Appendix A

To: Sue Geniesse, Elizabeth Ledet, Rebecca Knudson, Sheila Lyons, Oregon Department of Transportation, Constance Beaumont, Department of Land Conservation and Development

From: Dru van Hengel, Mike Tresidder and Mathew Berkow, Alta Planning + Design

Date: July 28, 2011

Re: Memorandum #1 (subtask 2.1) - Bicycle and Pedestrian Travel Assessment Report Project

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The following memorandum summarizes the bicycle and pedestrian data best practices and literature review for the ODOT Bicycle and Pedestrian Travel Assessment Project. This memo is intended to provide a frame of reference to complement the results of interviews with agency staff from throughout ODOT on the same topic which are presented in Memorandum #2. The information contained in these two memos will be synthesized into a single report that provides recommended next steps based on best practices and agency staff input that will allow ODOT to successfully improve its collection and utilization of bicycle and pedestrian data.

Memorandum #1 covers the following topic areas:

Types of Data

Overview

There are various kinds of data available to assist with planning bicycle and pedestrian facilities and networks. These data types can be grouped into several general categories, including 1) quantifying use, 2) surveying users, and 3) documenting facility extent. Each data-type requires differing degrees of expertise, time and access to various types of technology or software. In 2005, the Pedestrian and Bicycle Information Center grouped[1] the existing data sets into the following categories:

Table 1: Types of Bicycle & Pedestrian Data

Data Collection Type	Sub-group	Description
Counts to Quantify Use	Manual Counts	Data collected by persons in the field.
	Automated Counts	Data collected through the use of automated equipment (.e.g. infrared, video, pavement or pneumatic tubes).
Surveying Users	Targeting Non-Motorized Users	Surveys administered to individuals walking, biking, or participating in another form of non-motorized transportation.
	General Population Sample	Random-sample survey where all community members have an equal opportunity to be selected in a survey.
Documenting Facility Extent	Inventories	Collecting physical information about the transportation system (e.g., roadway segments, property parcels, crosswalk locations, etc.)
	Spatial Analyses	Mapping software (GIS/CAD) use to analyze and display facility data.

In addition to the items identified in the table above, this section also briefly discusses safety data, which are collected from collision and trauma reporting.

Limitations of National Data Sources

U.S. Census and American Community Survey - The decennial (every ten year) U.S. Census and annual American Community Survey are valuable national sources of information which include metrics of bicycle and pedestrian activity. The Census and American Community Survey, however, generally undercount the actual number of walking and biking trips made in a community. These surveys ask people to describe their mode of travel for journey to work (commute) trips, which make up less than 20% of all trips nationally. Thus, these data sets do not capture the bicycle and pedestrian activity of people who do not use these modes to travel to work, but do bicycle or walk for recreation, to conduct personal business or to socialize. Many of these other trip types are short enough to be completed on foot or by bicycle. Additionally, the surveys require that respondents choose only one mode (the one they used most often during the survey week). As a result, multi-modal trips, such as walking to transit, are not counted as a walking trip. Non-motorized trips by people who walk or bicycle to work once or twice a week are also not captured.

National Household Travel Survey - The National Household Travel Survey (NHTS) provides additional quantitative information with regards to bicycle and pedestrian trips, but only on a national scale. The NHTS methodology selects a random sample of U.S. households and asks each to complete a travel diary. All types of trips are collected, not just commute trips, and every component of a multi-modal trip is captured. However, the

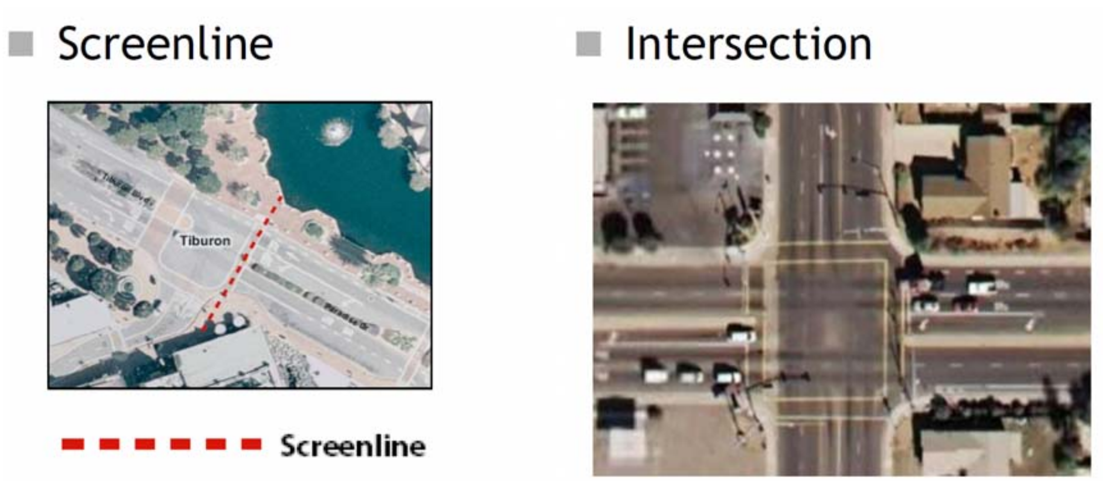
[1] PBIC Data Collection Studies (2005)

NHTS uses a smaller sample size than the U.S. Census, and is only useful at a national level. Recently, the NHTS has expanded its add-on program, which allows states and metropolitan planning organizations to purchase additional sample surveys for their area.

Counts to Quantify Use

One of the greatest challenges facing the bicycle and pedestrian field is the lack of documentation on usage and demand. Without accurate and consistent demand and usage figures, it is difficult to measure the positive benefits of investments in these modes, especially when compared to the other transportation modes such as the private automobile. A lack of data on facility usage limits the ability to justify project funding at a local level or as a part of grant applications and to learn from previous investments to understand what factors contribute to more walking and bicycling. It is for these or similar reasons that several national and local efforts have emerged to perform bicycle and pedestrian counts.

Most existing bicycle and pedestrian counts are performed manually, but several automatic count technologies have emerged in recent years and are increasingly being installed by agencies around the country. Before providing examples of existing count programs, it is necessary to distinguish between the two main types of manual counts[2]. Manual counts can be either screenline or intersection counts. As illustrated in the figure below, screenline counts document the number of users passing an imaginary line at either a mid-block or intersection location. Screenline counts are simpler to perform than intersection counts and thus can generally be performed by one person. Intersection counts, by contrast, are taken at the intersection of two streets and can document both turning and through movements. The additional complexity of an intersection count means that multiple counters may be required at busy intersections.



Below are examples from national, state, and municipal agencies that illustrate different approaches to bicycle/pedestrian count data collection, usage and analyses.

[2] The various automatic counter methodologies are described in the next section of this memo -- 'Count Data Collecting Equipment, Standards and Calibration'

National Bicycle and Pedestrian Documentation Project - The goal of the National Bicycle and Pedestrian Documentation Project (NBPD) is to assist communities in the United States to conduct consistent and useful counts and surveys of bicyclists and pedestrians and to ultimately use this data to create a non-proprietary national database that can be used for research, policy, and other purposes. The NBPD website contains templates for count forms and intercept surveys, as well as other information to aid communities in documenting bicycle and pedestrian activity, including training materials for conducting bicycle counts and surveys. The National Bicycle & Pedestrian Documentation Project was initiated in 2005 and is co-sponsored by Alta Planning + Design and the Institute of Transportation Engineers (ITE) Pedestrian and Bicycle Council.

Summary – *Website includes national bicycle and pedestrian count dates, count forms, intercept surveys and count training materials.*

Washington DOT - In 2008, the Washington State Department of Transportation (WSDOT) launched the *Washington State Bicycle and Pedestrian Documentation Project*. This effort, conducted in conjunction with the *National Bicycle and Pedestrian Documentation Project (*NBPD), was initiated to track growth in bicycling and walking across Washington State. In 2008, WSDOT adopted the *Washington State Bicycle Facilities and Pedestrian Walkways Plan*, which established the goal of doubling the amount of bicycling and walking by 2027. Bicycle and pedestrian counts were identified in the Plan as performance metrics for determining the State's progress toward this goal. The *Washington State Bicycle and Pedestrian Documentation Project 2010* summary report indicates that in 2010, nonmotorized counts were conducted in 30 communities across Washington at a total of 229 unique locations. The program is administered in partnership with the Cascade Bicycle Club. Over 300 volunteers signed up to perform counts in 2010.

Summary – *Manual count program launched in 2008 which uses volunteers to perform manual counts at over 225 locations around the state.*

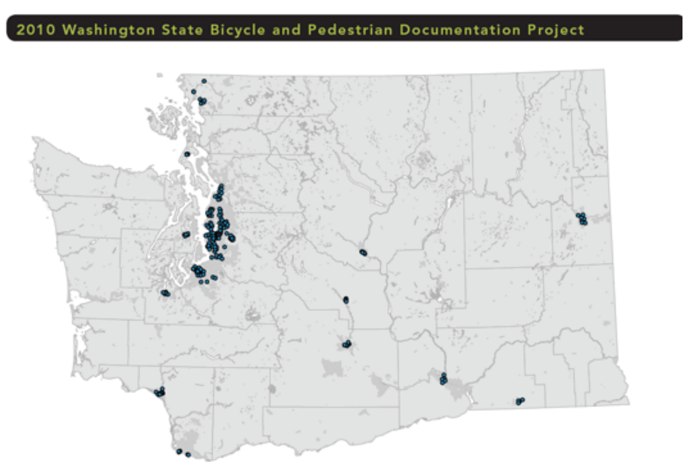


Figure 1 – The Washington State Bicycle and Pedestrian Documentation Project harnessed over 300 volunteers to perform manual bicycle and pedestrian counts in 2010.

Portland Bureau of Transportation - The bicycle count program of the Portland Bureau of Transportation (PBOT) dates back to 1991, with trends in bicycling reported in an annual Bicycle Count Report. The majority of Portland's count data are derived from manual counts performed by volunteer counters during the two-hour evening peak period (4-6PM). Manual counters record both the gender of the rider and whether they are wearing a helmet. Prior to 2008, counts focused on close-in neighborhoods and the Central City. Since then, the City has expanded its count locations greatly to include more locations citywide, with counts performed at 153 locations in 2010. In the early 2000's, Portland added a number of 24-hour automated "hose" counts on select bridges and multi-use paths. The Average Daily Bicycle Traffic Over the 4 Main Willamette River Bicycle Bridges graph is widely cited in national presentations and publications indicating the steady rise in cycling in Portland.

Summary – *City bicycle count program dates back to 1991 and currently includes over 150 count locations. Mostly manual counts at intersections performed by volunteers; 24-hour automated "hose" counts at select bridge and trail locations.*

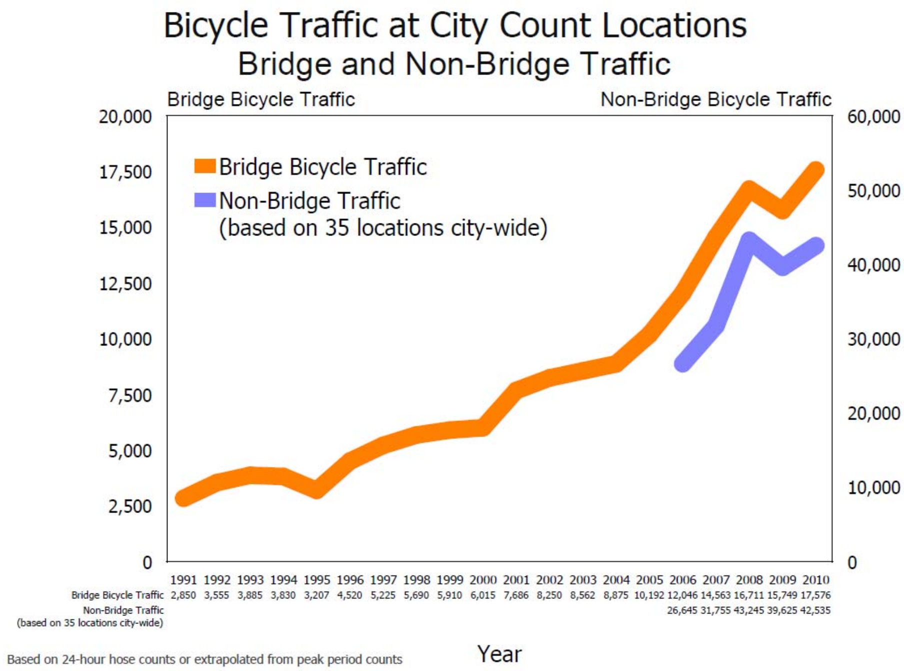


Figure 2 – The Portland Bureau of Transportation Bicycle Count Report has typically used four bridges as its core locations for measuring changes in bicycling. It recently developed a second core set of 35 non-bridge locations.

NYC DOT - NYC DOT has conducted manual 12-hour (7 am – 7 pm) screenline[3] counts of vehicles, pedestrians and bicycles since 1985. Counts are performed midweek (Tues, Wed or Thurs) in September. Historically performed by DOT staff, they are now done through a consultant, which has enabled the DOT to increase the count program dramatically – the DOT is now performing tri-annual counts to account for the inherent variability of a one day count and 18-hour counts (6 am – 12 midnight) at select locations. The DOT's *Commuter Cycling Indicator* report uses two noteworthy techniques in reporting the results of its bicycle counts (See figure below). It adjusts for the annual volatility of counts by reporting a 3-year rolling average (i.e., the indicator value for 2002 is based on the average of the counts from 2000, 2001 and 2002). Counts are indexed to Base 100 for Year 2000, which allows for simple comparisons between years and makes it clear that the indicator is not a count of all cyclists in NYC, but rather the best estimate of trends in cycling levels over time.

Summary – *Manual 12-hour screenline counts performed since 1985 are the source of NYC DOT's Commuter Cycling Indicator. Innovative methodologies include the use of a 3-year rolling average and indexing counts to a base year value of 100 for Year 2000.*

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[3] Refer to definition of screenline counts at beginning of this section

Based on Counts at Selected Commuter Locations

Indexed to Year 2000 = 100

Year	Value for Indicator	Index of Value for Indicator: 100 for Yr 2000	Year to Year Growth (% Change)	Year to Year Growth (Cyclists Counted)
1986	3,997	83	n/a	n/a
1987	3,867	80	-3%	-130
1988	3,513	73	-9%	-354
1989	3,005	62	-14%	-508
1990	3,277	68	9%	272
1991	3,645	75	11%	368
1992	4,294	89	18%	649
1993	4,518	94	5%	224
1994	4,918	102	9%	400
1995	5,229	108	6%	311
1996	5,551	115	6%	322
1997	5,229	108	-6%	-322
1998	5,114	106	-2%	-115
1999	4,716	98	-8%	-398
2000	4,829	100	2%	113
2001	4,927	102	2%	98
2002	6,046	125	23%	1,119
2003	6,879	142	14%	834
2004	7,366	153	7%	486
2005	7,693	159	4%	327
2006	8,355	173	9%	662
2007	9,327	193	12%	971
2008	12,328	255	32%	3,001
2009	15,495	321	26%	3,167
2010	17,491	362	13%	1,996

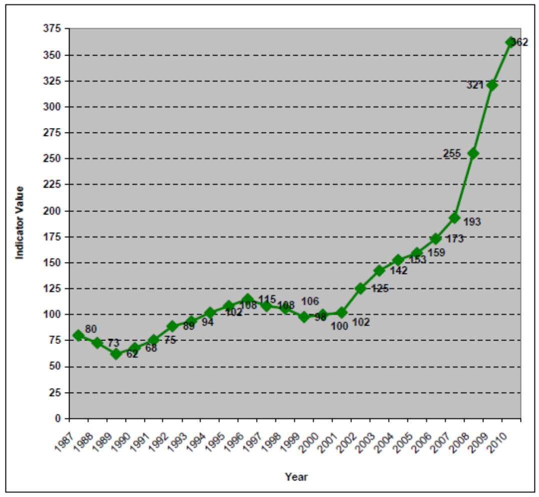


Figure 3 – New York City DOT's Commuter Cycling Indicator is based on 12 hour screenline count data and uses a three year rolling average to mitigate against annual fluctuations in volumes.

Surveying Users

Bicycle and pedestrian surveys are useful to understand the reasons people walk and bicycle, to collect socio-demographic information, and to discern attitudes about walking, biking and facilities. Surveys can inform prioritization of facilities and resource allocation, as well as design of future facilities and programs. Surveys are generally conducted either as a sample of the general population, or targeted specifically to non-motorized users. Surveys have been criticized for two common shortcomings. First, surveys frame the questions and limit the possible responses, thus increasing the chance that unexpected responses will be unrecorded or that questions will be misunderstood. Second, traditional survey collection methods, such as travel diaries and phone recruitment can under-represent certain population groups, such as the elderly and the poor. Clifton and Handy (2001) recommend using focus groups to test survey reliability and ensure they are worded so that the target audience understands the questions. Survey respondents should be compared with the population being sampled, and underrepresented segments of the population may need to be reached through different channels. Short intercept surveys can also be supplemented by longer take-home surveys.

National Bicycle and Pedestrian Documentation Project - As discussed in the count section above, the National Bicycle and Pedestrian Documentation Project website includes both a bicycle and pedestrian survey instrument in English and Spanish, as well as instructions for administering the survey. The NBPD survey instrument gathers information on trip purpose, trip distance, walking/cycling frequency, origin/destination and desired improvements.

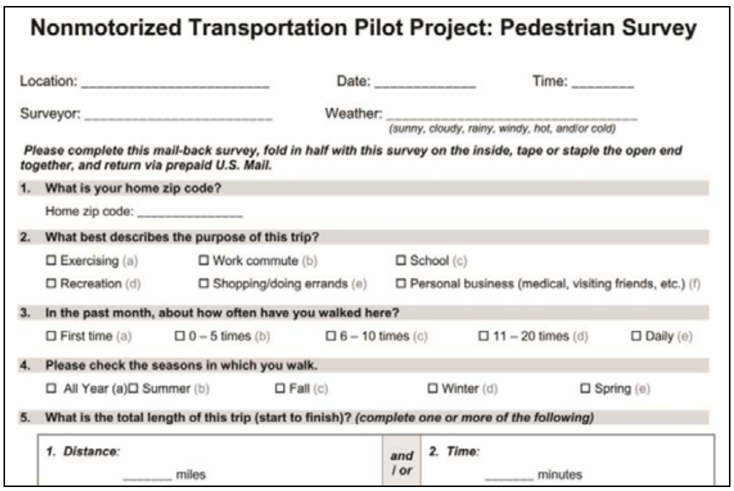
Measuring Walking and Cycling Using the PABS (Pedestrian and Bicycling Survey) Approach: A Low-Cost Survey Method for Local Communities - In 2010, the Mineta Transportation Institute (MTI), an organization funded by Congress through a collection of state and private funding, was contracted to develop a low-cost survey methodology for bicycles and pedestrians. MTI developed the Pedestrian and Bicycle Survey (PABS), which was designed to allow communities to answer such questions as:

- How much walking and cycling is occurring in my community?

- What is the purpose of walking and cycling trips?
- Who is completing the bulk of the walking and cycling trips?
- How often are people walking and cycling?

A primary objective of PABS was to develop a survey procedure that local government staff could easily implement without specialized technical support. The PABS methodology combines a low cost survey method with random sampling strategy. The report includes a sample survey instrument in English and Spanish, and recommendations for improving response rate.

Nonmotorized Transportation Pilot Program Summary of 2007-2010 Bicycle and Pedestrian Counts and Surveys (Marin County, California) - The Nonmotorized Transportation Pilot Program (NTPP) is a federally funded project that allocated $25 million each to four communities to determine whether increased investments in programs and projects would result in more people walking and bicycling. As a part of the evaluation portion of these projects, intercept surveys were performed in 2007 and again in 2010 for each community. The pedestrian survey instrument for Marin County, a portion of which is shown in the figure below, included questions regarding trip purpose, walking frequency, trip length, etc.


Nonmotorized Transportation Pilot Project: Pedestrian Survey

Location: ______________________ Date: ____________ Time: _______

Surveyor: ______________________ Weather: ______________________
(sunny, cloudy, rainy, windy, hot, and/or cold)

Please complete this mail-back survey, fold in half with this survey on the inside, tape or staple the open end together, and return via prepaid U.S. Mail.

1. What is your home zip code?
   Home zip code: ____________
2. What best describes the purpose of this trip?
   ☐ Exercising (a) ☐ Work commute (b) ☐ School (c)
   ☐ Recreation (d) ☐ Shopping/doing errands (e) ☐ Personal business (medical, visiting friends, etc.) (f)
3. In the past month, about how often have you walked here?
   ☐ First time (a) ☐ 0 – 5 times (b) ☐ 6 – 10 times (c) ☐ 11 – 20 times (d) ☐ Daily (e)
4. Please check the seasons in which you walk.
   ☐ All Year (a)☐ Summer (b) ☐ Fall (c) ☐ Winter (d) ☐ Spring (e)
5. What is the total length of this trip (start to finish)? *(complete one or more of the following)*

1. Distance: ______ miles	*and / or*	*2. Time:* ______ minutes

Figure 4 – A portion of the pedestrian survey instrument used to document the success of the Nonmotorized Transportation Pilot Project in Marin County, California.

Public Attitude Survey of Bicycle and Pedestrian Planning (State of Washington) - The State of Washington conducted a user survey as part of the development of the *Washington State Bicycle Facilities and Pedestrian Walkways Plan*. The survey report, listed as Background Report A of the plan, indicates that a telephone survey of 400 Washington residents was performed as a random digit distribution sample telephone survey. Questions included the prevalence, frequency, and distance of walking and bicycling, reasons for not walking or bicycling, recommendations for facilities and programs, level of support for additional state spending of transportation funds for walking and bicycling improvements, reasons for lack of support, etc. The survey found that 77% of respondents in the 18 to 34 age range were interested in bicycling more, while only 23% of those age 35 and older said they would like to bicycle more. It also found that *building safe places to bike and walk* was a priority, resulting in the conclusion that, “It may be best to plan for improvements in safety and accessibility of areas that can be shared by pedestrians and bicyclists.”

Statewide Survey on Bicycle and Pedestrian Facilities (Florida) - In 2005, the Center for Urban Transportation Research of the University of South Florida conducted a Statewide Survey on Bicycle and Pedestrian Facilities for the Florida Department of Transportation. The survey was a telephone survey designed to gain an understanding of knowledge, attitudes, and perceptions of bicycling and walking facilities and their use. The authors conclude that "Floridians highly value bicycle and pedestrian facilities and want to bicycle and walk more. However, bicycling and walking are not viewed as the safest modes of transportation. As a result, many look to government to invest more money to provide more and better facilities to improve bicycling and walking safety."

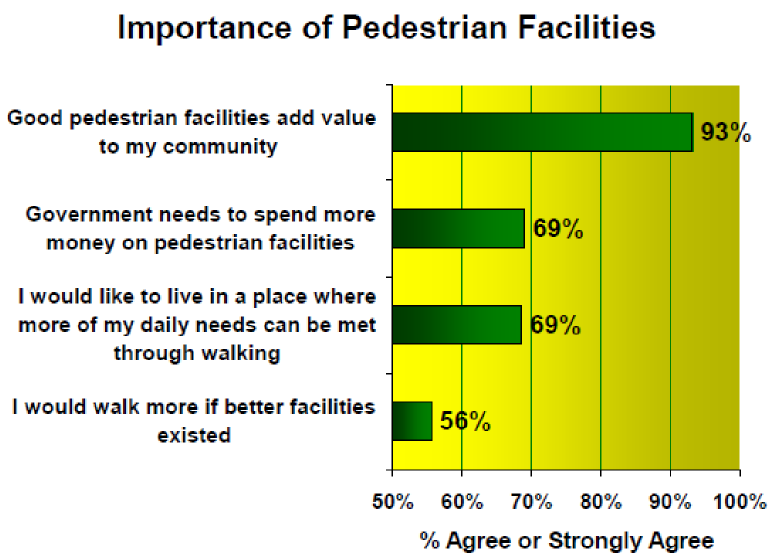


Figure 5 - Importance of pedestrian facilities, Florida Statewide Survey on Bicycle and Pedestrian Facilities (2005)

San Francisco State of Cycling Report - Produced by the San Francisco Municipal Transportation Agency (MTA), the *2008 San Francisco State of Cycling* report provides the baseline analysis of bicycling in San Francisco from bicycle counts and surveys conducted from 2006 to 2008. Bicycle surveys conducted in 2006, 2007, and 2008 asked whether respondents bike, why and what motivates them, barriers to bicycling, perceptions and satisfaction with facilities, and knowledge of outreach programs. Data was collected via a random phone survey and an intercept survey of "practicing cyclists." The analysis evaluates the demographic and opinion differences between frequent and infrequent cyclists (frequent cyclists were defined as those who self-reported bicycling two or more times per week).

Chicago Bicycle Users Survey Report - The Chicago Department of Transport published the *Chicago Bicycle Users Survey Report* in 2005 which documents the results of a survey completed to understand why people are riding, where they begin and end their trips, which bike facilities they currently use, and what factors could influence their decision to bicycle more. The survey contracted 5,337 unique phone numbers and achieved a 17.4% response rate. The primary reason given in the survey for increased levels of bicycling was people's greater concern for their health and fitness. This and other findings informed the strategies identified in the *City of Chicago Bike 2015 Plan* (2006).

Environmental and Facility Attributes

Information with regards to zoned and actual land use, bicycle or pedestrian facility type, weather, etc. provides valuable information to supplement count and survey data. For example, the *Washington State Bicycle and Pedestrian Documentation Project* includes a background data sheet (adapted from the National Bicycle and Pedestrian Documentation Project) which is completed for each count location and includes information such as facility type, facility length, surrounding land use, traffic volume, posted speed, etc. These are typical environmental and facility attributes commonly gathered during transportation planning projects. As discussed later in this memo, these attributes are often used to assess needs and evaluate projects.

Additional information to describe a given count location may be available at the state and national level and can be attached to the count data later. For example, a number of data sets are available to individuals that possess a license to ESRI corporation GIS software. ESRI is the leading and most commonly use brand of GIS software. Data sets that ESRI makes available to its licensed users include the location of various points of interest as well as transportation infrastructure such as streets and transportation terminals. ESRI data sets are valuable but come with the caveat that these national data sets frequently have minor discrepancies such as schools that are misnamed or particular points of interest that may be a block off. The following table identifies state and national data sources that provide information relevant to bicycle and pedestrian planning.

Table 2 – Additional environmental and facility attribute data sets

Category	Data Set	Source	Type of Data	Considerations
Transportation	ODOT State Railway System Linework	Oregon Spatial Data Library	Line	Data resolution is statewide.*
Transportation	Highways - 2007	Oregon Spatial Data Library	Line	Data resolution is statewide. *
Transportation	Detailed Streets	ESRI - Streetmap North America	Line	Includes posted speed data.
Transportation	Transportation Terminals	ESRI - Streetmap North America	Point	Bus, train, marine, subway
Land use	Zoning	Oregon Geospatial Enterprise Office	Polygon	Data is generalized (1:100,000K) and somewhat dated (compiled 1983 - 1986) but is the most comprehensive statewide data source available.
Environment	Water bodies (lakes and ponds)	Oregon Spatial Data Library	Polygon	Data resolution is statewide. *
Points of Interest	Landmark Areas	ESRI - Streetmap North America	Polygon	Polygon data set covering: schools, golf courses, shopping centers, cemeteries, hospitals, industrial parks, stadiums, government centers, military installations, prisons, amusement centers
Points of Interest	Shopping Centers	ESRI - Streetmap North America	Point	Generalized polygons
Points of Interest	Recreational Areas	ESRI - Streetmap North America	Point	Points of interest, stadium, golf course

Category	Data Set	Source	Type of Data	Considerations
Points of Interest	Institutions	ESRI - Streetmap North America	Point	School, church, cemetery, hospital, government center
Points of Interest	Oregon State Parks	Oregon Spatial Data Library	Polygon	Data resolution is statewide. *
Environment	Oregon Hydrography Water Courses - PNW Hydrography (streams and rivers)	Oregon Spatial Data Library	Line	Data includes watercourse data that are not relevant to bike/pedestrian analysis (e.g., pipelines and flumes).
Environment	United States Average Monthly or Annual Minimum Temperature	Oregon Spatial Data Library	Raster	Data resolution is statewide. *
Topography	3 Meter or 10 Meter NED	National Elevation Dataset (via USDA: NRCS: Geospatial Data Gateway)	Raster	Statewide topography coverage allows extraction of elevation data in addition to display of hillshade.
Admin	School Districts	Oregon Spatial Data Library	Polygon	Data resolution is statewide. *

* Resolution should be checked to ensure that accuracy is adequate for the geographic analysis scale.

Safety

Pedestrian and Bicycle Crash Analysis Tool (PBCAT) - The Pedestrian and Bicycling Information Center developed a Pedestrian and Bicycle Crash Analysis Tool (PBCAT), which is software that assists with collecting, organizing, and analyzing crash data. This freely-available program classifies the data into types of crashes to help planners identify the causes and contributing factors in crashes. The classifications are based on the National Highway Traffic Safety Administration's methodologies types. Users can customize the analysis output to match police crash reports used in their communities, and the software can record specific location information such as approach and travel direction if available. The software describes 40 types of crashes, which can be grouped to facilitate analysis or for an area with minimal data.

PBCAT also recommends engineering, education, and enforcement countermeasures based on typical crashes, using the web-based PEDSAFE and BIKESAFE countermeasure selection systems developed by the Federal Highway Administration (FHWA).

The North Carolina Department of Transportation (NC DOT) has utilized the PBCAT system to develop an online database that includes almost 40,000 bicycle and pedestrian crashes. It is publicly available, and users can create crash reports based on crash year, type, location, or contributing conditions.

Trauma reporting is useful for supplementing collision data, as hospital reporting of bicycle or pedestrian incidents that go unreported in collision databases are included.

Lessons Learned

This section provided an overview of count, survey and environmental facility data.

- **Counts** - Bicycle and pedestrian counts have historically been conducted manually, but automatic counters are becoming increasingly common. Counts are done by all levels of governments, including city, county and state and frequently make use of volunteer counters.
- **Surveys** - While count data can indicate usage levels of a given facility, it offers little information about the people walking and bicycling. For this reason, municipalities engage in user surveys that can provide insight into trip purpose, trip length, desired improvements, as well as concerns that keep people from walking or bicycling more.
- **Environmental and Facility Attributes** – While some count programs document facility attributes such as surrounding land use and traffic volumes, this type of data also is often available either at the local level or through state and national datasets.
- **Safety data** - The Pedestrian and Bicycling Information Center developed a Pedestrian and Bicycle Crash Analysis Tool (PBCAT), which assists with collecting, organizing, and analyzing bicycle and pedestrian crash data.

Count Data Collecting Equipment, Standards and Calibration

Overview

This section provides an overview of bicycle and pedestrian count methodologies, including manual and automatic counts. Methodologies range from manual counts, to simple automatic technologies such as pneumatic tube counters, to complex technologies such as video imaging systems. Each method has its own advantages and limitations, and the decision to use a particular method will depend on the purpose of the count, facility type and funding. The table and appendix cover the following count methods:

- Manual counts
- Pneumatic tubes
- Inductive loops
- Infrared (passive)
- Infrared (active)
- Pressure pads
- Video counts

Examples

The following table provides a summary of features, benefits, limitations and costs of manual counts and the various automatic count technologies. A more detailed discussion of each count method is provided as an appendix.

Table 3 – Count Method Summary

Method	Description	On-Street Shared	On-Street Bike Lane	Sidewalk	Off-Street	Differentiate Between Pedestrians and Cyclists	Benefits	Limitations	Reported Accuracy	Example Available Models	Model Cost	Manufacturer/ Contact
Manual Count	Collected by field data collectors	✓	✓	✓	✓	✓	• High accuracy • Can be combined with motor vehicle counts • Can obtain additional information such as gender and helmet use • Can measure direction and turning movements	• Resource-intensive	95-100%	Standardized count forms or templates available at: bikepeddocumentation.org	n/a	n/a
Pneumatic Tube	Senses pressure on tube	✓	✓	✗	✓	✗	• Easy to move • High accuracy • Inexpensive • Grouping does not pose significant problem • Measures direction • Ideal for temporary counting	• May pose tripping hazard • Problematic for street cleaning • Cannot detect pedestrians • Relatively short lifespan • Does not function well in slow or stopped traffic	95%+/-	Eco-Twin Logger, Pneumatic Tubes , Steel box Eco-Pilot Logger, Pneumatic Tubes , Steel box	$2,650 $2,050	www.eco-compteur.com www.eco-compteur.com
Inductive Loop Detectors	Senses magnetic field change as metal passes	✓	✓	✗	✓	✗	• Little maintenance • High accuracy • Grouping does not pose significant problem • Can distinguish between motorized and non-motorized traffic • Long lifespan • Ideal for permanent count locations	• Difficult to move • Expensive installation costs • Cannot detect pedestrians	95%+/-	Eco-Twin Logger, 2 inductive loops Eco-Twin Logger, 4 inductive loops Eco-Pilot Logger, 1 inductive loop Eco-Pilot Logger, 2 inductive loops Eco-Pilot Logger, 4 inductive loops TRAFx Magnetometer	$2,350 $2,850 $1,750 $1,975 $2,250 $1,000	www.eco-compteur.com www.eco-compteur.com www.eco-compteur.com www.eco-compteur.com www.eco-compteur.com *www.osi-ls.com*
Passive Infrared	Detects a change in thermal contrast	✗	✗	✓	✓	✗	• Little maintenance • Easy to move • Can detect pedestrians • Can detect direction of travel	• Cannot distinguish between bicycles and pedestrians • Grouping can pose problems • Varying accuracy	75-95%+/-	Eco-Twin, 1 Pyro Lens Eco-Twin, 2 Pyro Lens Eco-Pilot, 1 Pyro Lens Eco-Pilot, 2 Pyro Lens Trafx 3G	$2,650 $3,000 $2,025 $2,400 $1,125	www.eco-compteur.com www.eco-compteur.com www.eco-compteur.com www.eco-compteur.com www.trafx.net
Active Infrared	Detects an obstruction in the beam	✗	✗	✓	✓	✓	• Little maintenance • Easy to move • Can detect pedestrians • Can distinguish between bicycles and pedestrians (if two are installed)	• Cannot detect direction of travel • Requires equipment on either side of path of travel • Grouping can pose problems	95%+/-	TM 1550-4K TM 1550-8K TM 1550-16K	$760 $810 $860	www.trailmaster.com www.trailmaster.com www.trailmaster.com
Video	Analyzes pixel changes or analyzed by a person	✓	✓	✓	✓	✓	• Little maintenance • Can detect direction of travel • Can distinguish between bicycles and pedestrians (if analyzed by a person)	• Difficult to move • Expensive installation costs • Limited software availability • Considerable staff time. • Difficult detection at night and bad weather.	95%+/-	Autoscope Solo Terra	$6,000	www.econolite.com

Lessons Learned

There are advantages and disadvantages to using manual versus automatic counts. For example, manual counts can be included in existing motor vehicle counts. This approach can reduce costs, ensure (or yield) a higher level of accuracy than automated counts, and allow for collection of other factors such as gender and helmet use. Conversely, automatic count technologies are useful in conducting longer-term counts; establishing daily, weekly, or monthly variations; and can significantly reduce labor costs as they typically require fewer person-hours for the actual counting efforts.

Automatic detection is an emerging field, but installation of existing counter technologies by agencies around the country is increasing rapidly. While manual counts can be performed at any type of location, the most appropriate automatic count technology depends on the count location, purpose, flow densities and modes, accuracies required, and available funding. Below is a summary of the best uses of each general type of count detection.

Table 4 – Summary of Count Methodologies

Detector Type	Summary
Manual counts	High accuracy, but resource intensive method. Can measure direction of travel, turning movements, as well as additional information such as gender and helmet use.
Pneumatic tubes	Best suited for short bicycle counts and provide relatively good accuracy.
Inductive loops	Best for detecting bicyclists traveling along hard-surface bike lanes or pathways.
Passive infrared	Best suited for locations where there is little grouping; however, passive infrared cannot distinguish between bicycles and pedestrians.
Active infrared	Can distinguish between bicyclists and pedestrians, and is therefore appropriate for shared use pathways.
Video detectors	Can provide information concerning user type, behavior, and demographics, in addition to count data. They can also provide a visual means of validation if video scenes are recorded using a digital video recorder.

Put another way, the appropriate automatic count technology depends upon the bicycle/pedestrian facility type. Note that manual counts and video detection can be used on all facility types. However, while software to classify different users is advancing, it remains expensive. The following general guidelines for the other automatic count technologies can be provided:

Table 5 – Summary of Automatic Count Uses by Facility Type

Facility Type	Summary
Bicycle Lanes	Inductive loop detectors are the most appropriate method for counting in bicycle lanes.
On-Street Shared-Use Environment	Pneumatic tubes and inductive loops are the most appropriate for counting bicycles on-street in a shared-use environment.
Sidewalks	Passive infrared technologies is the most appropriate for counting pedestrians on sidewalks.
Shared-Use Paths	A combination of count technologies such as loop detection and infrared is appropriate on shared-use paths.

Other general considerations include:

Physical installation - Some infrared technology requires sensors to be installed on both sides of the pathway, while other devices can be effectively installed in locations with poles/street lights on just one side of the pathway or sidewalk, such as in an urban setting.

Error factors - All automated count technologies have an error factor, which means that they will fail to detect a certain percentage of passing bicycles or pedestrians. Research indicates that 'non-detection rates' vary from 1% to 48%, depending on the technology and model[4]. Correction factors can be developed by comparing automated counts with manual counts. Adjustments are required to account for the amount of delay before the device can count another user, the angle of the video camera or infrared sensor, and the sensitivity of an in-pavement loop detector or pneumatic tube. The accuracy of the counting device should be determined and reported along with the results.

High-density flows - Currently available sensors are generally reliable in detecting presence. However, the identification of individual users within a tightly packed group is still problematic, and grouping can cause high rates of error. The latest computer vision techniques are able to collect and use a higher resolution of information, which show promise in providing greater accuracies in individual identification, though costs are still significant.

Limited literature - To date, there is a limited amount of peer-reviewed literature on the subject of automatic count technology reliability. A 2008 San Diego County study found a 12% to 48% non-detection rate for passive infrared counters and 15% to 21% non-detection rate for active infrared counters (Ragland et al. 2008). Infrared sensors tend to undercount pedestrians most likely because they do not detect pedestrians when they are walking exactly side-by-side (Schneider et al. 2009). A recent study evaluated the accuracy of inductive loop detectors on multiuse paths in Boulder, Colorado (Nordback and Janson, 2010). It found that loop detectors counted on average 4% fewer bicycles than manual counters at the same location. The study concluded that 'inductive loop detectors can provide accurate measure of bicycle use on a pathway, but only when detectors are properly installed, calibrated, maintained and free of external interference.'

[4] Note that the accuracy rates reported by individual vendors of count technology tend to be higher than those found in research. However, the technology continues to advance so non-detection rates may now be better than those indicated in available academic research.

Data Archiving & Accessibility

Data collection efforts are of limited value if the data cannot be systematically retrieved. Agencies across the country have developed systems for archiving and retrieving transportation data, including crash data, traffic signal data and traffic count data. An example of each is provided below.

Crash Data

Statewide Integrated Traffic Records System (SWITRS) -The California Highway Patrol (CHP) maintains the Statewide Integrated Traffic Records System (SWITRS), a database that serves as a means to collect and process data gathered from a collision scene. The Internet SWITRS application is a tool by which CHP staff and members of its Allied Agencies throughout California can request various types of statistical reports in an electronic format. Custom reports can be created by the user to capture data relevant to specified criteria such as Jurisdiction, Location, or Annual or Quarterly reports by date. There are also a variety of standardized reports that meet pre-selected criteria as determined by the CHP. These reports are available as Adobe Acrobat PDFs or can be downloaded as raw data for use in local databases.

Figure 6 – The California SWITRS database allows users to generate custom crash reports online.

Traffic Signal Data

Portland State University researchers Christopher Monsere and Kristin Tufte will soon begin a research project that aims to begin archiving and developing useful visualization tools from multi-modal data gathered by traffic signals. This will be done as part of a project funded by OTREC for 2011 titled *Multimodal Data at Signalized Intersections*. According to OTREC's website, the Portland (OR)-Vancouver (WA) metropolitan region's officially designated archived data user service PORTAL – the Portland Oregon Regional Transportation Archive Listing – at present primarily contains vehicle observations on freeways. This project aims to enhance PORTAL as a transportation data archive to include facilities other than freeways and be multimodal by including data being generated from the region's central signal system (TransSuite). Presently, these data are not stored, analyzed, or mined in a systematic manner. According to the research proposal, the central signal system generates three types of data that are worthy of archiving

- Count, speed, and calculated occupancy from system detectors (placed about 400 feet in advance of the intersection);
- Cycle split logs (recording the duration of each phase); and
- Data from other detectors that may be configured to generate data (such as advanced loops in bicycle lanes at some signals or pedestrian push-button activations).

The study's preliminary efforts will select a small subset of intersections to explore in depth the development of a framework. As part of this effort, the researchers will define how the signal system data should be archived, the appropriate schemas, and the development of scripts to transfer, process and upload the data. They will investigate other signal archives (such as the Systematic Monitoring of Arterial Road Traffic and Signals (SMART-SIGNAL) at the University of Minnesota as well as relevant ADUS standards. The research also aims to develop robust, intuitive and interactive visualization tools to improve understanding of the signal system operation and provide a multi-modal view of the system.

Traffic Count Data

Some state DOT's make traffic count data available online. For example, the North Carolina DOT website has a link to Turning Movement Counts where existing traffic counts can be accessed. Many of the counts also document pedestrian movements, though volumes tend to be extremely small.

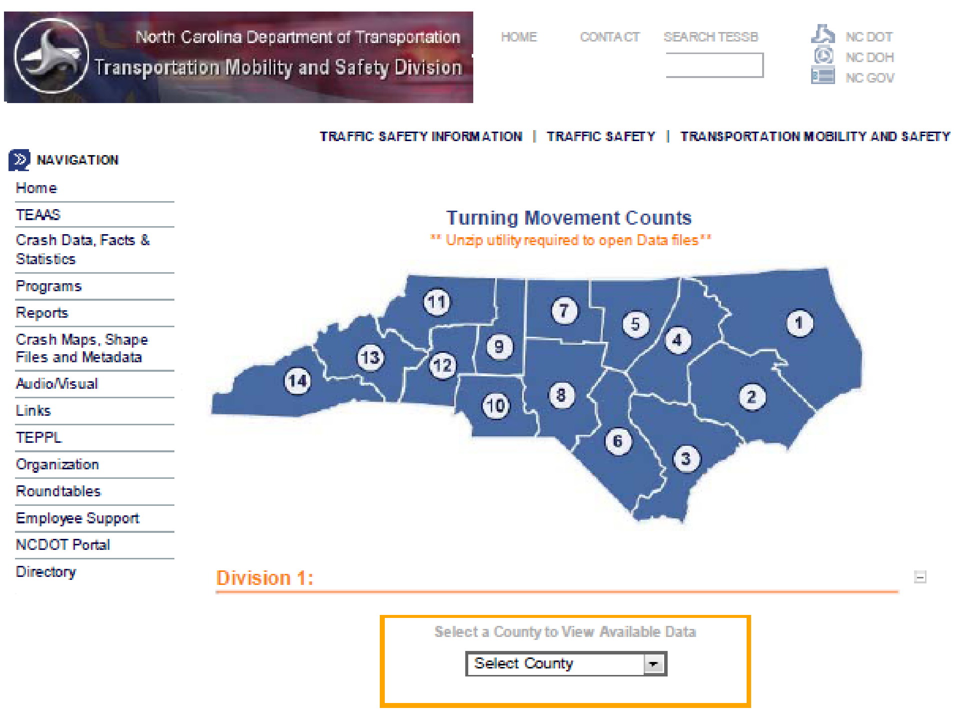


Figure 7 – The North Carolina Department of Transport has a number of traffic counts available for download on its website.

The Colorado DOT is currently developing a system called AVID (Analyze-Visualize-Integrate-Disseminate), which will provide public access, contingent upon registration, to traffic data. CDOT reports quite a bit of data sharing amongst agencies. CDOT accepts traffic data from outside agencies. Once AVID is up and running, traffic count data submitted by outside agencies will become available for retrieval. CDOT currently accepts 24 hour data into its system, which will include bicycle and pedestrian counts from its various automatic counter locations.

Lessons Learned

- Data archiving and accessibility are critical for optimizing the value of data collection programs.
- Several agencies have developed online interfaces for data archiving and retrieval that facilitate the use of existing data.
- Features of data retrieval systems vary, but may include data downloadable in multiple formats and custom report generation,

Local Systems Planning Methodologies

Overview

This section provides an overview of methodologies at a local systems planning level for:

- Assessing the need for bicycling and pedestrian facilities
- Evaluating systems alternatives related to bicycle and pedestrian travel modes
- Analyzing the effects of improved bicycle and pedestrian facilities on future traffic conditions

There is no one industry standard methodology for considering bicycle and pedestrian investments during local planning efforts, which is particularly a reflection of the differences in available data. However, a number of common methodologies emerge when reviewing the bicycle and pedestrian plans from across the nation.

Assessing Need

Needs analysis is a common component of bicycle and pedestrian planning documents. Though they tend to vary in the details, many needs analysis studies include the following information:

- **Collision Analysis** - Collision data is helpful in identifying possible deficiencies in network accommodations for bicyclists and pedestrians, as well as allowing future improvements to focus on historically hazardous components of the non-motorized network. When displayed on maps, collision data can be used to identify areas or clusters of activity, which can be a visually compelling justification for network improvements.

- **Public Input** - Public input is a critical component to needs analyses and the greater planning effort. Public input provides legitimacy to the planning effort and allows the project team to assess problems in a network that may be otherwise overlooked by parties less familiar with the project. Public input can be collected through website surveys, comment cards, public forums/meetings, walk/bike audits and others.

- **Facilities Inventory** – An inventory of existing bicycle and pedestrian facilities is a fundamental component of bicycle and pedestrian planning. Mapping this information is commonly used to identify gaps in the existing network or locations may be underserved with facilities in general.

- **Count Data (if available)** - Bicycle and pedestrian counts track activity and patterns within a specified geographic area. While some jurisdictions have regular count programs, others may only have count data gathered at specific locations/facilities, if at all. Count information can be used to justify the expansion of network recommendations or improve the existing non-motorized network.

The following specific examples indicate the various ways in which data is used in the needs analysis phase of planning projects to identify deficiencies (Arizona), walk/bike potential (Portland), level of service (Washington DC, Florida, Highway Capacity Manual), and factors contributing to non-motorized crashes (New York City).

- **Deficiency** - The *Arizona Pedestrian Safety Action Plan,* completed in 2009, used three general categories (demand, deficiency and severity) for prioritizing pedestrian projects. The deficiency criterion specifically looked at pedestrian need and was a composite of sidewalk availability, crossing risk (based on number of lanes and presence of median), crossing opportunities (distance to crossing facility), pedestrian crashes, traffic speed and traffic volume.

- **Potential** - The *Portland Pedestrian Master Plan* (1998) included a Pedestrian Potential Index metric as an evaluation criterion. This metric was comprised of policy factors (based on street designation in local and regional plans which indicated their relative importance for pedestrians; such as a 'Pedestrian District'), proximity to destinations, and quantitative factors based on household travel survey results (using factors that were correlated with greater levels of walking).

- **Level of Service** - A comprehensive roadway inventory was performed as part of the background analysis of the *District of Columbia Bicycle Master Plan* (2005). Field measurements were taken on 406 miles of major collector and arterial streets (about 45 percent of all DC streets). Roadway lane and shoulder width, speed limit, pavement condition, and on-street parking data were collected and used in the scientifically-calibrated Bicycle Level of Service (Bicycle LOS) Model to evaluate the comfort of bicyclists on roadway segments. In addition to evaluating existing conditions, improving Bicycle LOS was identified as one of three main milestones of the plan: 50 miles of DC streets will have better Bicycle Level of Service ratings by 2010 and 100 miles will have better Bicycle Level of Service ratings by 2015. In 2003, the Florida Department of Transport and a research professor from the University of Florida authored a paper entitled *A Review of Approaches for Assessing Multimodal Quality of Service* (2003). The 2010 version of the *Highway Capacity Manual* includes a multi-modal level of service methodology for the first time.

- **Safety** - The *New York City Pedestrian Safety Action Plan* (2010) used statistical analysis to correlate pedestrian crashes with a wide-ranging dataset which included factors such as street width, adjacent land use, nearby transit stops, socioeconomic status, racial/ethnic composition of neighborhoods, etc. The models attempted to control for pedestrian exposure to crashes, using factors like population, vehicle registrations, presence of traffic signals (generally located at higher-volume intersections) and transit usage.

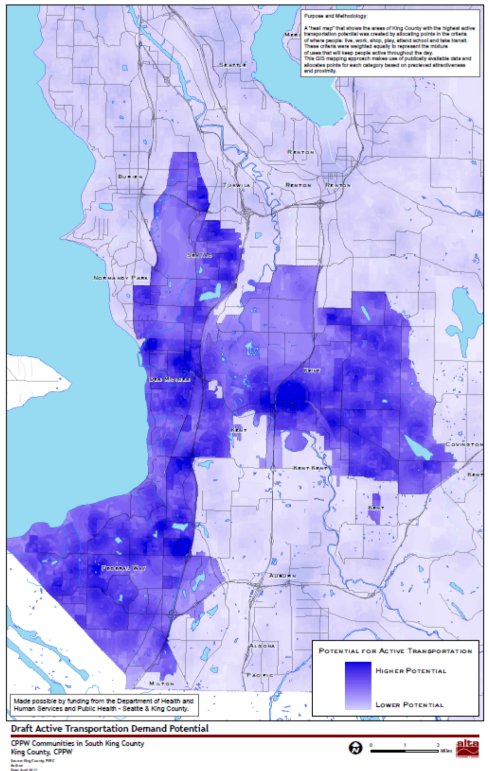


Figure 8 – This demand map uses land use and population data to visualize potential for walking and bicycling throughout King County, Washington based on existing conditions.

Evaluating Systems Alternatives

General transportation planning processes commonly develop various alternatives (i.e., groups of transportation projects and programs) which are then evaluated and a preferred alternative selected. Evaluation of different alternatives may include various evaluation criteria, some of which may be based upon output from travel demand models.

Predictive travel demand models typically do not have the ability to model bicycle and pedestrian activity. One reason for this is that relatively lower levels of bicycle and walking (as compared to motor vehicle use) means that the household surveys which serve as a primary input in the development of travel demand models typically do not collect enough data to robustly model the effects of different bicycle and pedestrian investment strategies. However, while advanced modeling of systems alternatives is generally not yet possible, many jurisdictions do make use of available data sources to inform planning decisions.

Measures of bicycle and pedestrian 'demand' or 'potential use' are a common use of existing data, as described in the examples below. Demand models typically identify key bicycle and pedestrian trip attractors (employment, commercial centers), trip generators (typically based on population data from the Census, such as population density, number of zero-vehicle households, etc.). Raster based GIS analysis can be used to assign a score that considers the distance to the various trip attractors and generators at each potential project location. Trip detractors such as high speed or high volume road and crash history can also be used.

The following examples indicate how data is used to prioritize bicycle and pedestrian projects:

- The *Arizona Pedestrian Safety Action Plan*, completed in 2009, used three general categories (demand, deficiency and severity) for prioritizing pedestrian projects. The demand criterion was based on census data and considered the amount of employment per unit of population, population density, road density, and journey to work data.

- The *Portland Pedestrian Master Plan* (1998) included a Deficiency Index which included missing sidewalks, difficult and dangerous street crossings, and lack of a connected street network.

- The *Wisconsin Bicycle Planning Guidance* (2003) document, developed by the Wisconsin Department of Transportation to aid MPOs and local communities, recommends the following factors be considered to assess potential use of a bicycle facility –Location of employment centers, commercial facilities, mode transfer points, parks and other recreational areas, educational facilities area demographics (population density and age, household size and type), and trip length.

Analyzing Effect on Future Traffic Conditions

As discussed above and later in the predictive modeling section, current travel demand models generally lack the ability to model the effects of bicycle and pedestrian investments and their effect on future traffic conditions in a statistically valid way. For example, per Washington State law, one of the objectives of the *Washington State Bicycle Facilities and Pedestrian Walkways Plan* was to determine the role of bicycle and pedestrian transportation in reducing automobile congestion. The plan approached this question pragmatically, stating 'Encouraging more people to bike or walk for short trips will reduce the release of harmful carbon emissions. Barriers to walking or cycling must be removed to broaden the appeal of these transportation choices.' To this end, Milestone Report B of the project focused on existing conditions and analyzed bike and pedestrian connections for gaps and opportunities.

Lessons Learned

Municipalities across the nation use a number of planning methodologies to perform needs analysis and evaluate systems alternatives, depending on locally available data. Common inputs to needs analysis include collision data, public input and facilities inventory data. These same inputs are frequently used in project evaluation criteria, which often include measures of public support, safety benefit, filling gaps in the existing network and measures of demand that consider proximity to trip generators and attractors using land use and population data. While municipalities are increasingly performing bicycle and pedestrian counts, most planning efforts are done in areas that lack comprehensive count programs that would allow count data to systematically inform these analyses. As discussed elsewhere in this memo, advanced modeling to evaluate the effect of non-motorized transportation investments on future traffic conditions is still in the development phase.

Methodologies for Measuring Before and After Effects

Overview

Many municipalities see the value of measuring the before and after effects of installing bicycle and pedestrian facilities or making other improvements to enhance non-motorized travel. As with many planning projects, funding and other limitations mean that the monitoring piece is often left undone. There are, however, several examples of research performed by university professors and municipal agencies that measure the effectiveness of various facility treatments. In Oregon, the Portland Bureau of Transportation and Portland State University have partnered on various projects, with PBOT installing the facilities and PSU researchers evaluating their effects. Such partnerships exist in other states as well, including Florida and Minnesota.

There are several methodologies that can be utilized to measure the impacts of installing a given facility, including:

- Manual or automatic bicycle and pedestrian counts to measure changes in use
- Video traffic counts or manual observations to observe before and after volumes, behavior and interactions
- Intercept surveys of both motorized and non-motorized users to understand perceptions
- Household surveys to understand detailed travel behavior

Facility Evaluation

An excellent compendium of bicycle facility research is available online at the website for the Bikeway Design Guide developed by the National Association of City Transportation Officials (NACTO) (http://nacto.org/cities-for-cycling/master-reference-matrix/). A few examples are provided below:

Non-Motorized Transportation Pilot Program Count/Survey Reports - The Non-Motorized Transportation Pilot Program (NTPP) is a federally funded project that allocated $25 million each to four communities nationwide (including Marin County, CA, Columbia, MO, Sheboygan, WI and Minneapolis, MN) to determine whether increased investments in programs and projects would result in more people walking and bicycling. Before and after studies were an important component of this program. Using the National Bicycle and Pedestrian Documentation Project methodology, manual peak hour counts and intercept surveys were performed at locations throughout each community. Summary reports were produced in 2007 and again in 2010 to document changes in non-motorized transportation use over the four year study period.

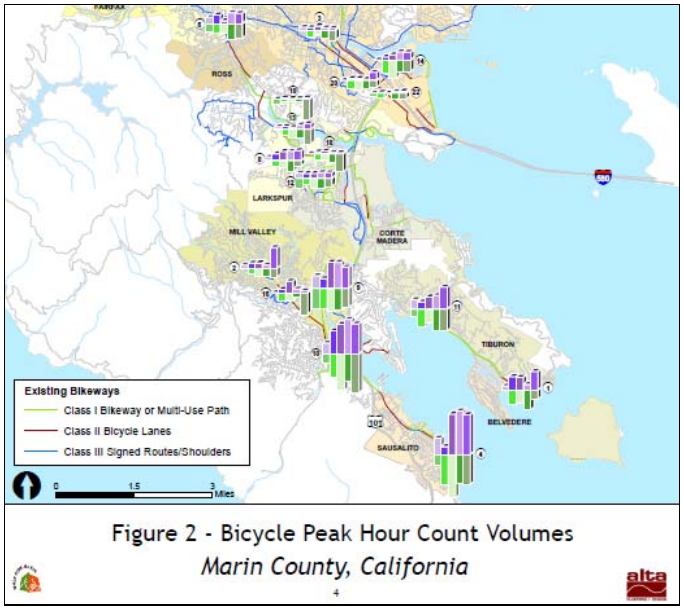


Figure 9- The Marin County summary report presents four years of count data. Weekend peak hour volumes are presented above the x-axis while weekday volumes are presented below the axis.

Evaluation of Bike Boxes At Signalized Intersections - The City of Portland installed 12 bike boxes within its downtown core area in 2008. With funding from the Portland Bureau of Transportation (PBOT) and the Oregon Transportation Research and Education Consortium (OTREC), Portland State University performed a study to examine road users' understanding of the markings, their effect on safety, and if use of color improved compliance with the device. Bike boxes with and without a green thermoplastic treatment were examined for differences in interactions between bicyclists and cars. The study utilized before and after video monitoring and motorist/bicyclists surveys. Video monitoring was conducted over a 48 hour period at the selected intersections, as well as at intersections without bike boxes as a control group. Surveys were distributed to motorists and bicyclists through postcards that directed respondents to an online survey. In order to increase the response rate, survey respondents were entered into a drawing for gift cards.

Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Buffered Bike Lanes - In 2009, the City of Portland removed vehicle lanes to install innovative bicycle facilities. To measure the impacts of these new facilities, the Portland Bureau of Transportation commissioned Portland State University to perform a study that evaluated the interactions between bicyclists and motorists approximately one year after installation. The purpose of the study was to determine how motorist/bicyclist interactions changed with the removal of traffic lanes for the installation of the new facilities. Surveys were conducted amongst multiple user groups and video data was collected at intersections along the cycle track and buffered bike lane. This study utilized before and after video monitoring and motorist/bicyclists surveys. Surveys were collected by distributing postcards along the project sites that directed respondents to an online survey. Survey respondents that completed the survey were eligible to enter a drawing for four $25 gift cards.

Bicycle Report Cards

Some jurisdictions develop regular reports to monitor bicycle and pedestrian facility investment and usage. For example, US cities such as San Francisco, Portland and New York issue annual bicycle count reports. Other excellent examples come from outside of the United States and include cities such as Copenhagen and Melbourne, who bring metrics of the bicycle network and cycling rates together with survey results of cyclists' perceptions into bi-annual Bicycle Account reports. These user-friendly reports use a table format to report progress towards plan goals and show bi-annual indicators such as miles of bicycle facilities, the number of crashes, cycling volumes and perceptions of the network (see figure below from the *Melbourne Bicycle Account*).

Cyclist behaviour	2008	2007	
Number of inbound cyclists on cycling arterials in morning peak:			
Swanston Street, corner of LaTrobe Street	414	366	
Albert Street, corner of Gisbourne Street	182	171	
Footscray Road, corner of Docklands Drive	768	622	
Princess Bridge	982	803	
Canning Street, corner of Princess Street	690	654	
Yarra River, North Bank, adjacent to Gosch's Paddock	1108	940	
Yarra River, South Bank adjacent to Alexandra Gardens	398	343	
Overall cycling	**2008**	**2007**	**2006**
Bikes as a percentage of vehicles in the central city[1] between 7am and 10am	9%	8%	4%
Cycling infrastructure and safety	**2008**	**2007**	**2006**
Pedestrian/cyclist shared lanes	66km	63km	61km
On-road cycle lane	51km	50km	47km
On-road green painted cycle lane	0.7km (20 locations)	0.5 km (15 locations)	0.3km (8 locations)
'Copenhagen' cycle lane	1km	1km	0km
Cycle track maintenance (AUD)	$230,000	$230,000	$230,000
Cycling capital works (AUD)	$2,300,000	$3,000,000	$2,390,000
On-street cycle parking spaces	1,450	1,330	1,220

Figure 10 – This table from the Melbourne Australia bi-annual Bicycle Account report presents a number of cycling metrics in a single table, including kilometers of facilities, number of bike parking spaces, bicycles as a percentage of central city vehicles, and annual maintenance expenditures.

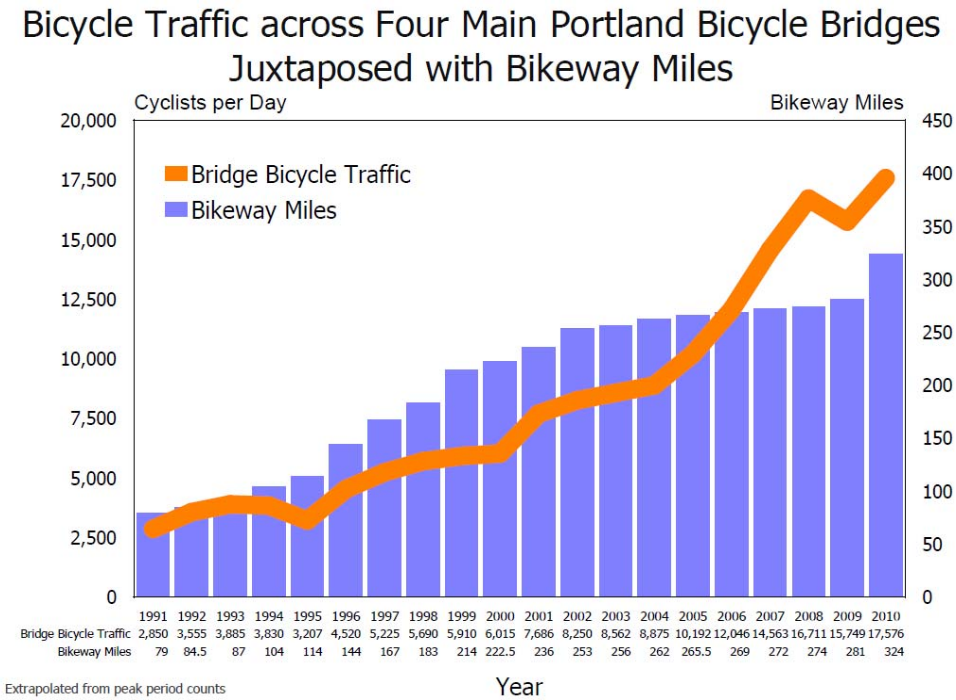


Figure 11 – This effective figure from the annual Portland Bicycle Count Report shows the number of bikeway miles and the number of cyclists crossing four main Portland bridges.

Lessons Learned

- Established methodologies exist for measuring the before and after effects of installing bicycle and pedestrian facilities.
- Carefully planned before and after counts and surveys can be used to identify changes in use, understand interactions between vehicles and non-motorized users, and gauge perceptions of motorists, pedestrians and bicyclists.
- Partnerships between university researchers and municipal governments (including both city and state agencies) are common, with excellent local examples in the Portland region. State DOTs such as Florida and Minnesota actively fund non-motorized transportation research.
- Bicycle and pedestrian report cards can be excellent ways of assembling and tracking trends for relevant metrics such as miles of facilities, count volumes, crash history, user perceptions, etc. in a single document.

Overview of Methodologies used by other DOTs

Overview

This section provides an overview of practices used by other Departments of Transportation (DOTs) for considering bicycling and pedestrian needs in planning, project development, and evaluation. While specific documents from a variety of DOTs are referenced throughout this memorandum, this section provides a more general overview of practices of select DOTs from around the country that have taken a leading role in planning for bicycles and pedestrians.

Agency Practices

Colorado Department of Transportation (CDOT)

Planning

CDOT uses public and partner input to help assess the need for facilities. It also looks at crash and safety data. At present, bike and pedestrian traffic data analysis has not been done to assess future conditions.

Project Development

CDOT's new bike/pedestrian policy requires that bike and pedestrian accommodation be routine in developing any kind of project. There are three possible exemptions: 1) If bicyclists and pedestrians are prohibited by law from using the roadway; 2) the cost of establishing bikeways or walkways would be excessively disproportionate to the need or probable use (exceeding 20% of the cost of the larger transportation project; and 3) Where scarcity of population or other factors indicate an absence of need. The decision not to accommodate bicyclists or pedestrians must be documented and reviewed by the Regional Transportation Director and the State Bicycle and Pedestrian Coordinator.

Evaluation

Two and a half years ago, CDOT switched from sporadically collecting two hour manual bicycle and pedestrian counts to an approach that aims to parallel vehicular traffic data collection. Similar to what is done for motor vehicles, they are developing two count programs:

- Continuous count program – 24/7 all year; hourly data; CDOT is currently collecting 24 hour counts at various locations on two or three of the heaviest used trails in the state.
- Short duration count program – CDOT has five mobile passive infrared counters that are used on trail locations; Local municipalities can request a counter which CDOT will install. The mobile counters are usually kept at a location for a week, or until a traffic pattern is established.
- CDOT also received a grant from Kaiser Permanente (a health care plan provider) to install permanent loop detectors. In distributing these on-street counters, CDOT selected locations slated for bicycle facility improvements (5 of the 6 counters) so they can measure before and after effects.

Installing a select number of continuous count stations and conducting a much larger number of short duration counts each year will enable the CDOT to approach the quality and quantity of data already available on motorized vehicles. CDOT asked the vendor of its internal traffic data analysis and data warehousing software solution and system called TRADAS, which creates their annual statistics (AADT, factoring, etc.), to make modifications to handle non-motorized data. Over the next six months, CDOT will be researching how to use the continuous data it has collected to develop daily, seasonal, weather and other necessary non-motorized adjustment factors.

Documenting before and after usage is one of the goals of CDOT's new counting program. CDOT will soon be working on its first ever statewide bicycle and pedestrian plan and CDOT staff anticipates that the development of a methodology for evaluating impacts of new facilities will be included.

CDOT is also currently developing another system called AVID which will provide access to traffic data to the outside world. CDOT reports that there is quite a bit of data sharing amongst agencies and that the agency accepts traffic data from outside sources and makes them available for retrieval on AVID. The agency accepts 24 hour data into its system and already has several bicycle and pedestrian counts.

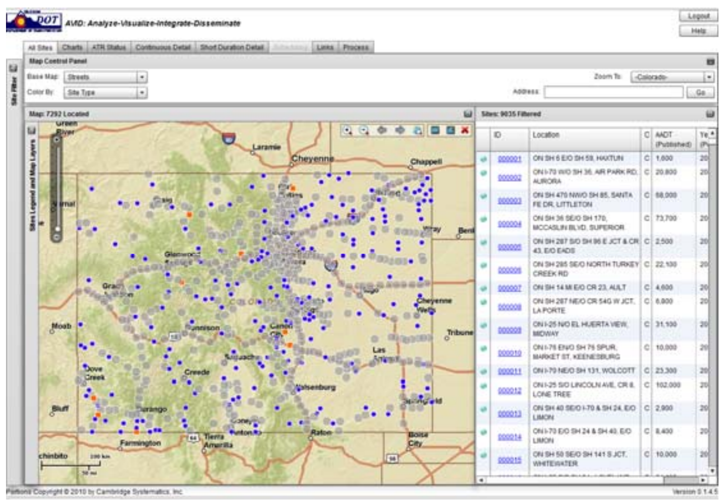


Figure 12 – CDOT is currently developing an online archive of traffic count data which will also include 24 hr data from automatic bicycle and pedestrian counters.

Washington State Department of Transportation

Planning

State law RCW 47.06.100 called for the development of a Washington State Bicycle Facilities and Pedestrian Walkways Plan. The 2008 plan sets a goal of decreasing collisions by five percent per year for the next 20 years, while doubling the amount of biking and walking. To satisfy the state requirement that the plan develop an assessment of statewide bicycle and pedestrian transportation needs, the planning process looked to local TIPs and developed a list of bicycle and pedestrian projects. The plan also included a gap list of projects, some of which did not have planning level cost estimates. These included sidewalk gaps on state highways, a number of trail projects and bicycle facility projects. The state project list has been used in project planning and the WSDOT has pulled from this project list when putting together federal grant applications. The list identified approximately

$1.6 billion in unfunded need. The project list allows the DOT to periodically evaluate how well they are completing projects on the list.

WSDOT established the Washington State Bicycle and Pedestrian Documentation Project in 2008. One reason for the documentation project is to measure progress toward the state bicycle and pedestrian plan goal of doubling the amount of walking and cycling in the next 20 years. Once the project has collected five years worth of data, WSDOT hopes to evaluate the counts at different locations to understand the effects of surrounding land use, roadway characteristics, etc. For example, WSDOT will look at the land use and facility characteristics of high count locations and then integrate this information into project planning to attempt to identify steps that can increase the amount of walking and bicycling at other locations.

Project Development

The Pedestrian and Bicycle Safety Program is the primary WSDOT bicycle and pedestrian funding program. The legislature set this program up to focus on serious and fatal injuries. As such, the evaluation of collision data is required for project funding. Complete streets and other emerging bike/pedestrian policies and funding sources may drive a need for more data regarding facilities and use in the future. For example, the Washington legislature recently set up a complete streets grant program. While this grant program does not yet have funding attached to it, it will ultimately make funding available to local jurisdictions that have complete streets ordinances in place.

Evaluation

Similar to other state DOTs, there are few examples of before and after studies. Safe Routes to Schools programs do before and after assessments, which is a federal program requirement. WSDOT is considering instituting similar requirements into its grant programs, but a proper count technology to facilitate this has not yet been identified. One possibility would be to have an automatic counter loaner program.

WSDOT also produces a quarterly Gray Notebook, which according to the WSDOT website 'presents articles in a way that makes the topics' relationship to the six Legislative policy goals (Safety, Preservation, Mobility, Environment, Economic Vitality, and Stewardship) – and WSDOT's own strategic goals – more clear.' This safety section of this report currently dedicates five pages to documenting bicycle and pedestrian safety trends.

California Department of Transportation

Planning

Caltrans recently developed a Complete Streets policy. The policy states that Caltrans develops integrated multimodal projects in balance with community goals, plans, and values. Caltrans seeks to address the safety and mobility needs of bicyclists, pedestrians, and transit users in all projects, regardless of funding. Bicycle, pedestrian, and transit travel are facilitated by creating "complete streets" beginning early in system planning and continuing through project delivery, maintenance, and operations.

To ensure successful implementation, Caltrans manuals, guidance, and training are being updated and developed. Caltrans manuals and guidance outline statutory requirements, planning policy, and project delivery procedures to facilitate multimodal travel, which includes connectivity to public transit for bicyclists and pedestrians. In many instances, roads designed to Caltrans standards provide basic access for bicycling and walking. Caltrans'

Complete Streets policy does not supersede existing laws. An updated Caltrans Highway Design Manual (CHDM) will be released to meet the requirements of the Complete Streets policy.

Caltrans' Systems Planning Branch and staff from twelve districts develop various strategic and policy plans at the State, district and corridor levels. These plans consider all modes.

The typical way in which bicycle or pedestrian data might influence a planning project would be data collected by a local or regional agency in its Bicycle Transportation Plan (BTP) for Bicycle Transportation Account awards. The estimated number of existing bicycle commuters and the estimated increase in the number of bicycle commuters resulting from implementation of a bicycle transportation plan is a BTP requirement in CSHC Section 894.2. BTPs are one of the requirements for local agency eligibility for Bicycle Transportation Account awards.

Caltrans collects data related to State highway conditions, maintenance, traffic volumes, and level of service.

Project Development

The needs of non-motorized transportation users are an essential part of all highway projects on State highways. Design guidelines for bicycle and pedestrian accommodation are found in the *California's Highway Design Manual* (CHDM) and the *California Manual on Traffic Control Devices* (CMUTCD). The CHDM establishes uniform policies and procedures to carry out the highway design functions of the California Department of Transportation (Caltrans). All city, county, regional and other local agencies responsible for bikeways or roads where bicycle travel is permitted must follow the minimum bicycle planning and design criteria contained in the CHDM (See California Streets and Highways Code Section 891). The CMUTCD establishes appropriate standards and specifications for all official traffic control devices in California.

Every project has a team that develops a purpose and need statement. Caltrans is working to make sure this statement discusses all modes, as this statement determines the scope of the project. The goal is to have more projects consider bicycle and pedestrian accommodation from the onset rather than as an afterthought, when bicycle and pedestrian accommodation can be prohibitive because of cost.

In practice, local agencies and the public, not data, tend to drive the amount of bicycle and pedestrian accommodation on state roads.

Caltrans recently hired a contractor to collect bike/pedestrian data at locations of concern. Low resolution video was collected 24 hours a day, and reviewed for pedestrian activity in certain high traffic, multi-lane areas. This was a relatively low-cost operation that yielded data which influenced traffic operations.

Evaluation

Caltrans administrates money from a percentage of the local gas and excise taxes set aside for bicycle transportation in the form of the Bicycle Transportation Account. In the distribution of money to local agencies, there is guidance with regards to monitoring, but limited resources do not allow for enforcement. Many local agencies do report on the success of the facilities. Monitoring for bicycle and pedestrian travel is also relatively uncommon on Caltrans or local facilities. Data collection and monitoring are required when agencies apply for experimental treatments not present in the MUTCD.

Caltrans does not generally collect bicycle and pedestrian data. However, the department did purchase an Add-On to the 2009 National Household Travel Survey (NHTS) to obtain non-motorized travel and behavior data. Caltrans purchased 18,000 surveys with the intention of having data statistically significant at the district level. This data is currently being analyzed.

Arlington County Division of Transportation (Virginia)

Arlington County, Virginia is the smallest self-governing county in the nation (26 square miles). It has also been one of the pioneers of automated bicycle and pedestrian counting. The county found that organizing volunteers for quarterly manual bicycle and pedestrian counts was time consuming and susceptible to the "roulette effect" of the weather. After installing the first automatic counters, the county was for the first time able to document the baseline numbers of people using a given trail. They learned that even in bad weather, some trails served hundreds of cyclists a day, and in fair weather the most popular trails served several thousand users – more than many residential streets. They could see morning and evening peaks indicating commuter behavior and a different mid-day peak on weekends more indicative of recreational use. This information allowed county staff to communicate about non-motorized user behavior in a more informed way with the public, executive leadership, and elected officials.

The county installed its first two automatic counters in the Fall of 2009. It currently has seven automatic counters in the field, with plans to install 15-20 more counters in the next year. Most of their counters combine passive infrared technology and inductive loops to count bicycles and pedestrians on multi-use trails. They are also about to install loop detection for bicycles at a few on-street locations. They have one counter that uses a piezo (pressure) sensor to count bicycles on trails. Arlington is committed to building a network of automatic counters and has found bicycle and pedestrian count data extremely valuable.

Automatic Counters

The automatic counter data is used in a variety of ways, including:

- **Grant funding** – When seeking state or federal grant funding, they have documented numbers of users at specific project locations.
- **Before and after effects** – The County had counts on a bridge location that crossed a freeway. Two years ago they opened a trail with an underpass connection below the same freeway. In two years bridge use has dropped from a few hundred cyclists a day to near zero, and the trail link has climbed from zero to a couple of thousand per day. Documenting the before and after effect of this new trail has allowed for a cost benefit analysis of the facility.
- **Maintenance** – The County now has trail usage data to support establishing priorities for trail snow clearing.
- **Land-use effects** – Data from two counters located 100 feet apart near the intersection of two trails show very different travel patterns. These different patterns reflect different land uses and travel preferences along the different corridors, (i.e. commuter vs. recreational/neighborhood users).

- **Transportation infrastructure** – On two particular trail corridors that are also served by Washington Metrorail (the subway), up to 80% of cyclists avoid the trails when it rains, which may indicate the appeal of having alternative travel options available.

Manual Counts

Arlington still conducts manual counts once a year, in September, as recommended by the National Bicycle and Pedestrian Documentation Project. They conduct these manual counts for the following reasons:

- **Calibration** – To calibrate their automatic counters.

- **Demographics** – To obtain demographic information such as gender and helmet use (for example, they know that approximately 2/3 of cyclists are men).

Being an early adopter of automatic counter technology, Arlington offers a couple of lessons learned:

- The first priority was to put counters where they knew they had significant numbers of bicycles and pedestrians. This helped to justify continued investment in bicycle and pedestrian infrastructure.

- Being able to support decisions with good data is very helpful.

- Continuous data collection allows Arlington to identify patterns and trends, such daily patterns, monthly differences, and year-over- year increases.

- Counters are useful for justifying repeat funding when funders see that their money is well spent.

Lessons Learned

- Those agencies that have implemented counts as a routine part of planning, project development or project evaluation cite a variety of benefits including benchmarking, traffic operations improvements, and prioritizing maintenance.

- Practice is lagging policy in most of the agencies contacted, such that planning goals are specifying performance targets that can not yet be quantified.

- There is a wide variety of practices across the country.

Methodologies for Developing Predictive Models

Overview

While there is great interest in developing predictive models for bicycle and pedestrians, there are few examples in practice. Portland Metro is on the leading edge of non-motorized transportation model development. The planning agency has made particular progress with their bicycle model, while pedestrian modeling is in an earlier stage of development. This section provides an overview of Metro's bicycle model and its potential applicability to ODOT and Oregon communities in general.

Bicycle Modeling

Metro's bicycle model was developed in concert with research completed by Portland State University. A study by Dr. Jennifer Dill equipped bicyclists with GPS units for a period of seven days, and gathered data from 149 participants and 1,689 total trips. The data covers trip purposes, length, destinations, average speed, reasons for biking rather driving, and more. Dr. John Gleibe and PhD student Joe Broach later developed a route choice model, using the GPS data collected by Dr. Dill to identify the relative attractiveness of different bicycle facilities as well as the effects of roadway characteristics such as speed and traffic volume on bicycle route choice.

Network Development - The algorithms that make up Metro's route choice model can be used to build models in other parts of Oregon. However, the local road and bicycle network will need to be built for each community, which is where most of the heavy lifting will occur. Metro's bicycle route choice model includes the following elements:

- Proportion of route on off-street paths, bike boulevards, bike lanes
- Proportion of route on links with grade > 2%
- Turns, traffic signals, stop signs per mile
- Traffic volumes of on-street travel and opposing links at left turns
- Bridge bicycle facility type
- Distance
- Commute or non-commute trip

Trip Assignment and Mode Choice - For trip assignment, the model runs up to nine alternate routes and assigns a utility to each one based on the factors described above. Because bikes can travel on any street, it is desirable to have the entire roadway network in the model. This is an important distinction, as some travel models are run on a sketch network that does not include all roads. Furthermore, the bike network also includes links that are not on the street network but are open to bikes.

Mode choice is based on trip utility, which can now be calculated for bicyclists. Thus, in theory the impacts of a particular project or more likely a set of projects can be modeled. However, the effects of building a single facility are likely to be rather nuanced, impacting the routes of select cyclists in a given city or region. Metro modeling staff pointed out that they are not generally interested in using the model to develop specific numerical estimates, but rather in identifying relative differences -- for example, between a baseline network and an enhanced network. Thus, Metro envisions using the model for exercises such as comparing different networks during RTP updates, as part of greenhouse gas estimating as a part of the state requirements, for completing sub-regional analysis as a part of corridor plans, etc.

Validation Data – As with all models, the bicycle model depends strongly on validation data. Metro is currently interested in identifying additional 24-hour count locations. Modeling staff suggest that choke points make ideal locations for performing counts. This strategy helps limit the number of count locations required. Data gathered by counting cyclists at each point where they can potentially cross a river, railroad or freeway allows for the modification of model factors in order to route cyclists consistent with observed behavior.

Cost-Benefit – There are several costs associated with developing and operating a bicycle model. The largest potential cost is building the network. Validation counts are another expense. Finally, model run time is not trivial, as millions of paths are individually analyzed several times. The actual costs associated with these various items will vary based on community size as well as the amount of existing data. It is also noteworthy that to use models to analyze future conditions, it is necessary to develop data to reflect future conditions including the network and land uses.

Bicycle Modeling - Lessons Learned

The algorithms developed by Metro and its partners for its bicycle model are likely applicable for other Oregon communities. In fact, they are currently being provided to the MPOs in the Eugene and Salem areas. However, network development and validation counts are required to develop a complete model application that utilizes the Metro algorithms. The time and expense required to do so are not trivial and depend on the size of the community to be modeled. Key questions for further research will be to identify methods for gathering network data, performing validation counts, and considering the costs and benefits of completing bicycle models for communities around the state.

Pedestrian Modeling

As discussed above, pedestrian modeling in the Portland Metro region is still in an early stage of development, though this work will be done by Metro in collaboration with Portland State University. Below is a brief discussion of pedestrian modeling.

Recent research studying the link between walking and environmental factors has found that certain environmental factors such as land use, regional transit stations, and sidewalk completeness are positively correlated with pedestrian volumes (Berke et al. 2007). However, these studies have not clearly demonstrated a causal link between environmental factors and pedestrian activity (Handy 1991; Boarnet and Crane 2001).

While several traditional transportation demand models combine bicycle and pedestrian travel, three of the most significant differences between the two modes are:

- Walking trips are generally shorter than bicycling trips. This may affect the spatial scale of analysis.
- *A large percentage of walking trips are trips to access other modes*, including the automobile or transit. Bicycle trips are generally stand-alone trips. Modeling should consider the fact that pedestrian trips may not replace automobile trips, but may result from those trips. Conversely, the quality of the walking environment may need to be considered in predicting transit mode shares.
- *The decision to ride a bicycle involves a greater conceptual leap than the decision to walk.* Public health and social marketing fields have shown that the decision to even consider riding a bicycle is a multi-staged process involving a variety of interacting personal, social and environmental factors. Attitudinal research is

important for modeling and understanding pedestrian travel, but is perhaps most significant for bicycle travel (Federal Highway Administration 1999).

In 2006, Caltrans contracted with the Traffic Safety Center of University of California Berkeley and Alta Planning + Design to develop a model for estimating bicycle and pedestrian demand within San Diego County. The model is based on morning peak period counts at 80 locations and considered 34 land use, urban form, and other variables. Additional research methodologies that provide a framework for predicting pedestrian demand include:

- Benham, J. and B. G. Patel. (1977). A Method for Estimating Pedestrian Volume in a Central Business District," Transportation Research Record 629, Transportation Research Board, Washington D.C, 22-26.
- Desyllas, J., E. Duxbury, J. Ward, and A. Smith. (2004). Pedestrian Demand Modeling of Large Cities: An Applied Example from London. Center for Advanced Spatial Analysis, University College London, Available online, http://www.casa.ucl.ac.uk/working_papers/paper62.pdf. June 2003.
- National Cooperative Highway Research Program. (2008). Pedestrian Safety Prediction Methodology. NCHRP Report 17-26. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w129p3.pdf
- Raford, N. and D. Ragland. (2004). Space Syntax: Innovative Pedestrian Volume Modeling Tool for Pedestrian Safety," Transportation Research Record 1878, Transportation Research Board, Washington D.C., 66-74.
- Raford, N. and D. Ragland. (2005). Pedestrian Volume Modeling for Traffic Safety and Exposure Analysis. University of California Traffic Safety Center white paper. Retrieved 9/25/2009 from http://repositories.cdlib.org/its/tsc/UCB-TSC-RR-2005-TRB2/

Conclusion

This memo has provided an overview of best practices relating to bicycle and pedestrian data collection and use. While established and consistent methodologies for the collection and utilization of bicycle and pedestrian data are not yet established, data is commonly used in planning and project development. Furthermore, agencies across the country are taking exciting steps to improve both the quantity and quality of bicycle and pedestrian data.

The various considerations for collecting and using bicycle and pedestrian data identified in this memo and summarized below will be combined with the review of agency practices to develop a focused set of recommendations for improving the collection and utilization of bicycle and pedestrian data by ODOT and throughout Oregon.

- **Types of Data** – The state of the practice indicates that there is no single perfect data source. Each data source has its benefits and limitations in terms of what it can tell a jurisdiction about bicycling and walking. Agencies make use of count, survey, facility and collision data to inform their planning, project and policy decisions.
- **Count Data Collecting Equipment, Standards and Calibration** – Automatic bicycle and pedestrian count equipment continue to advance and many agencies at all levels of government are working to install a network of both continuous and rotating count stations.
- **Data Archiving & Accessibility** – Several agencies have developed online interfaces to facilitate archival and retrieval of various types of data, both for agency staff and the public.
- **Local Systems Planning Methodologies** – While there are variations in methods for bicycle and pedestrian planning and project development, needs analysis and project evaluation are fairly standard aspects of many plans and are increasingly using data analyses.
- **Methodologies for Measuring Before and After Effects** – There are many good examples of research projects to evaluate the before and after effects of bicycle and pedestrian projects. There are several examples from the Portland region. Partnerships between public agencies and universities to perform the research are common. The increased investment in automatic count technologies promises further opportunities for measuring the impacts of particular investments.
- **Overview of Methodologies used by other DOTs** – Practices vary by state, but there are also many similarities. Common themes are the use of public involvement and collision data to identify bicycle and pedestrian projects as well as the use of policy directives to include bicycle and pedestrian facilities in roadway projects. Agencies are increasingly investing in count programs and automatic counter technology and developing new funding mechanisms to support investments by local municipalities.
- **Methodologies for Developing Predictive Models** – Agencies are poised to overcome the historic difficulties of modeling bicycle and pedestrian activity, which is partially being spurred by initiatives to develop strategies to reduce greenhouse gas emissions. Portland's Metro has developed a bicycle model whose algorithms can be used elsewhere in Oregon, though additional work to build local networks and perform validation is required and can be significant. Pedestrian modeling is in a slightly earlier stage of development.

Appendix - Count Data Collecting Equipment, Standards and Calibration

Manual Counts

Manual counts are taken by field data collectors to count the number of bicyclists or pedestrians based on observations. Manual counts can be conducted exclusively for bicyclists or pedestrians, or they can be integrated into an existing motor vehicle count program which can assist in reducing costs. However, it should be recognized that if the counts are integrated into a motor vehicle count program, the count locations may have been selected based on data needs for motor vehicles, and may not be the optimal location for counting cyclists. Manual counts can be conducted for any type of bicycle facility, and can include screenline counts or intersection counts.

Because the counts are done manually, many communities have also incorporated additional observations, such as counting other road users (including equestrians, rollerbladers), gender, bicycle helmet use, drivers running red lights, and bicyclists riding in the proper direction.

Manual counts are generally more accurate than automatic counts, although weather and daylight can affect the quality of the data, particularly in high volume locations. Manual counts are much more labor intensive than automatic counts, which can limit the number of locations and the time period for which counts can be taken.

Pneumatic Tubes

A pneumatic tube counter is an intrusive pressure sensing device that is laid across the path of travel and records pressure on the tube (see ***Figure 13***). Tubes can be used on both on-street and off-street bicycle facilities but cannot count pedestrians. It is an effective and inexpensive bicycle count device that can easily be moved and is ideal for short-term bicycle counts.

While some types of counters lose accuracy if a group passes, tubes do not. If two tubes are used, travel direction can be detected. However, the tubes may pose a tripping hazard if used on a path, may pose a problem for street sweepers, have a short lifespan due to physical wear and tear, and do not function well in slow or stopped traffic. Typically, pneumatic tube counters have a +/-95% accuracy.

Installation includes fixing the tubes to the path of travel and attaching the count logging device to a stable object. There is little maintenance required however the tubes should be checked regularly to ensure they have not become cut or loose, and battery power is sufficient. Typical cost for a pneumatic tube counter is $1,750-$2,350. The majority of operational costs include staff hours to install, uninstall, and retrieve, analyze and store data.

Figure 13 - Pneumatic Tube

Inductive Loops

Inductive loop detectors sense a change in the magnetic field as large metal objects, such as a bicycle, pass over the device. This device is installed in the ground and is intended for long-term bicycle counts. It does not count pedestrians. Inductive loops are often placed under bicycle lanes (see ***Figure 14***), and off-street pathways (see ***Figure 15***). Opportunities exist to use inductive loops on shared use roadways if road closures are present (see ***Figure 16***).

While some types of counters lose accuracy if a group passes, inductive loops are better at detecting individuals within groups. Inductive loops do not pose problems for street cleaning; however, they cannot be easily moved. Typically, loops have +/-95-98% accuracy.

Inductive loop installation requires cutting into pavement or the ground and mounting of the counting device. There is little maintenance required, depending on manufacturer however batteries need to be replaced regularly. Inductive loops can last years and are estimated to have a 10-30 year lifetime. Costs range between $1,100 and $3,000 and are supplied by TRAFx and Eco-Counter. Installation costs depend on location. Operation costs include staff hours to retrieve data, which can be done remotely.

Figure 14 – Inductive loop in bicycle lane

Figure 15 - Inductive loop on multi-use path

Figure 16 - Inductive loop on local bikeway at road closure

Infrared (Passive)

Passive infrared counters detect a change in thermal contrast as an object passes. These count both bicyclists and pedestrians; however it does not differentiate between bicyclist and pedestrians. These non-intrusive devices are installed on stable objects adjacent to the path of travel (see ***Figure 17***).

Passive infrared counters are relatively inexpensive, consist of only one unit and can be moved easily. Some can detect direction of travel. Passive infrared counters' accuracy is diminished when groups or clusters of people pass and when the ambient temperature is not significantly different from the objects counted. Typically, it has +/-75-95% accuracy. Validation counts should be conducted to calculate count discrepancy and develop an adjustment factor.

Maintenance includes replacing batteries (typically annually) and downloading counts. Count download frequency depends on the memory of the device and path activity. Typical costs for a passive infrared counter range between $580-$3,000 and are available from Eco-Counter, TrailMaster and TRAFx. Warranties range between one and two years. Operating and maintenance costs include time spent retrieving data from unit.

Figure 17 - Passive infrared counter

Infrared (Active)

Non-intrusive active infrared counters detect a break or obstruction in the infrared beam as an object passes and can count both bicycles and pedestrians if two devices are installed (see ***Figure 18***). Most active infrared counters can be calibrated to detect a break for a specific amount of time. For example, they can be calibrated to detect a break that is one second or longer thereby counting only pedestrians and not faster bicycles. Active infrared counters typically consist of two pieces that are mounted opposite each other on a path or sidewalk and are not appropriate for bicycle lanes.

As with most counters, active infrared counters have diminished accuracy when groups or clusters of people pass. Active infrared counters can distinguish between bicycles and pedestrians if two units are installed; it is easy to move and is inexpensive. Accuracy varies by manufacture but is typically +/-95% accurate absent of groups or clusters. Validation counts should be conducted to calculate count discrepancy and develop an adjustment factor.

Maintenance includes replacing batteries (typically annually) and downloading counts. Count download frequency depends on the memory of the device and path activity. Typical costs for an active infrared counter range from $860-$1,000 and are available from TrailMaster with a one year warranty.

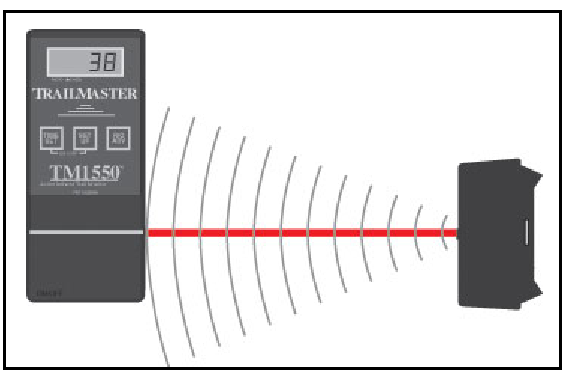


Figure 18 - Active infrared counter

Pressure Pads

Pressure pads, like pneumatic tubes, detect a change in pressure on the path of travel (see ***Figure 19***). The pads are often installed in the ground on hiking trails and paths and are intended for long term counts. A literature and vendor review found pressure pads for pedestrian detection only. Most pressure pads are installed on unpaved trails where only pedestrians have access.

Accuracy varies by manufactures but is typically +/-95% accurate absent of users other than pedestrians. Validation counts should be conducted to calculate count discrepancy and develop an adjustment factor.

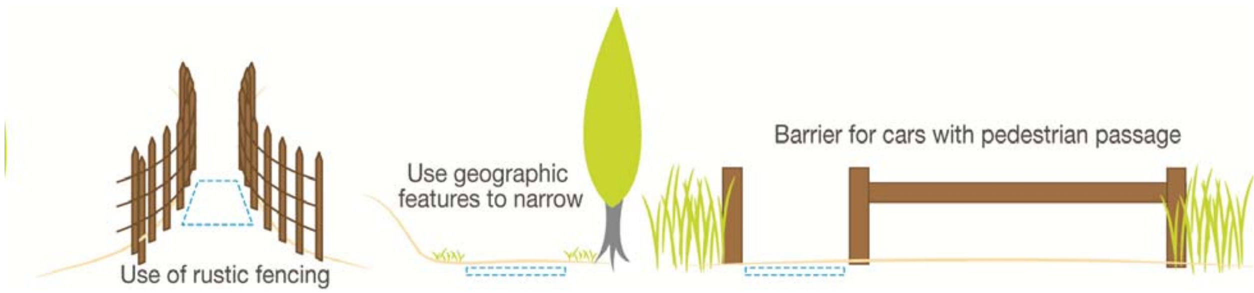


Figure 19 - Pressure pad

Video

Video-based detection technologies are non-intrusive detectors that detect the presence of objects in a pre-determined area of a video scene using computer vision techniques (see *Figure 20*). A number of vendors supply traffic and pedestrian video detection systems, such as Peek Traffic, Traficon, Iteris, and Econolite. The Econolite system can be used to detect bicycles and pedestrians at actuated signals but can also be used to count cyclists.

Video count technology benefits include little maintenance, and if analyzed by a person, can detect direction of travel and distinguish between bicycles and pedestrians. The application of video detection is limited by available software and available power supply. No vendor to date has developed an inexpensive software program to accurately differentiate counts between users such as vehicles, pedestrians, and cyclists. Accuracy is affected by mounting location, visibility, and lighting. Accuracies can also be affected by grouping of pedestrians and/or cyclists. Typically, video counters have +/-95% accuracy when detecting all modes of travel.

Installation includes fixing video cameras at least 20-feet above the subject area on a stable object with available power supply. The Econolite video detection system costs $6,000 per approach and includes a 3 year warranty.

Figure 20 - Video counter