Bicycle Mobility Systems

Introduction

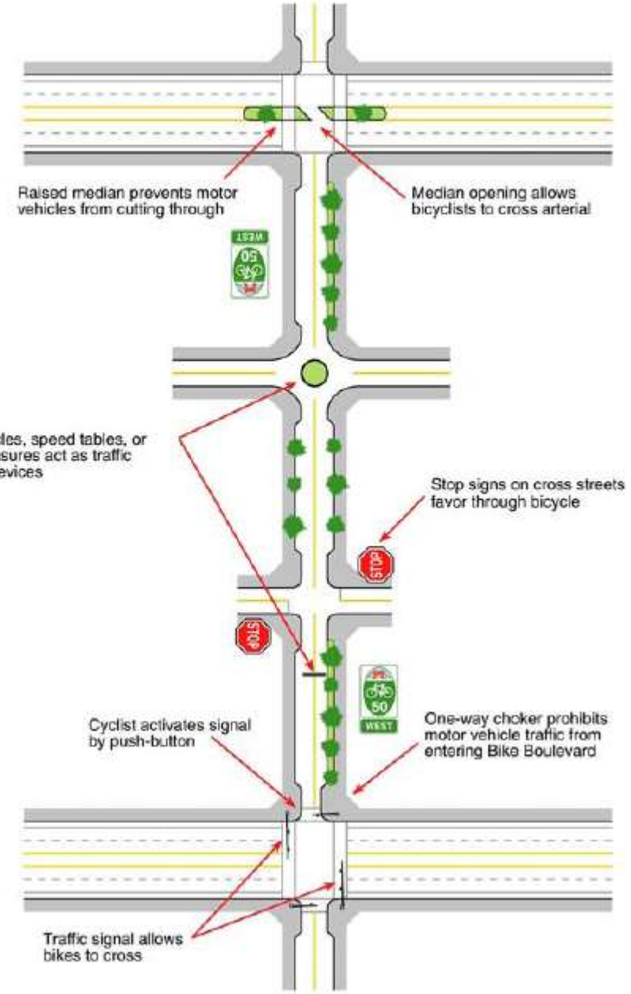
In the United States, approximately 63% of trips take place within a "bikeable distance" (five miles from origin to destination).[1] Yet, more than 82% of trips five miles or less are made by automobile whereas only 1.3% of such trips are made by bicycle.[2] For all trips, less than 1% are made by bike.[3] However, some cities have demonstrated that the bicycle does have a place in the traffic system. For example, in Boulder, Colorado, the bicycle accounted for 21% of commute trips and 14% of all trips.[4] Davis, California is also notable as 17% of all trips in the city are made by bicycle.[5] In larger cities, the bicycle has a place in commuter travel, being used for 5% of such trips in Portland, Oregon; 2% in San Francisco, California; and 1% in Chicago, Illinois.[6]

The European approach to bicycle mobility demonstrates the importance of the bicycle as an integral part of the transportation system. For example, in the Netherlands, the bicycle is used for almost a quarter of all journeys, and for distances up to 7.5 kilometers it is the most popular means of transport. In fact, in 2005, 35% of all trips up to 7.5 kilometers were made by bicycle. Notably, bicycle use is dependent on the distance covered. Approximately 70% of all journeys in the Netherlands are shorter than 7.5 kilometers. Nevertheless, the strong position of the bicycle over short distances (35%) extends into the total modality split with the bicycle being used for 27% of all trips.[7]

High quality bicycle-friendly infrastructure is a prerequisite to the bicycle achieving and retaining a full status position in a traffic system and to a higher proportion of bicycles in the modal split. It begins with an integral design at the network, connection, and facility level. The quality of facilities offered to cyclists should be assessed with the same criteria as the quality offered to other road users.

High quality infrastructure also requires five key factors in the development of a cycle network: cohesion, directness, safety, comfort, and attractiveness. Cohesion requires that connections link up from a cyclist's point of departure to their destination. The two major components of directness at the network level are in, terms of distance, the extent to which a network provides the opportunity to cycle the most direct route possible, and in terms of time, connections that optimize traffic flow. At the network level, there are many measures that can be implemented to enhance safety. These include avoiding conflicts with crossing traffic, separating vehicle types, reducing speed at points of conflict, ensuring recognizable road categories, and ensuring uniform traffic situations. Cyclists must also be able to comfortably use the connections, meaning that encounters between bicycles and cars are minimized and attraction points are clearly signposted so that cyclists can easily find their destinations. Attractiveness is also an important consideration and should be enhanced by running connections through built-up areas in varied surroundings with well-maintained public space, providing adequate lighting, and locating connections in areas with a low risk to social safety. (See the Appendix of this chapter for a summary of the main requirements for a cycle network).

Graphic



Cyclists also need facilities to park their bicycle safely, easily and tidily. The fear of theft leads to reduced use of bicycles. In high bicycle-use areas establishing public parking facility requirements is a dynamic process that is not satisfied with simple formulas. For example, points of departure (homes), destination points (companies and institutions as well as service and retail centers), and transfer points (public transport stops) have different parking needs. In city centers, for example, the type of bicycle storage facility can encourage or discourage cyclists. For instance, the introduction of free, supervised storage is very effective in stimulating the use of bicycles and reducing theft[8].

[1] LEED ND Core Committee 2006, *Understanding the Relationship between Public Health and the Built Environment*, Available online. Viewed 2/6/09.
[2] League of American Bicyclists, *Ride for the Environment*, Available online. Viewed 2/6/09.
[3] Pucher, J., Buehler, R. (2008). Making Cycling Irresistible: Lessons from the Netherlands, Denmark, and Germany. *Transport Reviews*, 28: 4, 495-528. Available online. Retrieved 4-2-09.
[4] League of American Bicyclists 2005, *Bicycle Friendly Communities (Boulder, Colorado)*, Available online. Not working 2/6/09.
[5] League of American Bicyclists 2005, *Bicycle Friendly Communities (Davis, California)*, Available online. Not working 2/6/09.
[6] City of Seattle 2008, *Seattle Urban Mobility Plan: 8 Bicycle and Pedestrian Travel*, Available online. Viewed 2/6/09.
[7] Ministry of Transport, Public Works and Water Management Directorate-General for Passenger Transport 2007, *Cycling in the Netherlands*, Ministry of Transport, Public Works and Water Management Directorate-General for Passenger Transport, Den Haag.

[8] CROW, 2007, *Design Manual for Bicycle Traffic*, Ede, NL.

Implications of Not Addressing the Issue

- Decreased accessibility to community destinations, particularly by vulnerable populations
- Increased air pollution and related health impacts caused by automobile traffic
- Increased obesity and related illnesses
- Higher costs for transportation as a percentage of household budgets
- High traffic noise nuisance
- Lower levels of mobility for all social, economic and age groups
- Increased congestion and trip travel time
- Higher municipal costs related to road and parking facilities for automobiles
- Continued high traffic mortality and injury rates, particularly for pedestrians and cyclists

Goals

Eliminate obstacles, create incentives and enact standards to achieve the following:

- Increase mobility choices, thereby enhancing social equity
- Enhance public safety, particularly for cyclists
- Increase municipal cost savings for infrastructure construction and maintenance
- Increase household cost savings for transportation expenses
- Reduce per capita vehicle miles traveled (VMTs)
- Make cycling more advantageous than traveling by automobile in terms of convenience, comfort and time spent traveling
- Improve public health through increased physical activity
- Overcome cultural barriers such as status or perceived unsuitability of cycling for women
- Promote the supportive goal of high density, multiple destination centers

Potential Sustainability measures

These metrics should be considered when evaluating the success of the zoning and code ordinances discussed above. Careful analysis and evaluation of these statistics will provide an accurate indication of whether the measures are producing their desired results and create guideposts to re-defining the zoning code where the metrics demonstrate underperformance.

- Modal share for cycling travel
- Amount of service facilities in the bicycle network at Level of Service C or better
- Regulate average speed along main cycle routes to between 4 to 7 km of 16 km/h for 85% of journeys[9]
- Travel time to the nearest lockable bicycle parking facility at a public transport stop within a regional or supraregional core area is between five and ten minutes from the point of origin[10]
- Mortality and injury rates for cyclists
- Amount of per capita spending over time for mobility
- Amount of per capita vehicle miles traveled
- Fluctuations in obesity levels
- Percentage of women, children and elderly cycling activity
- Amount of transportation congestion
- Amount of carbon emissions and other air pollution.

[9] *See* 2005-2020 Municipal Traffic and Transport Plan by the Utrecht municipal council, cited on p. 19 of "Design Manual for bicycle Traffic, CROW Record 25, Ede, NL.
[10] Ibid.

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KEY STATISTICS:

- In the United States, approximately 63% of trips take place within a "bikeable distance" (5 miles from origin to destination)
- More than 90% of trips take place by automobile
- Motor vehicle traffic accidents are the number one leading cause of unintentional injury deaths for all age groups between 1 and 64[11]
- Two-thirds of adults are either overweight or obese[12]
- Childhood obesity rates have tripled since 1980 (6.5% to 16.3%)[13]
- In the United States bicycle trips as a percentage of all trips represents less than 1% while it is significantly higher in European countries: 27% in the Netherlands, 16% in Denmark [14]
- The bicycle is the most efficient form of transportation, using 35 calories per passenger mile compared to 1860 for the automobile and 880 for rail[15]
- Cycling activity supports 11,000 jobs in Colorado[16]

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		ACHIEVEMENT LEVELS (NOTE: HIGHER LEVELS GENERALLY INCORPORATE ACTIONS OF LOWER LEVELS)				
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
 Interurban cycle track, Delft, NL	**Remove Obstacles**	▪ Eliminate free or low cost on street parking and charge market pricing, particularly in the city centers *(see Parking Framework Section)*  Secure bicycle parking, train station, Delft, the Netherlands	▪ Eliminate single or limited use zones in neighborhood, community and town centers ▪ Include cycling infrastructure additions or improvements with all transportation infrastructure projects ▪ Establish exclusive and convenient bicycle rider activated or exclusive bicycle traffic signal control standards ▪ Amend level of service standards to incorporate bicycles ▪ Amend traffic analysis protocols to address "person trips" rather than only automobile trips	▪ Limit new residential development to within two miles from a town or city center ▪ Amend street standards that fail to integrate bicycle standards, with the exception of limited access highways and selected major arterials	▪ A critical first step in overcoming obstacles is comprehensive policy planning. For an overview of successful bicycle planning in Europe, see: Fietsberaad 2006, *Continuous and integral: The cycling policies of Groningen and other European cycling cities,* Fietsberaad Publication No. 7, Amsterdam. Available online. Retrieved December 2, 2010. ▪ An American example of comprehensive bicycle planning: City of Redmond, WA, Bicycle System Plan. Available online. Retrieved December 2, 2010.	Bronze ▪ Washington D.C., variable market based parking fees.. A percentage of revenues is directed to bicycle system enhancements. *Performance Parking Pilot Program.* Available online. Retrieved December 2, 2010. Silver ▪ City of Portland. *Zoning Code, Section 33.130—Commercial Zones* (see Mixed Commercial/Residential Zone). Available online. Retrieved December 2, 2010. ▪ For required infrastructure for cycling see: City of Aurora, Colorado (2008). *Bicycle Facility Design Guidelines.* Contact the planning department.

[11] National Vital Statistics System, National Center for Health Statistics, Centers for Disease Control.
[12] Behavioral Risk Factor Surveillance System (BRFSS), Centers for Disease Control.
[13] Ibid.
[14] Pucher, J., Buehler, R. (2008). Making Cycling Irresistible: Lessons from the Netherlands, Denmark, and Germany. *Transport Reviews*, 28: 4, 495-528. Available online. Retrieved 4-2-09.
[15] Lowe, Marcia (1989). *The Bicycle: Vehicle for a Small Planet.* Worldwatch Institute.
[16] Outdoor Industry Association Active Outdoor Recreation Economy Report, 2005

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 Bicycle route intersection treatment, Paris				 Bicycles welcome on streets adjacent to Notre Dame Cathedral, Paris	▪ Victoria Transport Institute (2009), *Multi-Modal Level-of-Service Indicators: Tools For Evaluating The Quality of Transport Services and Facilities.* Available online. Retrieved December 2, 2010. ▪ City of Delft, "Bicycle Action Plan II 2005 – 2010" (2005). In Dutch only. Available online. Retrieved December 2, 2010.	▪ California Manual on Uniform Traffic Control Devices, Part 9 Traffic Controls for Bicycle Facilities Available online. Retrieved December 2, 2010. ▪ Shift in measuring traffic capacity to assessing mobility. Montgomery County, MD. *Policy Area Mobility Review.* Available online. Retrieved December 2, 2010. ▪ Incorporation of person trips. Moving People. Denver Strategic Transportation Plan 2008. Available online. Retrieved December 2, 2010. Gold ▪ Limits on the location of new residential development---*Boulder Valley Comprehensive Plan.* Tiered growth boundaries. Available online. Retrieved December 2, 2010.
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
 Cherry Creek bicycle trail, Denver, Colorado (Photo: Bicycle Colorado)	**Create Incentives**	▪ Permit off street bicycle parking in lieu of automobile parking	▪ Reduce transportation or traffic related impact fees for provision of bicycle facilities	▪ Density bonuses for high quality bicycle facilities and integration with larger system	▪ Queensland, Australia, *End of Trip Facilities for Bicycle Riders (2006).* Standards for access, changing facilities, showers, lockers, etc. Available online. Retrieved December 2, 2010.	Bronze ▪ Sacramento County, *Zoning Code, Title III, Chapter 30, Off-Street Parking* (bicycle parking and shower facilities in lieu of auto parking). Available online. Retrieved December 2, 2010.

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		Bronze (Good)	Silver (Better)	Gold (Best)	References/Commentary	Code Examples/Citations
 Signals, cycle track coloring, surface markings. Rotterdam, NL.  Bicycle parking garage. Amsterdam Central Station.  Bicycle signal green light	**Enact Standards**	▪ Establish context specific uniform traffic guidelines for bicycle facilities that are related to the function of roads and uniformly applied to particular road and intersection types ▪ Establish street cross-section design criteria for new and retrofitted existing streets that include on-street bicycle facilities ▪ For cycle paths and shared routes establish consistent and specific standards for the following: ▪ Use color to make cycle tracks and lanes clear to the road users ▪ Sign postings ▪ Bicycle route and warning signage for preferred routes ▪ Lighting on cycle routes ▪ Recognizable road categories such that every traffic amenity and provision is recognizable to all road users ▪ Reflection strips on main cycle routes ▪ Crossings ▪ Signals ▪ Ramps ▪ Sight distance ▪ Obstructions	▪ Avoid conflicts by separating traffic types, reducing the speed of motorized traffic, and limiting the amount of motorized traffic on major cycle routes ▪ Minimize waiting times at traffic lights by having remote detection on cycle routes ▪ Establish bicycle parking and storage standards: ▪ Mandatory bicycle parking or storage for all uses including residences ▪ Situate bicycle storage facilities in or on the edge of a core shopping area ▪ Situate bicycle storage facilities no more than 30 meters away from a busy area ▪ Ensure a good visual relationship and attractive walking route between the destination point and the bicycle storage facility ▪ Locate bicycle parking in the most convenient locations near entrances ▪ Lockable bicycle storage facility at all major activity centers ▪ Set standards for signage design, type, frequency of placement for different route types and street volumes ▪ Assign maximum waiting times at stops for cyclists ▪ Reduce waiting times for cyclists at signalized intersections by concurrent extension of a green phase for cyclists to the detriment of motorized traffic	▪ Replace intersections with roundabouts whereupon cyclists have right of way ▪ For main cycle routes limit the number of intersections where cyclists do not have the right of way to near zero ▪ Require direct integration into or creation of a cycling network with a mesh width of no more than 750 feet Reduce waiting time for cyclists at traffic lights by using a "green wave," *(an intentionally induced phenomenon in which a series of traffic lights are coordinated to allow continuous traffic flow over several intersections in one main direction)* for bicycle traffic timed at 10-15 mph instead of the usual 25 mph. ▪ Require secure bicycle storage facilities for all residential dwelling units ▪ Require that major activity centers and transit stops be equipped with lockable bicycle storage	▪ Design Manual for bicycle Traffic, CROW Record 25, Ede, NL. ▪ City of Aurora, Colorado requires bicycle lanes for all collector and arterial streets ▪ City of Aurora, CO establishes detailed bicycle lane striping, and stencil dimensions and location criteria for treatments for mid-block bus stops, various street intersection situations ▪ City of Portland, OR, Installing Bike Parking Guidelines. Available online. Retrieved January 25, 2010. December 2, 2010. ▪ City of Aurora, CO establishes shared use path standards covering at grade crossings for midblock, adjacent path and complex intersection crossings ▪ Comment on color standards: For example, red is now the national standard for cycle tracks and cycle lanes in the Netherlands. It is believed that by using the red color, cycle provision become more recognizable and visible resulting in a favorable effect for cyclists comfort (ease of use) and traffic safety. The use of colors can also support the continuity of the route.	Bronze ▪ For signage and bicycle lane stencil standards see the City of Aurora, CO, Bicycle Facility Design Guidelines, February 2008 ▪ For new city street construction design criteria incorporating on-street bike lanes, see City of Aurora, CO City Code Chapter 126-36. ▪ City of Portland, OR. Table 266-6, Minimum Required Bicycle Parking. Available online. Retrieved December 2, 2010. ▪ City of San Francisco Planning Code Article 1.5 Sections 155.4 and 155.5 Bicycle Parking Requirements for New and Renovated Commercial and residential buildings with 4 or more units. Requirement of bicycle racks or other means of storage (number, design standards, location) Available online. Retrieved December 2, 2010. ▪ City of San Francisco, Planning Code Article 1.5 Section 155.3 (Shower facilities and lockers for new and renovated commercial and industrial buildings). Available online. Retrieved December 2, 2010. Silver ▪ Louisville, Kentucky, Chapter 9 Appendix 9A Bicycle Parking Design Manual. Available online. Retrieved December 2, 2010.

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		Bronze (Good)	Silver (Better)	Gold (Best)	References/Commentary	Code Examples/Citations
 Way-finding signage for cyclists, near Maasland, the Netherlands	**Enact Standards (con't.)**	▪ Require connections or enhancements to cycling routes near main departure points and destination areas ▪ Establish landscape vegetation standards to minimize nuisance from wind and rain ▪ Require bicycle detection for all signal detection devices ▪ Establish bicycle parking standards that include both the number and location of facilities ▪ Require shower and changing facilities for established type and size employment centers	 Intersection treatment, Delft, NL	▪ Require separate bicycle traffic light signals ▪ Establish standards and develop bicycle boulevards for selected routes  Human powered bicycle ferry on the canal. Delft, NL	▪ U.S. Department of Transportation (2008), Making Signal Systems Work for Cyclists by David Gibson Available online. Retrieved December 2, 2010. ▪ U.S. Dep't. of Transportation. European Approaches to Bicycle and Pedestrian Facility Design Available online. Retrieved December 2, 2010. ▪ U.S. Dep't. of Transportation Bicycle Parking And Storage Standards. Available online.. Retrieved December 2, 2010. ▪ ITE (2003), Innovative Bicycle Treatments. Available online. Retrieved December 2, 2010.  Bicycle tunnel, Delft, NL	Gold ▪ Mandatory lockable bicycle storage facilities at major activity centers. Central Midlands Council of Governments (2006). CMCG Model Policy Guidelines for Pedestrian-Bicycle Circulation. Available online. Retrieved December 2, 2010. ▪ Amsterdam, NL. "Green Wave" traffic light timing at 10-11 mph. Raadhuisstraat pilot project. Available online. Retrieved December 2, 2010.

Strategic Success Factors (supportive policy and programs)

A successful outcome requires that regulatory tools be grounded in solid comprehensive policy planning and accompanied by competent administration and supportive programs.

Planning Policy

- Incorporate “complete streets policies” in comprehensive land use and transportation plans (see Complete Streets Framework Section)
- Develop a specific bicycle mobility plan integrated with the overall transportation plan
    - As part of this plan recognize differing cyclist competencies, bicycling behavior, a systemic approach and incorporation of high quality infrastructure
    - Planning activity should result in the most direct bicycle route possible such that in many cases using the bicycle is quicker than the car

Programs & Administration

- Engage in communication regarding bicycle routes as well as the benefits of bicycle use
- In high density, high intensity activity areas introduce public transport bicycle programs an infrastructure
- Provide road safety lessons to children in primary schools
- Bar car traffic through city centers or car free zones while allowing bicycle traffic on specific days, during specific times or as part of a permanent approach
- Create infrastructure and programs that prioritize cyclists over cars in the urban core
- Establish “no excuse” (easy and comfortable) bicycle routes or paths to primary destination points
- Designate development intensification zones based on proximity and accessibility to the city
- Promote “bicycle in the chain” to encourage use of the bike in combination with public transport
- Offer local businesses a bicycle plan in which fiscal benefits are given to employees to purchase and use the bicycle
- Provide free, supervised bicycle storage facilities for high activity centers
- Increase bicycle crossing points in high traffic, destination rich areas
- Eliminate discontinuities between mobility systems

APPENDIX

A. Summary of Main Requirements for a Cycle Network

(Source: Design Manual for bicycle traffic, CROW Record 25, Ede, NL)

MAIN REQUIREMENT	IMPORTANT ASPECTS	EXPLANATION
Cohesion	• Network Completeness (inside built-up area) • Route Completeness (outside built-up area) • Match with need to travel	The mesh width of the network is no more than approximately 250 meters Centers and important amenities are interconnected At least about 70% of all bicycle journeys are made via the cycle network
Directness	• Directness in terms of distance • Directness in terms of time	Minimization of the number of intersections where cyclists have no right-of-way Minimize the stopping frequency
Safety	• Avoid conflicts with crossing traffic • Separated vehicle types • Reduce speed at conflict points • Recognizable road categories • Uniform traffic situations	Summed up for all intersections, the number of crossing movements made by cyclists times the intensity of the passing flow of motorized traffic, weighed according to speed is minimized Summed up for all road sections, the density of motorized traffic times the density of bicycle traffic times the speed difference squared times the length of the road section is minimized In the case of major speed differences, cyclists are separated from motorized vehicles Where the cycle network crosses networks carrying other vehicle types, speed differenced between both are reduced Every amenity should be recognizable as such to all road users Cycle amenities and intersection solutions are related to functions of tracks and roads for bicycle and motorized traffic. Solutions that are characteristic of a certain type of road should not be used on other types of roads.
Comfort	• Prevent Traffic Nuisance • Ease of Finding Destination • Comprehensibility	Encounters between bicycle s and cars are minimized Towns, cities, villages, districts and amenities that attract the public are signposted The network makes the best possible use of spatial and landscape features so users can form a mental map.
Attractiveness	• Social Safety	Networks, and particularly the main routes with them, meet the requirements of social safety. At network level, this means that busy routes are plotted in areas where there is sufficient social control in the community.

B. Option Diagram for Road Section inside the Built-Up Area

(Source: Design Manual for bicycle traffic, CROW Record 25, Ede, NL)

				CYCLE NETWORK CATEGORY		
Road Category	**Max. Speed of Motorized Traffic**		**Motorized Traffic Intensity**	**Base network**	**Cycle Network**	**Main Cycle Route**
	N/A		0	Solitary Track		
Estate Access Road	Walking Pace or 20 miles/h		1 – 2.500	Combined Traffic		Cycle Street or Cycle Lane (with right of way)
			2.000 – 5.000			
			> 4.000	Cycle Lane or Cycle Track		
District Access Road	30 miles/h	2x1 Lanes	Irrelevant	Cycle Lane or Cycle Track	Cycle Track or Parallel Road	
		2x2 Lanes		Cycle Track or Road Parallel		
	45 miles/hour			Cycle Track, Moped/Cycle Track, or Parallel Road		