfoundation.org.au); at <http://bit.ly/19RTEe9>.

Hans-Joachim Vollpracht (2010), "They Call Them Coffin Roads," *Routes-Roads*, N° 347, World Road Association (www.piarc.org); at www.vtpi.org/Vollpracht.pdf.

VTPI (2012), *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org/tdm).

Vicky Feng Wei and Gord Lovegrove (2010), "Sustainable Road Safety: A New (?) Neighbourhood Road Pattern That Saves VRU (Vulnerable Road Users) Lives," *Accident Analysis & Prevention* (www.sciencedirect.com/science/journal/00014575).

Wikipedia (2011), *Public Transit Networks, Transportation Geography and Network Science*, Wikipedia Books (<http://en.wikibooks.org>); at <http://bit.ly/1GINIy0>.

WSDOT (2011), *Washington's Complete Streets and Main Street Highways: Case Study Resource*, Washington State Department of Transportation (www.wsdot.wa.gov/LocalPrograms/Planning) at <http://tinyurl.com/ks6cq6>.

www.vtpi.org/compstr.pdf