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VMT Reductions

A FRAMEWORK FOR MONITORING THE PERFORMANCE OF DEMAND MANAGEMENT AND VEHICLE MILES TRAVELED (VMT) REDUCTION ACTIVITIES

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16. ABSTRACT:

This report presents a framework to support performance monitoring for demand management related to VMT reduction. The framework consists of performance monitoring measures and a system for their collection and dissemination. The report also provides the context within which the framework would exist, and describes how it will support a wide variety of other statewide and regional needs, thus providing additional incentive for its adoption. The intent of the Framework is to not only meet the requirements of Washington state's legislative requirement to reduce VMT per capita (RCW 47.01.440), but to do so in a way that provides WSDOT and its partner agencies with information that supports planning and programming. The report also provides an excellent framework for developing and reporting congestion-related performance measures in support of MAP-21.

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PROBLEM STATEMENT

WSDOT needs a performance monitoring framework that supports planning for and programming of the implementation and operation of an efficient, multi-modal transportation system. Increased use of alternatives to the single occupant vehicle are vitally important to meeting the state's climate change, transportation sustainability, and mobility goals, and the state needs to track whether the state's efforts in these areas are successfully moving the state towards those goals. Meeting these goals will involve implementation of a wide array of demand management approaches, such as providing services and infrastructure to support the use of transit, carpooling and vanpooling; the implementation of user fees to fund the operation, repair, and expansion of transportation services; and the encouragement of land uses that enable and encourage low cost travel such as walking and biking.

SUMMARY RECOMENDATION

This report recommends a two-level performance monitoring framework for tracking the performance of the state's demand management activities related to VMT reduction and climate change. The recommended framework will meet legislative requirements for monitoring the effectiveness of the state's demand management activities and resulting changes in vehicle miles traveled per capita in the state. Measures recommended for inclusion in the Demand Management/VMT Monitoring Framework are separated into two basic categories: ***Summary Outcome Measures*** which describe overall changes in travel occurring at the state level, and ***Explanatory Measures,*** which describe where changes in travel behavior are occurring as well as whether planned growth in areas with multi-modal travel opportunities are occurring. Explanatory measures would be collected and reported at the regional level and are designed to illustrate whether regional transportation plans are achieving their expected travel outcomes.

The framework meets the requirements of RCW 47.01.440, and also provides WSDOT and its partner agencies with information that supports planning and programming. The recommended summary outcome measures are presented below in Table 1. These measures describe the cumulative effects of the state's demand management and sustainable travel programs on overall travel behavior in the state, given growth in population and economic activity. These measures also meet the reporting requirements that exist in state law.

Table 1: Recommended Summary Outcome Measures (Statewide Data)

Measurement Categories	Measures	Data Source
Vehicle Miles Traveled (VMT)	Statewide VMT	HPMS
	Statewide VMT / Capita	HPMS + Population from OFM
	Statewide LDV VMT	HPMS
	Statewide LDV VMT per Capita	HPMS + Population from OFM
Transit Use	Statewide Transit Ridership	National Transit Database
	Statewide Transit Revenue Hours of Service	National Transit Database
Statewide Levels of Biking and Walking	Counts of Biking and Walking	Bike and Pedestrian Documentation Project
Commute Mode Share	Percent of Commute Trips by Mode Reported	American Community Survey

While the recommended summary outcome measures listed above describe changes in travel in the state, they lack details that describe where and why changes in travel are occurring. Neither do they provide significant insight into the likelihood of future changes in travel behavior occurring. The Explanatory Measures are designed to meet these needs. Table 2 presents these recommended measures.

Table 2: Recommended Explanatory Measures (Regional Data)

Measurement Categories	Measures	Data Source
Location of Population Growth	Change in percentage of regional population in designated growth areas	Washington State Office of Financial Management
Location of Employment Growth	Change in percentage of regional employment in designated growth areas	US Census LODES/On the Map
Peak period mode split on key travel corridors	Changes in network use	Agency collected traffic volume counts, transit ridership, and selected other count data
Travel to work mode split	Changes in commute mode split in designated growth areas	American Community Survey supplemented with Commute Trip Reduction survey data

The core concept of the explanatory measures is that the metropolitan planning organizations (MPOs) would identify from their adopted transportation plans those geographic areas that are expected to exhibit low VMT/capita due to the availability of multi-modal travel options and where growth is expected to occur in their region in support of the state's growth management and climate change goals. WSDOT and its partner agencies then work together to monitor the actual changes in the percentage of regional population and employment occurring within those key geographic areas. WSDOT and its partners would also monitor the actual travel behavior occurring within that limited set of selected geographic areas to determine whether the mode choices predicted in the regional plan for those key areas are in fact the choices being made by travelers.

Changes in the percentage of regional population and employment occurring in the selected growth areas combined with statistics about the modal choices actually occurring in those areas provide the key indicators that describe the effectiveness of the demand management activities and policies being taken in each region. That is, they describe whether the adopted plans are succeeding in encouraging growth to occur in places that can efficiently serve significant portions of the travel demand using modes other than the single occupant car. And they describe whether people are taking advantage of those travel opportunities. If these things are occurring, the State's demand management objectives can be met.

MPO participation is key to this process. MPOs need to work in concert with WSDOT to select the geographic areas and transportation corridors to be monitored. Having the MPOs lead the selection of the geographic areas and facilities that will be monitored allows each MPO to 1) bring their local knowledge to the monitoring process, 2) ensure that the monitored geographic areas and facilities effectively describe the key travel changes expected to occur in the region, 3) limit the cost of data collection, and 4) focus that data collection on the key travel movements serving the region.

REPORT ORGANIZATION

The remainder of this report is organized as follows. The background to the project and the needs of WSDOT are first explained. Then the recommended framework is described, including descriptions of the data needed to implement the initial version of the framework. The report then discusses important improvements that can be made to the framework as additional resources become available or as new technologies all for the improvement, enhancement, and increase in the amount and nature of data available for monitoring travel in the state. Next, the report discusses how this same framework can be used, with only a modest expansion of effort, to help guide updates to the Department's plans and priorities. The framework also has the potential to meet the needs of the MAP-21[1] congestion reporting requirements. As a result, how a slightly expanded framework can be used to effectively meet these reporting requirements is discussed in the fifth section of this report. The final section of the report presents a specific series of activities and recommendations for WSDOT to follow in order to implement and use the monitoring framework.

PROJECT BACKGROUND

Demand management includes all strategies which, while ensuring that the public has good and efficient travel opportunities, encourage the public to travel in ways that minimize their impacts on others, including the impact of that travel on the public's finances. Demand management strategies can be used to reduce VMT while supporting the economic health of the state. As a result, demand management is one of the three foundations of Moving Washington, and the VMT reduction goals detailed in RCW 47.01.400 are part of the state's overall approach to climate change mitigation and its efforts to reduce the state's production of greenhouse gas

[1] "Moving Ahead for Progress in the 21st Century" is the name of the current federal legislation that funds the national surface transportation program. It was signed into law by President Obama in 2012.

(GHC) emissions. To help achieve the state's climate change mitigation goals, a multiagency, multi-stakeholder working group, the Transportation Implementation Working Group (TIWG) was formed.

The TIWG identified a wide range of demand management techniques for implementation, ranging from encouraging discretionary travel during times of low congestion, to providing and encouraging shared rides during congested periods, to the implementation of user fees to fund the operation, repair, and expansion of transportation services, to even the encouragement of land uses and land use layouts that enable and encourage low cost travel such as walking and biking. The TIWG divided these strategies into three basic categories:

- transit, rideshare, and commuter choice programs
- compact and transit-oriented development and bicycle and pedestrian accessibility
- transportation funding and pricing strategies.

While WSDOT participates in all these areas, much of the necessary work must be undertaken by agencies other than WSDOT. Consequently, it is important for WSDOT to work with these agencies as part of its demand management and VMT reduction monitoring effort in order to obtain a truly accurate picture of the activities that are planned to help manage demand, meet the state's VMT reduction goals, and track and report those activities' performance.

As a result, WSDOT is engaged in the multi-agency process established by the legislature and the governor in RCW 47.01.440 to identify and implement cost-effective strategies to reduce transportation sector greenhouse gas emissions, in part by reducing vehicle miles traveled per capita in the state. That same legislation requires that WSDOT[2]

(a) develop measurement tools that can, with a high level of confidence, 1) measure annual progress toward benchmarks at the local, regional, and state levels, 2) measure the effects of strategies implemented to reduce vehicle miles traveled while adequately distinguishing between common travel purposes, such as moving freight or commuting to work, and 3) measure trends in vehicle miles traveled per capita on a five-year basis;

(b) establish a process by which the Department can periodically evaluate progress toward the vehicle miles traveled benchmarks, measure achieved and projected emissions

[2] These are slightly re-worded versions of RCW 47.01.440, paragraphs (2)(e) and (2)(f). They were reworded in to increase their clarity with respect to this report.

reductions, and recommend whether the benchmarks should be adjusted to meet the state's overall goals for the reduction of greenhouse gas emissions.

It is also apparent from reading RCW 47.01.440 that those who wrote the legislation understand the need to balance the desire for demand management and VMT reduction in the name of CO_2 emission reduction against the need for high levels of mobility to help strengthen the economy. This concern is directly voiced in the RCW clauses that require WSDOT to study the impacts of VMT reduction strategies on specific groups that could potentially be harmed by VMT reduction policies.

The resulting study confirmed that the geographic areas that have the strongest potential for reductions in VMT per capita *without causing economic hardship* are the most densely developed regions of the state, where alternative modes of travel can be provided cost effectively. These are the areas where there are also strong economic benefits to providing multi-modal solutions to regional mobility needs. In these areas, successful demand management and VMT reduction strategies provide a variety of significant benefits in addition to CO_2 reduction, including reducing the size of state transportation system investments, decreasing environmental impacts, improving quality of life, and increasing economic competitiveness in key job sectors.

At the same time, less dense areas of the state can undertake a number of programs and policies that both strengthen those areas and reduce the need for vehicle travel. However, these actions often differ from plans and policies that are appropriate in dense urban areas.

Consequently, activities to reduce VMT can be expected to vary considerably among geographic regions in the state. Good regional transportation planning will correctly identify the activities that are appropriate for each region. This framework is designed to take into account those regional differences.

In the current fiscal climate, it is difficult to find funding for additional data collection to support monitoring of demand management and VMT reduction activities. There is also public pressure to increase the state's accountability for how public funds are spent.

Given these realities, the project team looked for ways both to reduce the cost of monitoring the effectiveness of demand management and VMT reduction activities and to increase the applicability of the results of those monitoring efforts to a range of departmental decisions. The intent is to decrease the cost of overall data collection requirements while simultaneously improving the availability of the information needed to make a wide range of decisions.

On the basis of considerable input from numerous WSDOT and MPO staff, the researchers decided that the best approach would be to track both state level outcomes of demand management and VMT reduction, as well as key regional level activities and outcomes. The state level outcomes summarize the overall effects of demand management on statewide travel activity. The regional statistics describe where and why the observed travel trends are occurring. The approach selected is described in the following section.

INITIAL FRAMEWORK IMPLEMENTATION

This section of the report describes an initial, cost-effective performance monitoring system that will support integrated transportation system and land-use decision making across multiple levels of government and describes the partnerships with local agencies and MPOs necessary to deliver that system. It describes the initial implementation of the framework. The vast majority of this initial system implementation can be performed using existing data sources. Because there are significant limitations in the data currently available, improvements that should be made to the framework as new data sources become available are described in the next section of this report.

This demand management/VMT monitoring framework is separated into two basic categories of measures: ***Summary Outcome Measures*** and ***Explanatory Measures***. Summary Outcome measures track overall mobility within the state by mode of travel. Explanatory Measures are designed to identify and describe the key demand management and VMT reduction activities in each region of the state and then track whether those activities are achieving the envisioned travel behavior changes.

Recommended Summary Outcome Measures

The Summary Outcome measures recommended for tracking at the state level include the following:

- statewide vehicle miles of travel (VMT)
- statewide light duty vehicle miles of travel (LDV VMT)
- statewide transit ridership and revenue hours of service
- statewide levels of biking and walking
- commute mode share.

In addition, supporting statistics such as population, employment, and transit revenue hours of service will be collected to describe the context for the mobility measures. Only by understanding the context of the aggregated statewide statistics can WSDOT understand the degree to which demand management and VMT reduction efforts in the state are succeeding.

Table 3 summarizes where the data for each of the recommended data items are to be obtained during the initial implementation of this demand management monitoring framework.

Table 3: Recommended Summary Outcome Measures and Data Sources

Measures	Data Source
Statewide VMT	Highway Performance Monitoring System (HPMS)
Statewide VMT / Capita	HPMS + Population from Office of Financial Management (OFM)
Light Duty Vehicle VMT (LDV VMT)	HPMS
LDV VMT per Capita	HPMS + Population from OFM
Statewide Transit Ridership	National Transit Database
Statewide Transit Revenue Hours of Service	National Transit Database
Counts of Biking and Walking	Bike and Pedestrian Documentation Project
Percent of Commute Trips by Mode Reported	American Community Survey Supplemented with Commute Trip Reduction and National Highway Travel Survey Data

Statewide Vehicle and Light Duty Vehicle—Vehicle Miles of Travel

RCW 47.01.440 states that WSDOT must track and report "per capita vehicle miles traveled in the state by licensed vehicles weighing less than 10,000 pounds." (For convenience, this measure will be referred to in this report as "light duty vehicle VMT" or "LDV VMT") The definition in the statute explicitly omits heavy duty truck travel from the VMT reduction goal to ensure that measures taken to reduce vehicular travel do not limit the economic competitiveness of, or the level of economic activity occurring in, the state by restricting the truck travel that supports that activity.

RCW 47.01.440 requires reducing per capita LDV VMT. The RCW is based on a 2008 forecast of total VMT for the year 2020, which was 75 billion (about 5.4% assumed to be heavy duty vehicles). This statute indicates reductions in light duty vehicle VMT/capita of 18 percent by 2020, 30 percent by 2035, and 50 percent by 2050. WSDOT analysis from 2010 indicates that meeting the light duty vehicle VMT/capita benchmarks equates to 7,065 VMT/capita in 2020, 6,031 VMT/capita in 2035, and 4,308 VMT/capita in 2050.[3] The statute requires that WSDOT report the current LDV VMT/capita statistic every five years.

While only this one statistic is required by statute, it is appropriate for WSDOT to track four separate but highly useful state-level statistics that describe vehicle travel. The remaining three statistics are all readily computed, given the need to compute LDV VMT/capita. Taken together these four measures allow the Department to describe the overall changes in motor vehicle travel within the state. The four high-level statistics WSDOT should track are

- total statewide VMT
- total LDV VMT
- total statewide VMT per capita,
- total LDV VMT per capita.

By using these four variables, the amount of vehicle travel taking place can be examined both with and without respect to freight traffic, and with and without the influence of changes in population. Together these four statistics describe the key outcome measures desired by RCW 47.01.440—that is, whether programs and activities undertaken at all levels of government across the state have an impact on the amount of personal vehicle use occurring in the state.

Statewide VMT statistics are currently available annually as a result of existing WSDOT federal reporting activities. WSDOT produces an annual VMT estimate each year as part of its Highway Performance Monitoring System (HPMS) data submittal to FHWA. The statewide VMT estimate is based on traffic volume statistics collected and stored at the road section level in the HPMS.

It is a relatively modest, but non-trivial, analytical task to remove truck travel from this estimate to meet the legislative requirements. In addition to a total volume statistic, each HPMS segment contains a truck volume estimate (which is also further broken down into single-unit and combination trucks). The presence of these data enable truck travel to be removed from the

[3] Appendix I, Table I-1 in http://www.wsdot.wa.gov/NR/rdonlyres/7CE0134C-9E0F-41DC-BE5F-0363D046245B/0/04Appendixc.pdf

statewide VMT computation, thus allowing that process to also compute an acceptably accurate estimate of LDV VMT.

Similarly, estimates of annual statewide population can be obtained from the Population Unit of the Forecasting Division of the Office of Financial Management. When combined, these two data sources allow WSDOT to track the four recommended statewide VMT statistics.

Statewide Transit Ridership and Revenue Hours of Service

While RCW 47.01.440 does not specifically call for reporting statewide annual transit ridership, this statistic is an excellent indicator of the effectiveness of transit in providing mobility at the state level. It can help illuminate how much personal travel has been shifted away from cars to available transit services. In urban areas, transit services are one of the major alternatives to the single occupant vehicle. Increasing transit use, especially during the peak period, is an important way to reduce peak period demand for limited highway capacity during times when urban roads are most routinely congested. Effective use of transit services is also a key to supplying urban mobility as density increases within urban areas because of the Growth Management Act.

As with statewide VMT, the statewide summary transit statistic provides only a high-level overview of the total change in transit use. It is therefore necessary to gather other transit statistics to understand why and where transit use is changing in the state. At the state level, it is recommended that WSDOT also continue to collect and report on the total number of *revenue hours of service* provided by the state's transit agencies. This figure gives a good summary of the amount of transit service provided by local agencies. Changes in the number of revenue hours of service can be expected to directly result in changes in total transit ridership. These and other transit performance statistics should also be tracked at the regional level to gain a more complete understanding of why and how transit use is changing.

Both annual transit ridership and the number of annual revenue hours of service are collected and reported annually by all transit agencies that receive federal funding. Passenger ridership[4] and a wide variety of other transit operating statistics are reported annually by all public transit agencies to the Federal Transit Administration through the National Transit

[4] The reported ridership statistic is "unlinked trips," which is equivalent to "boardings." This is slightly greater than the number of transit riders, as it does not reduce the number of boardings to account for transfers from one bus to another as part of a trip that requires using more than one bus route.

Database (NTD). These reports include all of the desired ridership and service reporting data necessary to track changes in VMT.

These statistics are already provided to WSDOT by the individual transit agencies. WSDOT publishes them in the annual Summary of Public Transportation report. The current version of this report is M3079.03, which was initially published in November 2012, covered calendar year 2011 transit agency performance, and was updated in December 2012.

These data can also be obtained through the American Public Transportation Association (APTA), which maintains a website containing a large amount of transit agency data, including unlinked passenger ridership, annual passenger miles, annual vehicle revenue miles, and annual vehicle revenue hours of service. These data can be obtained from the following URL: http://www.ntdprogram.gov/ntdprogram/data.htm. Quarterly updates based on samples can also be obtained through APTA at the following URL: http://www.apta.com/resources/statistics/Pages/ridershipreport.aspx. The exact timing of the posting of these data is not known, but at a minimum, the annual statistics are available within one year. For example, as of December 2012, statistics for 2011 are available on-line.

Statewide Levels of Biking and Walking

The third major mode shift that is required to reduce the amount of vehicle miles traveled is a shift to non-motorized travel: walking and biking. WSDOT currently works with a large number of communities, the MPOs, and volunteer groups to collect data on biking and walking behavior through the Washington State Bicycle and Pedestrian Documentation Project (WBPDP). The 2012 WBPDP effort collected two-hour counts at 202 locations on a weekday morning in October and at 207 locations on a weekday afternoon.

While an excellent start to the collection of bike and pedestrian activity data, this non-motorized count program is not funded at the level of the motorized and transit programs discussed above, and as a result, the data collected by the WBPDP do not provide a statistically valid estimate of walking and biking activity in the state. However, continuing to count consistently at the WBPDP locations will provide a good indicator of changes in walking and biking behavior in the state. The governor has publically expressed interest in expanding the WBPDP, and funding has been allocated for research to examine ways to improve the estimates of walking and biking in the state.

Commute Mode Share

The last set of measures recommended for reporting at the state level comprises the journey to work mode split Currently the most widely and consistently available data source for these statistics come from the American Community Survey (ACS). The ACS is sent to roughly 1 out of every 40 households in the state each year. ACS commute mode statistics from that annual survey[5] can be used to track changes in how state residents choose to travel to work. While commute travel represents only slightly more than one-quarter of all vehicle miles traveled, it is travel that usually occurs during the most congested parts of the day and is the target of a large percentage of the demand management strategies employed in the name of congestion relief and air pollution emissions reductions.

The ACS data also provide estimates of mode choice for carpooling, telecommuting (work at home), and other travel modes not directly addressed by any other statewide statistics. The ACS also covers all of the state and is updated annually.

ACS data can also be aggregated for small geographic areas, although the limited sample size means that for some small geographic areas, statistical reliability can be achieved only after more than one year of data collection. It may be possible to leverage state funding to expand the ACS sample size for Washington state by working with the Census Bureau, as a number of other states have done. Results from the ACS can also be supplemented with data from the National Household Travel Survey (NHTS) when those are available.[6] Commute Trip Reduction (CTR) survey data can also be used to supplement knowledge of changing work trip mode split patterns, and offers the advantage of a much larger set of survey data, and the survey asks commuters to report how they actually commuted in the previous week rather than how they normally commute. Comparison of ACS and CTR data also provides insight into the effectiveness of CTR activities.

[5] A limitation in the use of the ACS data is that the way the ACS asks the question may cause the ACS to underestimate the use of modes of travel that are not "the usual" mode selected. For example, someone who drives to work three days a week and rides a bike the other two days, is likely to answer the ACS "usual mode to work" question as "drive alone." This will under-represent the 40 percent share of their commute that is served by bike travel. Many "alternative commute modes" (e.g., biking, telecommuting) are a common but "less usual" travel mode for many commuters. They will be more likely to be under-represented in the ACS responses.

[6] The NHTS is conducted every 5 to 7 years, with the next version planned for 2015, although funding for the 2015 survey has yet to be fully secured.

Explanatory Measures

While the summary outcome measures listed above describe changes in travel occurring in the state, they lack details that describe where and why those changes are occurring. Neither do they provide significant insight into the likelihood of future changes in travel behavior occurring. The explanatory measures are designed to address these information needs. The explanatory measures also provide context for the summary outcome measures. While the state may adopt policies and plans that affect VMT, these plans and policies truly take effect at the local and regional levels. The explanatory measures are designed to yield insight into the outcomes from the implementation of these plans at the local and regional levels. As a result, the explanatory measures explain why the trends apparent from the state-level statistics are occurring, as well as provide information to help WSDOT more accurately forecast the future performance of currently planned demand management and VMT reduction activities.

The core concept of the explanatory measures is that the MPOs would identify from their adopted transportation plans those geographic areas which are expected to exhibit low VMT/capita due to the availability of multi-modal travel options and where growth is being encouraged to occur in their region in support of the state's growth management and climate change goals, and where travel behavior should shift to lower use of single occupant motor vehicles. The MPOS, WSDOT, and their partner agencies then work together to monitor the actual changes in the percentage of regional population and employment occurring within those key geographic areas. The partners would also monitor the actual travel behavior occurring within that limited set of selected geographic areas and on the key travel corridors serving those selected geographic areas to determine whether the mode choices predicted in the regional plan for those key areas are in fact the choices being made by travelers.

The explanatory measures are thus divided into two subsets of measures. One subset addresses whether population and employment is growing in areas which regional plans indicate are capable of meeting travel needs at low rates of VMT/capita. The second subset of measures monitors whether actual travel in these desired growth areas is occurring in the modes expected by the regional plans. The intent of the first set of measures is to first determine if regional growth is actually occurring in places where transportation investments have been planned and prioritized to help lower VMT/capita. The intent of the second subset of measures is to determine if the planned demand management measures within the region are having the intended effect in those areas where they are expected to be most effective.

These measures are discussed in detail below. Table 4 summaries the recommended measures and their data sources.

Table 4: Recommended Explanatory Measures and Data Sources

Measures	Data Source
Change in percentage of regional population in designated growth areas	Washington State Office of Financial Management
Change in percentage of regional employment in designated growth areas	US Census LODES/On the Map
Changes in transportation corridor network use: Vehicle (person) volume Transit volume Bike and pedestrian volumes	Agency collected traffic volume counts, transit ridership by route from transit agency, and selected other local count data
Changes in commute mode split in designated growth areas	American Community Survey supplemented with Commute Trip Reduction survey data

Geographic Subareas

It is recommended that WSDOT work with each MPO to identify and select a subset of its region for monitoring. This document is intended to start those conversations. As part of those conversations, the partner agencies will further clarify their respective roles, responsibilities, and reporting duties while ensuring that the performance monitoring needs of the legislature and partner agencies are met. The output of these discussions is also intended to eliminate duplication of effort, limit the cost of data collection and analysis, ensure that the roles assigned to each agency are within their capabilities, and focus the available resources on monitoring those aspects of the regional plans that are pivotal to the success of the plan implementation.

In general, the MPOs should select geographic subareas identified from the adopted plans for each region where the three strategies identified by the TIWG are being implemented:

- transit, rideshare, and commuter choice programs,
- compact and transit-oriented development and bicycle and pedestrian accessibility
- transportation funding and pricing strategies.

The selected geographic areas should be those expected to represent significant amounts of growth in the adopted regional transportation plans and/or that already serve as significant population and employment centers in the region. They should also be places where the region is encouraging growth in order to meet state growth management and climate change goals. These geographic areas should be places where demand management activities are most effective, and should therefore be places where reductions in VMT per capita should be occurring. When the percentage of population and employment in the region occurring in these areas grows, the regional VMT/capita should decline, leading to declines in VMT/capita for the entire state.

These geographic areas will likely be identified in the adopted regional plans as dense subareas that include mixed development—or that are expected to become more dense and contain more mixed-use development—as these attributes are necessary for shared rides and non-motorized travel to be competitive with the automobile and thus able to capture a significant share of travel.

In selecting these subareas, good starting places are any designated growth centers adopted by the region. That is, each region should identify subareas where growth is desired, in part because they can be effectively served by the available and planned transportation services. The framework will then monitor both the amount of growth in those locations and the travel behavior associated with the trips made to those geographic subareas.

In addition, the region should monitor existing and planned major employment centers if those centers are not already included in the previously identified subareas. (Major employment centers do not need to be tracked independently of other geographic subareas. They are mentioned separately only because some demand management activities are centered on work trips, and tracking behavior to major employment centers will provide insight into the performance of those efforts.)

The MPOs and WSDOT will also benefit from selecting other geographic subareas for monitoring when tracking travel behavior in those subareas will provide insight into either 1) changes in travel behavior to key parts of the region, 2) how new transportation facilities or travel management efforts within those subareas are performing, or 3) whether growth in other parts of the region are affecting travel behavior in those subareas.

For each selected geographic subarea, the following measures are recommended for tracking relative to the regional plans:

- growth in population and employment within the defined geographic area/center
- changes in the percentage of total regional population and employment occurring within the defined geographic area/center (that is, whether the center now contains a greater or lesser portion of the population / employment as a result of growth occurring in the region).

Measured data would be compared with previously collected data on these topics, as well as against benchmarks obtained from the adopted regional plan. Data are currently available for all of these measures, although the statistical reliability of those measures—which affects how often they can be updated—is subject to the design and size of the specific subarea. That is, it is statistically more reliable to detect changes in population or employment for large areas such as downtown Seattle, than for small areas, such as a designated growth center in Spokane County.

The Washington State Office of Financial Management (OFM) provides annual updates of population statistics at the census block group level. By using these data and GIS software, it will be possible to compute annual updates of population (total population and change in population) for geographic subareas. The OFM also supplies data at this level of aggregation on the total number of housing units and the change in total housing units. These housing unit estimates will not be necessary for the primary framework reporting measures, but they will be very useful for the analytical tasks that support discussion of the results.

Employment data are also available at these same geographic scales, but these data are not as robust or as timely as the population data. Employment estimates from the (free) US Census LODES/On the Map[7] product should be available annually. However, the project team could find data only through 2010, meaning that the availability of the employment data may lag the population data by up to two years. LODES/On the Map is a "modeled" data set. It provides estimated job totals by job type at the census block level. These data can be readily aggregated to the jurisdiction level or any other geographic subarea level desired by using GIS software.

Together, the change in population and employment combined with the relative size of that change compared to the rest of the region allows both the MPO and WSDOT to understand whether the regional policies designed to encourage in places where transportation services can

[7] http://lehd.ces.census.gov/datatools/onthemap.php?name=WhatisOnTheMap

be provided in financially and environmentally sustainable ways are creating the desired outcomes.

Observed Travel By Mode

The second subset of explanatory measures is designed to track whether the trips being made in the selected/key geographic portions of the region are in fact using the financially and environmentally sustainable modes of travel as expected by the regional plan. Two sets of measures are recommended for monitoring. These two sets of measures are

- mode share of commute travel (drive alone, carpool/vanpool, transit, walking, bike) to the geographic areas being monitored for population and employment growth, and
- person throughput and mode share on major transportation corridors serving those selected geographic areas.

The first of these measures is relatively simple to obtain. Commute mode share is available through the ACS as described for the summary outcome measures above. The ACS data are available annually at the census block level. Thus, the MPO, WSDOT, or other government agencies can use these data to aggregate commute mode split statistics for geographic areas or centers of their choosing – in this case, the geographic subareas selected by the MPOs to monitor for population and employment growth.

What is not clear without actually defining particular geographic areas or centers is how frequently the ACS survey will produce statistically stable mode share data on the journey to work. The frequency with which changes in mode share based on ACS data can be reported with statistical confidence is a function of the size of the geographic area. Summary ACS data are released annually for geographic regions of 65,000 or larger. It is expected that most major urban centers should produce reliable journey to work[8] data every one to three years. It is also possible to use CTR data—and where available NHTS data—to supplement the ACS data within these subareas to track commute mode choices. The CTR Program collects commute data from

[8] Note that the ACS journey to work question about mode choice does not fully answer the question about mode choice, as the respondent supplies only the "usual" mode of travel on the ACS survey form. The phrasing of this question is likely to under-represent the use of alternative modes (i.e., non-motorized modes or teleworking) that are used only periodically (e.g., once a week). The ACS also reports the "dominant" mode—so a commuter who rides his/her bike to a bus, and takes the bus to work, will likely report a "transit trip," even though a bike was also used. Additional effort is needed to address the limitations in the ACS data. These limitations are discussed in the "Facility" subsection of this report section, and in the "Future Improvements" section of the report.

several hundred thousand employees every two years, so areas of the state that are CTR affected may find CTR data very useful.

While the ACS data, even supplemented by the CTR and NHTS data, have limitations, they are an excellent, and readily available starting place for this framework. Unfortunately, the ACS has three major weaknesses with respect to reporting travel.

1) The ACS data for journey to work mode choice lack information about travel modes other than the "usual" work commute, which represents only about 25 percent of statewide VMT. That is, the ACS data do not describe either the modes people use to get to work commonly but less frequently than the "usual" mode, or the secondary modes used during the "usual" work commute.
2) The ACS does not contain mode use trip purposes other than the journey to work.
3) The ACS survey sample size limits the statistical reliability of the commute statistics for many geographic subareas of interest (as described previously, CTR data may be useful in some of these areas).

This leads to the second set of recommended explanatory measures which monitor actual travel behavior: corridor volume and mode split measures for major transportation corridors serving the selected geographic areas. Facility/corridor-based monitoring is necessary because it

- is the best way to capture information on all trip purposes
- provides additional insight into the importance of a variety of travel modes that may be used occasionally
- covers the 75 percent of travel which is not commute oriented,
- is useful for understanding the performance of state owned, operated, and maintained roads
- provides information on travel behavior by time of day and day of week.

In addition, the performance of major transportation corridors is key to the economic health of each region. "Corridors," rather than "facilities," are chosen as the basic unit for monitoring because in dense urban areas, transportation system improvements for major regional movements often take place across multiple facilities. For example, a new light rail line in central Puget Sound is meant to reduce travel demand on a freeway corridor and relieve traffic congestion on that roadway. It is therefore necessary to measure use of both the freeway and the separate light rail line. Similarly, if a high occupancy toll (HOT) lane was implemented within an existing roadway, WSDOT would need reports on both the entire facility and the HOT lane itself. Similarly, in many cases, parallel arterials are also an important component that provides corridor mobility and may need to be included in the definition of the corridor.

For the initial implementation of the framework, it is recommended that each region monitor multi-modal transportation corridors and specific facilities where either 1) those corridors are expected to experience changes in vehicular travel demand (a shift in mode split from SOV to other modes of travel) as a result of the region's demand management and VMT per capita reduction activities, or 2) where the corridors serve the major activity centers and/or geographic subareas selected for regional monitoring.

The multi-modal corridors selected should serve the primary activity centers in the region. The selected corridors do not need to capture all movements into/out of these activity centers. But they should capture the major movements that are subject to the demand management activities of the region. For example, a region might select a "corridor" that consists of a major freeway that carries an important transit movement, along with a parallel bike trail that provides a safe non-motorized path along that corridor. Parallel arterials would also be included in the definition of the "corridor" if those arterials were key to the regional plan's efforts to efficiently move travelers into and out of the major activity centers. Alternatively, the region might decide not to include parallel arterials if the arterials were used primarily for local movements, rather than as added capacity for regional movements. Specific attention needs to be paid to non-motorized facilities as the key non-motorized travel paths serving a geographic area may not be directly associated with major roads, as bikes may use lower volume, slower speed roads rather than major arterials.

High profile facilities in a region that are experiencing major expansion or operational changes (e.g., implementation of some form of user pricing) should also be selected for monitoring, as such changes are likely to result in changes in mode choice or levels of demand. MPOs should lead the selection of these corridors with input from WSDOT.

For each selected corridor, the following measures should be tracked:

- person throughput (daily/peak period) by mode
- mode share for the defined facility/corridor (peak period/daily).

Data for these measures may or may not already exist within each region as a result of current data collection activities. While vehicle volume data are readily available on all major state routes, and are likely available for all major non-state routes,[9] it is not clear whether person volume can be obtained for roads outside of the central Puget Sound freeway system.

At this time, WSDOT conducts vehicle occupancy counts only on the Puget Sound freeway system, and it is not clear whether that count program will be funded in the FY13-15 biennium. Currently, vehicle occupancy data are available for freeways in King County and southern Snohomish County because of the HOV lane performance monitoring program. Outside of the central Puget Sound area, WSDOT collects little or no vehicle occupancy data. (Some regions have done occupancy counting as part of special studies, but those data are not readily available to the author.)

As a result, measuring carpooling at the corridor level will require either increased data collection or the adoption of a non-traditional vehicle occupancy counting program. Florida DOT has stated that by using vehicle occupancy data available though crash reports it is able to estimate vehicle occupancy on specific corridors.[10] WSDOT has not validated this approach to vehicle occupancy data collection, which would be necessary before its adoption. However, if it worked, it would provide vehicle occupancy information for most major state routes. Another alternative would be to assume fixed vehicle occupancy values, but this would not allow changes in the amount of carpooling to be tracked outside of vehicle counts in carpool lanes and is therefore not recommended for inclusion in the framework.

It is possible to obtain transit ridership data by route from most transit agencies, but unlike the annual, total daily ridership statistics that were used for the statewide level of reporting, these data are not routinely reported to WSDOT or to FTA. Instead, the MPOs (or WSDOT) must specifically request these data from the transit agencies. Most agencies maintain ridership by route as part of their route performance analyses. However, WSDOT will need to work with these agencies to select the specific locations for which ridership counts are required.

As noted for the state-level reporting statistics, WSDOT already works with local agencies and volunteer groups to collect 2-hour biking and walking counts at over 200 locations in the state each year as part of the WBPDP. Some of these count locations are likely to meet the

[9] Because ech region selects its own corridors for inclusion in the regional report, it is not possible to determine whether vehicle volume data are available for all such corridors. However, most agencies track weekday vehicle volume on their key corridors, so it is expected that these data are available on major roads that are not state routes, as well as being available for state roads.

[10] Vehicle Occupancy Data Collection Methods (Phase 2), Final Report, Contract #BD015-14, August 2007. by Albert Gan, Kaiyu Liu, and Rax Jung of Florida International University.

needs for data on non-motorized activity on selected corridors. (Again, until WSDOT and regions define the corridors to be monitored, this data availability analysis cannot be completed.) Other corridors will not be covered by the WBPDP counts and will require the current WBPDP efforts to be expanded. When taken as a whole, the 2-hour counts provide a useful measure of changes in statewide biking behavior, but because of day-to-day variability in biking activity, these counts are unlikely to provide reliable estimates of year-to-year changes in bike volumes on specific facilities. The WBPDP data provide a good initial benchmark of biking activity, but like vehicle occupancy counts, additional resources will be needed to collect the data required to estimate changes in biking on these specific corridors with a high degree of confidence.

Data on the number of people observed walking are also collected as part of the current WBPDP efforts. As with biking, the WBPDP walking data will provide a useful initial benchmark of walking activity at the WBPDP locations and a useful state-level measure of changes in walking behavior. Also, as with the biking data, some of the WBPDP counts will correspond with corridors already being monitored and will therefore supply initial estimates of peak period, weekday walking behavior at those locations. However, these counts, while useful, do not provide a statistically reliable data source for tracking changes in walking behavior at the corridor level or as measures of people walking to destinations with a geographic region being monitored as part of this framework. An increase in the resources available for counting pedestrians will be needed to supply those estimates, and the local jurisdictions will need to be heavily involved in the selection of count locations that can be used to accurately monitor changes in the amount of walking taking place within the monitored geographic areas.

WSDOT Programmatic Reporting

One set of measures not included in the framework are those designed to track the specific performance of WSDOT's demand management and VMT reduction programs and policies. For example, no direct reporting or measurement of the Commute Trip Reduction (CTR) program is included in this framework, although the CTR program regularly provides performance reports to the legislature. Many WSDOT demand management and VMT reduction related programs currently have performance goals (e.g., the CTR program had 2011-2012 goals of reducing employee drive-alone rates by at least 10 percent and vehicle miles traveled per employee by at least 13 percent). These and other VMT reduction program results could be reported in addition to the recommended statewide and regional measures. However, these programs already produce reports, the results are included in some Grey Notebook and other reporting mechanisms, and the outcome from these VMT reduction efforts will be incorporated in the statewide and regional summary data included in the statewide and regional measures. Therefore, the researchers decided not to recommend republishing these statistics as part of the VMT reduction monitoring framework. WSDOT can add these previously published statistics if desired.

SECOND STAGE FRAMEWORK IMPLEMENTATION

While currently available data provide for an excellent starting point for monitoring the performance of TDM outcomes and tracking the success of VMT reduction activities, they limit the accuracy and completeness of the picture of how travel in the state is changing. If the state wishes to understand how and why travel behavior is changing in response to TDM and VMT reduction programs, the monitoring framework outlined above needs to be extended to collect data that are not currently readily available.

This second phase of the framework implementation includes the expansion of existing data collection efforts and the collection of data from new data sources. The result of this second phase of framework implementation is a better, more accurate system for tracking the effectiveness of the state's demand management efforts on changing travel patterns in the state.

The primary limitations of the initial monitoring framework described earlier in this report can be summarized into the following major areas:

- limitations in the data available through the ACS, the one survey done annually throughout the state, including the following:
  - a lack of data on travel other than the journey to work, which limits the ability of the available surveys to track travel behavior for the majority of trips made in the state,
  - a lack of data on modes other than the one "normal" mode that can be reported, which limits the ability to track the use of important subsidiary commute modes of travel which can contribute substantially to VMT reduction during the peak commute periods (although the CTR survey does not have this limitation),

  - a fairly small annual sample size which limits the statistical reliability of the ACS (the CTR survey also doesn't have this limitation, but not all parts of the state are CTR affected).
- a lack of data on vehicle occupancy on most roads in the state, which limits the ability of the framework to monitor changes in person throughput on key travel corridors
- limitations in data on walking and biking activity in the state, especially for non-recreational walking/biking (i.e., to/from work and shopping by bike and foot)
- the lack of an adopted method to track whether changes in land-use mix and density, combined with non-motorized infrastructure improvements, are increasing the opportunities people have to choose transit, biking, and walking modes of travel.

While these limitations can be solved with large increases in funding for data collection and staff time, the current financial situation makes it unlikely that these funds will be available in the near future. Consequently, the ability to upgrade the demand management performance monitoring framework is dependent on a combination of finding modest amounts of new funding for data collection, new ways to leverage existing data collection funds, and newer, lower cost ways to collect data.

The following recommendations would result in substantial improvements to the output from the framework, allowing it to more effectively inform key WSDOT and regional decision making:

- The availability of survey data that describe travel activity should be expanded through both increased funding and the creative use of partnership opportunities with jurisdictions and organizations that are interested in household surveys, in order to provide a more accurate and comprehensive understanding of travel behavior in key geographic subareas.
- Either research is needed into new methods for accurately estimating vehicle occupancy, or new data collection funding is needed for vehicle occupancy counting on key corridors in the state.
- Additional resources and partnership opportunities should be identified to expand the counting of non-motorized facilities.

- Once those funds have been secured, the number of permanent, automated count locations should be substantially increased to improve the understanding of time of day, day of week, and seasonal annual patterns in non-motorized travel.
- The availability of GIS data sets that describe the availability and attributes of non-motorized network infrastructure should be improved through additional work with local jurisdictions and potentially the private sector.
- As accurate, up-to-date data on the existence and attributes of non-motorized network infrastructure become more readily available, the framework partners should track changes in the availability of travel options to residents and employees within the monitored geographic subareas.

Each of these enhancements is discussed briefly below.

Travel Survey Data

WSDOT needs to further explore both funding and partnership opportunities for expanding the travel surveys to collect more complete data on travel behavior in key geographic subareas in the state. Better survey data are needed, especially for non-work trips and to describe the use of "unusual" commute modes, in order to gain better insight into the large portion of travel not currently covered by the ACS.

Expanding the ACS—either by adding several travel questions or by expanding the number of samples taken in some geographic areas—would provide significant benefits to both the state and local jurisdictions. Splitting the cost of these expansions with the local jurisdictions would reduce the cost of the expansion for all parties and might make such a cost increase more feasible.

Another survey activity that WSDOT may be able to leverage is the National Household Travel Survey (NHTS). The next NHTS is scheduled for 2015, and USDOT has listed the survey as a pooled fund study[11] in order to help states and local jurisdictions fund expansion to meet their data collection needs. Other survey efforts (e.g., routine transit agency rider/non-rider surveys) might also be leveraged to obtain additional travel behavior data.

One limitation with the NHTS is the infrequency with which it is performed, every five to seven years. Given that land use changes slowly, and that significant changes in the state's VMT

[11] http://www.pooledfund.org/Details/Solicitation/1349

per capita rates rely on significant increases in the number of people who live among land uses that effectively support non-motorized travel, tracking annual changes in mode share may not be as important as finding the most cost-effective way of collecting good mode data on all trips, not just the commute trips that the ACS currently tracks.

Finally, WSDOT should consider other potential survey opportunities. For example, new technology may allow development and implementation of lower cost surveys, provided that the biases inherent in technology-based surveys can be overcome.

Vehicle Occupancy Data

Either research is needed into new methods for accurately estimating vehicle occupancy, or new data collection funding is needed to support vehicle occupancy counting on key corridors in the state, or some combination of these is needed. Traditionally, WSDOT has funded a substantial amount of vehicle occupancy counting in the central Puget Sound region as part of monitoring the use of its fairly extensive HOV lane system. When the HOV system was initially implemented, this included monitoring on a number of arterial HOV lanes as well.

As budgets have become more constrained, the amount of data being collected has been reduced. While a variety of national and international research efforts have been undertaken, to date, no automated equipment is able to count vehicle occupancy with a precision equal to that of human visual observation, which itself is limited to specific locations during time periods when light is sufficient.

It is recommended that Florida's system for estimating vehicle occupancy on the basis of data obtained during crash investigations be tested by comparing estimates obtained from those data with the vehicle occupancy data available for Seattle freeways. This study would confirm whether the crash data, adjusted for biases in crash rates, provide vehicle occupancy estimates comparable to those from existing data. Because midday and weekend vehicle occupancy count data are also available for some years, it will also be possible to test whether crash data can be used to determine the occupancy rates for different days of the week and times of the day.

Should the Florida system work, it could be adopted throughout the state. This would resolve a significant issue with tracking changes in vehicle occupancy that result from demand management activities, especially given the need to also raise occupancies during midday on weekdays and weekends.

Should the Florida system not work with the desired level of accuracy, it is recommended that WSDOT consider sponsoring a pooled fund study to examine other mechanisms for collecting vehicle occupancy data, as person throughput (which requires vehicle occupancy) is likely to be a measure reported as part of the MAP-21 congestion performance measures.

The fall-back position would be to significantly expand the current vehicle occupancy program.

Bike and Pedestrian Volume Data

Additional resources and partnership opportunities are needed to expand counts of non-motorized facilities in the state. Currently, insufficient data are available on pedestrian and bike travel in the state, and relatively little funding has been made available to collect those data. Unlike vehicle (the HPMS) and transit (the NTD) counting programs, no currently funded programs provide statistically reliable estimates of statewide biking and walking behavior. While the importance of walking and biking is rising nationally, the interest in the use of these modes has yet to grow enough for WSDOT to design or implement a statistically valid statewide data collection program.

The WBPDP will provide a good initial measure of bicycle and pedestrian activity on many of the corridors selected for monitoring. However, because of funding limitations, the WBPDP program does not cover the middle of the day on weekdays or the weekends, nor because of the high day-to-day variability of most non-motorized facility volumes are the counts capable of tracking most year-to-year trends on specific facilities. Complicating the collection of those data are two additional factors: 1) bike and pedestrian activity is more widely dispersed than motorized traffic, and 2) WSDOT does not own or operate the vast majority of facilities for biking and walking.

For motorized traffic, the statistical sampling process mandated by USDOT (the Highway Performance Monitoring System) to produce accurate estimates of statewide VMT relies on the fact that most vehicle travel occurs on a relatively modest subset of the state's road miles. Data collection is therefore concentrated on the small subset of roads that produce the majority of vehicle miles of travel, and travel on the lower volume roads is estimated with much lower accuracy. The larger error associated with these lower volume road estimates does not appreciably affect the accuracy of the overall statewide estimate of VMT. However, bike and walk modes do not have this same characteristic. That is, we can not monitor bike traffic on the

Interstate system (or any comparable set of facilities) and reliably capture 40 percent of all bike travel in the state.

It is possible to identify important biking facilities. However, at this time, it is not known what fraction of statewide bike travel those facilities represent, as little data exist for even those important facilities, let alone smaller volume facilities such as residential streets. The collection of bike volumes is further complicated by the fact that few major bike routes are state facilities. Instead, they are trails and designated bike paths on city streets and county roads.

These same problems are even more significant for measuring walking behavior, as most walking takes place along city streets, in mixed-use environments where little pedestrian counting occurs. One of the major factors in reducing VMT per capita is an increase in mixed-use, moderate to high density development relative to segregated use, low density development. When good walking paths are provided in these mixed-use environments, research shows that people walk more and drive less. But physically counting these walking trips is difficult, given the variety of paths available within these dense environments, and very few if any of these walking paths are on state owned right-of-way.

Lastly, only recently have relatively inexpensive automated counters become available that are capable of counting both bikes and pedestrians with acceptable accuracy in many locations where counts are required, including trails, sidewalks, and crosswalks.[12] The availability of automatic counters allows for longer term counting programs, including the creation of permanent count stations. These are necessary to understand time of day, day of week, and seasonal patterns, which are in turn necessary to expand the WBPDP short duration counts to represent annual, non-motorized travel behavior. To begin to address these issues, the WSDOT Secretary has requested "quick response" funding to review the statistical reliability of the current bike and pedestrian count program and determine ways to improve the program. This is an important start to the improvement of these data.

To further meet these challenges, this framework recommends that WSDOT perform the following tasks:

- look for more opportunities to increase the agency's partnerships with local jurisdictions and advocacy groups so that these groups either provide data or funding to collect additional data

[12] The 2013 FHWA Traffic Monitoring Guide has a complete chapter on bike counting, and

- provide additional resources for collecting data, especially for adding permanent counters on non-motorized trails funded in part with state or federal transportation dollars as well as further expanding on the efforts initiated as part of the WBPDP
- support non-motorized data collection research that develops techniques to compute more accurate annualized statistics from short duration counts, as well as examines innovative, low cost ways to collect data on non-motorized travel.

WSDOT and many local and regional agencies are already doing these activities. However, greater support is needed at all levels of government. The WBPDP program uses the right model of engagement. The local jurisdictions and advocacy groups are partners in the collection of data. As a result of these efforts, the number of bike and pedestrian counts has expanded significantly in the past five years. Advocacy groups have funded the purchase and placement of equipment. Local jurisdictions are paying to operate these devices, as well as to store and make available the data they produce. WSDOT is providing funding, technical support, and oversight. The efforts of all parties just need to be expanded. At the same time, "more" may be insufficient, especially given the need for several quantum increases in data collection activity in order to produce an accurate estimate of statewide walking and biking travel. Consequently, it is recommended that the state look to support research into more innovative ways to inexpensively collect data on walking and biking activity.

GIS Data Describing Non-Motorized Facilities

The framework needs better data on the existence and attributes of the non-motorized transportation network. (The transit network data from most agencies in the state can be obtained electronically via General Transit Feed Specification (GTFS) data feeds, which allow agencies to share their schedules with Google and other Internet map services.)

WSDOT already has an initial set of bike facility maps, but it needs to work closely with the local jurisdictions and the MPOs to continue to update and improve the completeness and accuracy of those data. This is particularly important because tracking the extent and completeness of non-motorized transportation networks is crucial for examining whether expected growth rates in biking are occurring in monitored subareas. Many cities in the state are actively developing and publishing bike maps over the Internet. In addition, the private sector and various bike advocacy groups are also looking to improve the availability of these data.

Equally important is collecting better data on walking paths—and in particular sidewalks. As of May 2013, only one county in the state had a complete GIS-based sidewalk layer. Safe, convenient walking paths are critical to encouraging walking. Sidewalk data are important in determining individuals' ability to walk from one activity to another and also greatly improve the ability of analysts to predict the amount of walking taking place.

As with bike trail data, a number of public agencies and private groups are interested in improving the availability of sidewalk data. Following the successful WBPDP approach, it may be possible to use relatively modest amounts of funding by cooperating with local jurisdictions and citizen groups to cost effectively collect sidewalk data. For example, it may be possible to "crowd source" sidewalk data, much as MapMyRide[13] is doing for bike routes and WAZE[14] is doing for improved street networks and traffic congestion. Creative approaches, supported by WSDOT but leveraging the technology knowledge of advocacy groups, may be one way to significantly increase the quality of sidewalk layer data. Similarly, it may be possible to work directly with Google and Microsoft to collect sidewalk data as they photograph regions of the state.

It is recommended that WSDOT consider sponsoring a pooled fund study that seeks to generate sidewalk data from available digital images or from crowd sourcing.

Measures of the Availability of Travel Options in Monitored Subareas

It is recommended that as data on transit, bike, and pedestrian transportation networks become more readily available in urbanized areas across the state, the framework be enhanced to include tracking measures of "access to travel modes" for the monitored geographic areas. These measures allow WSDOT to understand if a growing percentage of the population has access to effective alternatives modes of travel.

As non-motorized network infrastructure data become more readily available, a mechanism should be developed within the framework that allows changes in the availability of travel options to be tracked within monitored geographic subareas. Any large-scale improvements in the effectiveness of demand management and VMT reduction activities will depend upon an increasing fraction of the state's population being able to access to multiple

[13] http://www.mapmyride.com/
[14] http://www.waze.com/

modes of travel. Such access occurs most often in more dense, mixed-use, urban and suburban environments that also have good non-motorized transportation infrastructure.

Because of the current lack of data on non-motorized transportation networks, the initial framework assumes that the "subareas selected for monitoring" have these characteristics. Under this assumption, growth in the population and employment that occurs in these areas will equate to an increase in the percentage of trips made via multiple modes. Unfortunately, not all "centers designated for growth" actually contain features that encourage travel via multiple modes. Many dense urban and suburban environments have poor land-use mixes, inadequate transit service, and/or incomplete non-motorized networks.

Therefore, it is recommended that the partners in the framework develop or adopt analytical tools that can describe whether geographic subareas within the state provide good multi-modal travel opportunities. These tools would indicate whether integrated transportation and land-use plans intended to decrease vehicle use while increasing multi-modal mobility were being implemented. They also could be used as aids in selecting non-motorized count locations, the data from which would then verify whether changes in actual travel behavior were occurring as expected in the adopted regional plans.

A number of methods produce an index, based on a combination of land-use data and information on the availability of bike, transit, and walking networks, to describe the "accessibility" of land via different modes. Tracking changes in these indices for given geographic subareas would provide framework users with information on whether their implemented growth strategies and transportation improvements were successfully increasing multi-modal travel options.

The Walk Score® website[15] is one of the best known of these methods. At this website, it is possible to enter an address and receive a score for that address describing how "walkable" that location is, e.g., whether a potential buyer of a house can easily walk to various types of activities from that location. The algorithm that underlies the Walkscore™ statistic has significant limitations. These limitations are based primarily on a lack of nationally available data, such as the availability of sidewalks. Walk Score® acknowledges the limitations of its publically available algorithm and states that improvements to its algorithm will be implemented as new data become available. Indices that describe the "accessibility" of given subareas to

[15] http://www.walkscore.com/

various activities via transit and bike modes can also be computed. It is also possible to combine these indices to create a multi-modal accessibility index. Indices can also be computed for defined geographic subareas (e.g., a neighborhood or a city), not just specific addresses, by aggregating the indices computed for specific locations within each subarea.

Tracking these indices over time, as well as weighting the indices by the population and employment within geographic subareas, would provide an excellent mechanism for determining whether a growing percentage of the state's activities can be reached by modes of travel other than the automobile. As the percentage of these activities increases, the success of the state's TDM activities should increase, and the amount of vehicle travel per person will decline. Knowing the locations where non-motorized travel should be occurring will also help define where agencies should perform pedestrian counts to understand the extent to which actual travel choices match the expected behavior.

It is therefore recommended that the adoption of these "accessibility indices" be pursued within this general framework as the data needed to support their computation become available. To help WSDOT select or develop these indices, a short paper was written on this subject as part of this project. The paper summarizes the current state of the art in the impact the built environment has on reducing VMT. Much of the work to date has been in the area of identifying the built environment (geographic areas) characteristics which indicate, or actively support, low levels of VMT per capita. A copy of that paper is included in this report as Appendix A. As part of that report, an appendix was developed which summarizes the various indices and tools currently available, as well as the data sources on which these tools rely. This summary of tools and data sources is presented as Appendix B in this document.

OTHER IMPORTANT USES OF THE MONITORING FRAMEWORK

While performing this study, it became clear to the project team that the framework also offers an excellent means of meeting a variety of other WSDOT project identification and prioritization decision support needs. It also provides an excellent mechanism for meeting the USDOT's MAP-21[16] congestion reporting requirements Consequently, the third stage of framework implementation includes additional measures that specifically address these needs.

[16] "Moving Ahead for Progress in the 21st Century" is the name of the current federal legislation that funds the national surface transportation program. It was signed into law by President Obama in 2012.

Additional WSDOT Uses of the Performance Monitoring Framework

One of the strengths of this framework is that with only modest extensions of the initial framework described above, WSDOT will not only be able to monitor the effects of the state's demand management activities, it will have excellent information that can be used to support updates to the Department's plans and priorities. This same information will show how demand management activities maintain mobility while also supporting the state's congestion relief efforts.

WSDOT's project priorities are closely tied to the regional plans. Many projects are selected in part on how they contribute to achieving the goals of the regional plans. As a result, if the assumptions and analytical outputs that underlie those plans (how much and where growth will occur, what other facilities are being constructed, whether some form of road pricing will be implemented and at what prices, how well specific facilities will perform) are incorrect, the WSDOT projects selected for implementation may no longer be optimal. The regional planning process is periodically updated to reflect changes, but a direct comparison of modal performance with goals has not been one of the key inputs to that update process.

By modestly expanding the data collection and reviews already being done as part of this framework, it will be possible to directly compare the plan's expected outcomes with actual performance. Where actual performance was not meeting desired outcomes, the region could reconsider its prioritized projects within the context of the changing conditions. For example, if growth was occurring in unexpected places, WSDOT's priority list might need changes. Such changes would be made as part of the overall regional plan update and only after the Department received input from the rest of the regional partners. Similarly, if specific modal shifts were required to provide the mobility needed, and those shifts were not occurring despite land uses changing as expected, the region might need to consider new or different demand management activities.

To meet these additional WSDOT information needs, data on the performance (delays) occurring in the transportation network should be added to the initial framework. The initial framework deals primarily with the volumes of people and vehicles traveling, plus the vehicle-miles-traveled in the state, as changes in mode share are the primary desired outcomes from demand management activities. This extension of the framework would add the following travel time statistics:

- mean travel time for defined peak period trips that use a monitored corridor
- 80^{th} percentile travel time for defined peak period trips that use a monitored corridor
- 95^{th} percentile travel time for defined peak period trips that use a monitored corridor.

Travel time values can also be expressed as indices such as the Travel Time Index and the Planning Time Index, should WSDOT desired them. The use of indices allows easier comparability between trips of dissimilar lengths, but indices are more difficult for the public to understand. Regardless of their form (travel times, delay measures, or indices), these statistics describe the combined effects of WSDOT's and regional TDM and physical transportation improvements on roadway performance, as well as the mobility provided within the state.

As with the selection of geographic subareas to be monitored, it is important that WSDOT and the MPOs agree on the definition of these trips, that is, the starting and ending points of the trips used to describe the performance of the roadway. In general, these should be "corridor specific" (i.e., a trip uses just one roadway, such as I-5) and represent a common trip in the region through the selected corridor. For example, in the central Puget Sound region, one monitored corridor would undoubtedly be I-5 to and from the north. A second would be I-5 to and from the south. WSDOT and the PSRC would decide on the definition of those trips. For example, they might choose a trip from Lynnwood to Seattle for the northern I-5 corridor. However, they could also choose a trip from just south of Everett (SR 526) to downtown Seattle to represent the performance of that corridor.

Differences in trip length will affect the travel time statistics, whether expressed in minutes or as an index. In general, as trips extend from the core congested portions of a region out to the less congested, exurban portions of the region, the average speed will get faster, meaning that the indices will decline. This is a function of trip design, not of changing roadway performance. Therefore, it is recommended that the selected trip definitions represent a common commute that contains the major congestion points in the monitored corridor.

The key to the travel time performance measure is not the trip design itself but the fact that actual data on roadway performance for that trip will be compared to estimated travel times for that same trip from the regional model adopted for the regional plan. That is, the regional plan will supply the benchmark mean peak period travel time against which actual data are compared. By applying equations produced by the SHRP2 Reliability research, the modeled mean travel times can also be used to estimate 80th and 95th percentile travel time benchmarks for a trip.

By comparing the modeled benchmarks with the actual travel times for the peak period, it is possible to determine whether the roadway is performing as well as, better than, or worse than expected.

Currently, the actual travel times can be obtained from one of two sources. WSDOT's traffic management centers, which cover some but not all major urban areas in the state, operate loop detectors that can supply these data for some freeway corridors. In addition, WSDOT has purchased the rights to an Inrix data feed that provides roadway speed data that can be used to compute travel times for designated trips. The USDOT has announced that in the future, it will supply a data set to WSDOT that will also allow these computations. USDOT is currently reviewing bids from private vendors for a data set that would provide travel time data for the entire National Highway System (NHS). USDOT has said that if this federal purchase occurs, the purchased data will be supplied to state DOTs for performance measurement purposes.

One constraint of this approach is that regional plans are generally developed for five-year increments, and often for longer periods. Data from regional model runs are therefore not available for annual comparison. Additional input is needed from the MPOs to determine whether this reporting should be limited to five-year intervals or the MPOs are comfortable with adopting a trend line between current and planned conditions and comparing actual conditions with that trend line.

In addition to the roadway travel time data, it is also recommended that WSDOT work with the regional transit service providers to collect data that describe the

- percentage of capacity used for transit services in the peak direction during the peak commuter hour on the monitored corridor.

The intent here is to provide a measure of transit system performance to accompany the roadway performance measure. Because bus transit travel speeds are often restricted by roadway congestion that is beyond the agency's control, the percentage of capacity is used as the transit corridor performance measure rather than a transit travel time measure. This allows analysis of whether the transit services being provided in the corridor are under-utilized, overcrowded, or appropriate.

Given these data, along with the modal volume and mode share data collected as part of the initial framework, WSDOT and the MPOs can compare actual performance with the planned performance in their regional plan. Differences between planned and actual outcomes can then inform plan updates.

Using the Performance Monitoring Framework to Meet MAP-21 Requirements

The USDOT is currently working on the development of performance measures related to roadway congestion. The public comments supplied in response to that effort have illustrated a significant divide. One set of respondents said they wish to see these measures relate specifically to roadway performance; another set of respondents (mostly representing urban areas where roadway expansion is not financially or politically possible) said they want to see these performance measures viewed more universally as "mobility measures"—since the solutions to congestion in dense, urban areas frequently involve increasing travel options via other modes, and those improvements would not be captured by performance metrics that referenced only roadway use and congestion.

Comparisons of actual performance with the benchmarks described in adopted regional transportation plans are an excellent way of meeting MAP-21 performance measure requirements for congestion, while also addressing the root cause of the disagreement over what those measures should be.

By using adopted regional plans to set the benchmarks against which performance is measured, each region/state will be able to define transportation solutions that are tailored to their own political/financial/geographic condition. They will also become more accountable for their planning efforts, and thus their project selection process. Where the most appropriate transportation mobility solutions are roadway improvements, these will be selected, and the key outcomes—reduced congestion and growth in volumes served—will be the outcome measures of importance. Where the most appropriate transportation mobility solutions are increases in multi-modal travel while maintaining current traffic volumes and decreasing delays through operational improvements, these outcomes too can be extracted from the plan and used as benchmarks against which actual performance can be compared.

Ultimately this will allow each region to pursue the improvements that meet local needs, while also being accountable for the performance resulting from those decisions.

NEXT STEPS AND RECOMMENDATIONS

This report recommends the use of adopted regional transportation plans as benchmarks against which changes in transportation system performance and travel behavior can be compared to determine the outcomes achieved by demand management activities in the state. The implementation of this approach requires buy-in from partner agencies in the planning and delivery of transportation services across the state. Additional resources also must be identified to fund the staff resources and data collection activities necessary to implement the framework since it requires new data collection, coordination, and analysis.

To implement the framework, the following activities are recommended. They are divided into near-term and longer-term actions.

Near-Term Actions

WSDOT should engage with the state's MPOs to gather their input on the ideas described in this report. The MPOs will be key partners in this process, and their input and ideas must be incorporated into refinements to the proposed framework. If the MPOs agree with the basic concepts presented in this report, they need to have considerable input into the following aspects of the framework:

- the identification of the resources (dollars and staff time) required to perform the agreed upon tasks.
- the exact measures to be reported
- how corridors, facilities, and geographic subareas are selected for monitoring
- the timing of the framework reporting (annually, every two years, etc)
- the agency responsibilities associated with producing the selected measures (i.e., what work the MPO is responsible for and what work WSDOT will perform)

As part of working with the MPOs, WSDOT and the MPOs should seek funding from USDOT both to test this approach and to promote its use as a way to meet the congestion reporting requirements of MAP-21.

WSDOT should also continue its ongoing efforts with the MPOs and its other partners in demand management to

- find additional funding to collect data on the use of alternative modes of travel

- continue to expand its partnerships with MPOs, local agencies, local communities, and advocacy groups to identify where to collect data, identify new funding sources to perform that data collection, and to share the data collected
- support research that develops techniques to compute more accurate annualized statistics from short duration counts
- find funding and partnership opportunities that allow for the collection of better survey based data on travel choices and behavior.

Relatively little data are available to describe either non-motorized travel or non-work-related travel behavior in the state. Improving the available data that describe these travel activities will be necessary to allow informed decisions to be made at the local, regional, and state levels. A key to this activity may be to creatively leverage funding available for different survey efforts.

The WSDOT/MPO partnership should also continue and expand their ongoing efforts to improve the availability of GIS layers that accurately describe the existence and attributes of transit and non-motorized transportation infrastructure, that is, the locations and attributes of sidewalks, bike paths, and transit stop features that are keys to the functionality of the travel networks that are alternatives to the single occupant passenger car.

It is recommended that WSDOT either

- research new methods for accurately estimating vehicle occupancy, or
- identify new data collection funding for vehicle occupancy counting on key corridors in the state, or
- some combination of the two.

Without successful results from this research or a sizeable increase in the funding available for collecting vehicle occupancy data, WSDOT will not be able to track changes in vehicle occupancy that result from efforts intended to promote ridesharing.

Longer-Term Actions

While additional funds are needed to collect much of the data required for the recommended framework, for research that dramatically changed the cost of data collection would make this task more affordable. An excellent example of the potential for change in data collection costs is the collection of GPS data from smart phone-based navigation applications,. The use of vehicle probes has allowed the collection of roadway performance (delay) data across an entire state's Interstate system for a fraction of the cost of having to buy, place, and operate traditional fixed sensors.

Therefore, it is recommended that WSDOT support research into innovative approaches that can dramatically change the cost of data collection in the areas of

- pedestrian counting
- bike counting
- travel surveys
- collecting data on the existence and attributes of non-motorized transportation infrastructure.

One possible approach for investigation is the development of crowd sourced data collection. For example, it may be possible to work with companies such as Google that routinely collect imagery (e.g., from the new Google glasses product) and process those images to count pedestrian and bike activity. Similarly it may be possible to dramatically lower the cost of gathering sidewalk availability data by viewing images already accessible on the Internet. Combining the two approaches might help capture data on sidewalk availability as well as bike and pedestrian volume. For example, WSDOT might sponsor a research project to develop a Smartphone application that would allow volunteers from neighborhood associations or other interest groups to directly enter detailed data on the sidewalks in their neighborhoods, with supporting images collected for quality control purposes. These electronic data could then be uploaded to local jurisdiction GIS files and shared among partner agencies.

Similar crowd sourced data collection efforts might also make it possible to collect travel survey data. Crowd sourced travel surveys could be complicated by the need to address social equity issues (that is, the poor have less access to electronic surveys and so could easily be under-represented in survey responses). Therefore, beyond developing and delivering a low cost survey a key part of the research would be to address the bias issues inherent in that process.

Finally, it is recommended that the partners in the framework develop or adopt analytical tools that produce indicators of whether geographic subareas within the state provide good multi-modal travel opportunities. These indicators would describe whether the integrated transportation and land-use plans intended to decrease vehicle use and increase multi-modal mobility were being implemented. That is, given improvements in the transportation system, the tools would indicate whether land uses were growing in ways that supported increased multi-modal travel opportunities. For these indicators to be meaningful, they would require improved data sets describing the non-motorized transportation network (i.e., complete sidewalk and bike route data). Appendix A includes a description of many of the currently available indices that could be considered for use. These indicators will change over time as new data become available.

APPENDIX A: REVIEW OF VMT INDICATORS

This review focused on tools that could serve as indicators of Built Environment (BE) factors that support reduced VMT and actual tools that measure actual travel behavior. Built Environments that support reduced VMT have a large number of trip origins and destinations in close proximity. A solid base of research has found that BE characteristics that affect travel can be summarized in 5 D's: density, diversity, design, destination accessibility, and distance to transit (other non-BE D's that affect travel are demand management and demographics). Areas with high residential and employment density, diverse land uses, highly connected streets, destinations within close proximity, and transit service within close proximity support more walking, more transit use, and fewer VMT. Built Environments that support reduced VMT are often no accident; they are the result of policies or public support for these lower-cost, healthier, more environmentally friendly, and often more convenient modes of travel. Therefore, in this review, the following indicators were searched:

- Indicators of policies or public support for walking, bicycling, or public transit
- Indicators of direct Built Environment support for walking, bicycling, or public transit ridership, including the 5 D's:
    - Density of residences and employment
    - Diversity of land uses
    - Design of street networks
    - Destinations in close proximity
    - Transit service in close proximity
- Indicators of actual travel behavior

Due to WSDOT's reporting requirements, it was understood that the ideal indicators would:

- Provide coverage for the entire state of Washington
- Have a fine spatial resolution, which would facilitate precise measurements that could be aggregated to various geographic scales, such as the neighborhood, city, county, or region (the largest desirable spatial scale is the city)
- Be updated regularly, ideally annually
- Have a clear and transparent methodology
- Would use a consistent methodology over time
- Be readily available and require few resources to gather and report

Research was conducted to identify indicators that fit these criteria. The search began with Walk Score, and its series of other indicators of how well a neighborhood can support a car-free lifestyle. The U.S. Census Bureau's data and tools were investigated, as well as resources from various Washington State agencies. Finally, pedestrian, bicycle, and public transit advocacy groups were reviewed for indicators that they use to track institutional support and use of these modes.

RESULTS

Twenty three tools were identified and reviewed (Table A-1). The tools fit into three broad typologies:

- **Report cards**, which are generally published by advocacy groups and are used to track institutional support for walking, biking, and other non-SOV modes of travel.
- **Composite indicators**, such as Walk Score, allow users to identify a location (address, neighborhood, city, etc.) for which an algorithm will be performed on various source data. The result is a simple score, rank, or other summary statistic that communicates something about the area's travel opportunities or behaviors.
- **Raw data** are the various data sources that feed into composite indicators or have been used in research on transportation and the built environment. They include census data, street network data, parcel data, and travel behavior data.

REPORT CARDS

Report cards consist of a series of indicators related to non-SOV travel that are tracked over time. The two report cards reviewed here were the 2012 Seattle Bicycle Report Card (page 3) and the Alliance for Biking and Walking 2012 Benchmarking Report (page 1). The 2012 Seattle Bicycle Report Card was published by the Cascade Bicycle Club and its purpose is to track the City of Seattle's progress toward reaching the goals outlined in the 2007 Bicycle Master Plan for 2017. It relies on data from the city of Seattle and reports on four main indicators: Ridership based on downtown bike counts, bike collisions reported to the Seattle Police Department, bike infrastructure, and bike funding.

Table A-1: Summary of Tools Reviewed

Type	Tool	Agency	Metric	spatial resolution and extent	Update schedule	Availability
Report card	Alliance for Biking and Walking 2012 Benchmarking Report	Alliance for Biking and Walking	Ped/bike policies, programs, advocacy, mode share, and safety, and public health	States and large cities across the U.S.	2 years	Online
Report card	2012 Seattle Bicycle Report Card	Cascade Bicycle Club	bike counts, bike collisions, bike infrastructure, bike funding	City of Seattle	probably 2 years	Online
Composite	Walk Score	Walk Score	nearby destinations, street network connectivity	buffered point locations worldwide	Continuously	Online and upon request
Composite	Bike Score	Walk Score	Bike infrastructure, topography, destinations, street network, and bike commute mode share	Large cities in North America	unknown	Online and upon request
Composite	Transit Score	Walk Score	Transit service, access	buffered point locations where proper data exist	Continuously	Online and upon request
Composite	One Bus Away Explore Tool	One Bus Away	Transit service area, destinations reachable via transit	buffered point locations in Seattle (and possibly wherever proper data exist)	Continuously	Check with Kari
Composite	TELUMI	Urban Form Lab	Transportation Efficiency (residential and employment density, destinations, street network, parking, topography, and affordable housing)	Grid cells in Puget Sound Urban Growth Area	none (published in 2005)	Urban Form Lab
Composite	Travel and the BE: A Meta-Analysis	JAPA article by Ewing and Cervero	Elasticites of BE variables organized into 5 D's: density, diversity, design, destination accessibility, and distance to transit	n/a, summarizes studies in various locations where the unit of analysis is the individual	None (published in 2010)	JAPA
Composite	On the Map	U.S. Census Bureau	Commute patterns, worker home and work locations	Census blocks across the U.S.	Annually	Online
Raw data	April 1 official population estimates	Office of Financial Management (OFM)	residential population	cities and counties in Washington State	Annually	Online
Raw data	Small Area Estimates Program (SAEP)	Office of Financial Management (OFM)	residential population	Census block groups in Washington State	Annually	Online
Raw data	Quarterly Census of Employment and Wages	Washington State Employment Security Department	Employment	Counties in Washington state	Quarterly, also Annual averages	Online
Raw data	The Washington Business Tax and Premiums Database	Various Washington State Agencies	Employment, destinations	Business firms in Washington State (may require geocoding)	Annually	Perhaps upon request
Raw data	Standard Statistical Establishment List (SSEL)	U.S. Census Bureau	Employment, destinations	business establishments across the U.S. (may require geocoding)	Annually	NW Census Research Data Center
Raw data	Washington State Parcel Database	UW Washington Geographic Information Service (WAGIS)	Land use, improvement characteristics, finest available geographic scale for distributing aggregate residential and employment populations	Parcels in Washington State	1-2 years	Upon request
Raw data	Proprietary destination data sources	Various private enterprises	Destinations	Business locations worldwide	Continuously	Varies
Raw data	Street infrastructure	Various private enterprises	Street network and characteristics important to routing	street segments in developed world	Varies, but probably several times a year	License fee

Raw data	Street infrastructure	Various transportation departments	Street network and characteristics important to planning and maintenance	street segments in various jurisdictions	Varies, but probably several times a year	Usually online or on request
Raw data	TIGER/Line Shapefiles	U.S. Census Bureau	Street network and address ranges	Street segments across the U.S.	Annually	Online
Raw data	OpenStreetMap	OpenStreetMap.org	Street network and various other features	Street segments and other points and polygons worldwide	Continuously	Online
Raw data	WA State Bicycle and Pedestrian Documentation Project	WSDOT	Bike and ped counts conducted on a single day in September	Count locations across Washington State	Annually	Request from WSDOT
Raw data	American Community Survey (ACS)	U.S. Census Bureau	demographic, economic, social, housing, financial, and commute characteristics	Various census geographies nationwide, smallest is block group.	Annually, but data represent 1 to 5 year averages	Online
Raw data	National Transit Database (NTD) Program	Federal Transit Administration	Transit ridership and service	Transit systems nationwide (no spatial data)	Annually	Online

The Alliance for Biking and Walking 2012 Benchmarking Report is a national report that looks at bicycle and pedestrian indicators across all 50 states and the 51 largest cities, which includes Seattle. It reports 28 benchmarks that reflect both inputs to support bike and pedestrian travel, as well as outcomes of these travel modes. Inputs include bicycle and pedestrian funding, presence of bike/ped master plans, measures of bicycle infrastructure, presence of advocacy groups, and participation levels of special events (e.g., bike to work/school days). Outcomes include mode shares, bike/ped fatalities and risk, and population health measures such as asthma and obesity prevalence. Several publically available secondary data sets are used to develop most of these indicators. The Alliance also sends a survey to state and city governments and reaches out to its network of advocates to gather data.

These report cards are feasible partially because the reporting unit is a large geography (state or major city) covered by a single Government (State DOT or City). This minimizes the data collection effort and allows for the use of population sample surveys like the National Household Transportation Survey (NHTPS) or the American Community Survey (ACS). Therefore not all indicators may be repeatable for smaller jurisdictions or on an annual schedule. Another shortcoming is that the indicators focus on direct inputs and outcomes of ped/bike travel and do not report on any land use patterns that make these modes more competitive.

Some state-level indicators reported in the Alliance for biking and walking 2012 Benchmarking Report could be used directly for this project (although the report is published biennially). It may also be possible to gather comparable data (e.g., spending on ped/bike infrastructure, mode share, participation in walk to school day, etc.) from cities, counties, or other smaller geographies. The advantage of using comparable indicators to the ones presented in the report cards is that they were developed with substantial input from bike/ped professionals and advocates and could represent generally agreed upon metrics. They would also allow for comparison beyond the state line.

COMPOSITE INDICATORS

Composite indicators apply an algorithm to data from various sources to present a simple score, rank, or other summary statistic that communicates the travel opportunities or behaviors of a place. Perhaps the most well-known example is Walk Score (page 4), in which the user types in an address and receives a score from 0 to 100 that describes the address' walkability. The score is based on an algorithm that calculates distances to nearby destinations in nine categories, weights each destination by distance and importance, then applies a penalty for street networks that are not well connected. Walk Score is oriented to individual users interested in specific addresses, but summary scores for cities, towns, or other geographies are possible by aggregating multiple scores on a per-capita basis. Walk Score compiles these area-based scores on what seems to be an annual basis for all cities in the U.S. The data used in Walk Scores algorithm comes from business listing data from Google and Localeze, road network data and park data from Open Street Map; school data from Education.com. Many of these data sources are continuously updated from official sources and user feedback, making it difficult to determine if a change in a Walk Score was due to a change in the built environment or a change in the data. Further confounding the utility of using Walk Score as an indicator is that its web site claims that it is always seeking to refine the algorithm – great if you're hunting for an apartment next year, not so great if you're trying to have a consistent indicator year after year.

Walk Score also makes a Bike Score and a Transit Score. Bike Score (page 6) is only available for about 25 large, North American cities. It consists of four indicators: a modified Walk Score, a measure of topography, a measure of bike infrastructure (bike lanes, sharrows, multi-use paths, and bike boulevards), and bike commute mode share. Bike Scores are not available for specific locations, although users may view "heat maps" of bike scores for the cities where Bike Scores exist. Bike Score is in beta testing and will likely be refined and expanded to more cities.

Transit Score (page 7) also has limited coverage. It is only available where transit agencies provide data in the General Transit Feed Specification (GTFS) format. Thirteen out of 30 transit agencies in Washington provide GTFS data. Transit scores are measures of service and access at a specific location. Transit service is calculated by weighting nearby transit stops by frequency and mode (rail receives more points than bus). Access is accounted for by weighting closer stops more than further stops. These weightings are converted to a 0-100 scale using a log function where a perfect 100 is defined as the average score of the center of five U.S. cities: San Francisco, Chicago, Boston, Portland, and Washington, D.C. Area (neighborhood, city) transit scores are also available, and are presumably calculated the same way area Walk Scores are calculated – on a per-capita basis.

One Bus Away's Explore Tool (page 8) suggests another metric of transit service. The tool is designed to allow users to identify types of destinations that can be reached by transit given some constraints defined by the user, such as travel time, maximum transfers and walking distance. The user enters these constraints and selects their origin location and the algorithm returns a map of the transit access area and all destinations within it. This tool designed for trip planning, but also can work as an indicator by identifying, for example, the number of dentist offices within a 30-minute transit trip. Like Transit Score, this tool relies on GTFS data. Destinations are identified from Yelp's database (Yelp is a website that offers user-generated reviews of businesses and other destinations). Unlike transit score, it does not provide a readily usable indicator. To use One Bus Away's Explore Tool to develop a simple indicator, like the number of dentist offices within a 30-minute transit trip, would require establishing what time of day the trip occurs (maybe and average weekday or weekend), how far the person is willing to walk, and how many transfers the person is willing to make.

One drawback to Walk Score's suite of indicators is that they do not reflect actual travel behavior (although the weights are based somewhat on research on the relationship between the BE and travel). Composite scores of the BE as it relates to actual travel behaviors could more accurately reflect the BE's support for reduced VMT in an area. This type of composite indicator was developed by the Urban Form Lab for the TELUMI project in 2005 (page 9). It identified nine features of the built environment that were related to transit ridership. Based on statistic models of these nine BE variables, the UFL identified areas of high, medium, and low transportation efficiency in the Puget Sound Region. The nine TELUMI variables captured residential and employment density, destinations, street network, parking, topography, and affordable housing. Many other researchers have quantified the various relationships between BE and travel behavior. Reid Ewing and Robert Cervero summarized much of it in a 2010 meta-analysis of travel and the built environment (page 11). They reviewed 50 articles and identified 13 BE variables related to individual travel behaviors (VMT, walking, and transit use) that were reported in 3 or more studies. The 13 BE variables were grouped into five D's: density, Diversity, Design, Destination Accessibility, and Distance to transit. Finally, the effect of each common variable on travel was calculated as a weighted average elasticity, which reflects the ratio of the percent change in travel behavior that results from a percentage change in the BE variable (Table A-2).

Table A-2: D's – Weighted Average Elasticities, from Ewing and Cervero's 2010 meta-analysis of travel and the BE.

		Weighted average elasticities		
D	**Variable**	**VMT**	**Walk**	**Transit**
Density	Household/population density	– 0.04	0.07	0.07
	Job density	0.00	0.04	0.01
	Commercial Floor Area Ratio (FAR)	n/a	0.07	n/a
Diversity	Land use mix	– 0.09	0.15	0.12
	Jobs/housing balance	– 0.02	0.19	n/a
	Distance to a store	n/a	0.25	n/a
Design	Intersection/street density	– 0.12	0.39	0.23
	Percent 4-way intersections	– 0.12	– 0.06	0.29
Destination accessibility	Job accessibility by auto	– 0.20	n/a	n/a
	Job accessibility by transit	– 0.05	n/a	n/a
	Job within one mile	n/a	0.15	n/a
	Distance to downtown	– 0.22	n/a	n/a
Distance to transit	Distance to nearest transit stop	– 0.05	0.15	0.29

The BE variables can be viewed as a sort of short list of indicators of areas that support lower rates of VMT and higher rates of walk and transit trips. Because the meta-analysis only included variables that were included in at least three studies, the raw data required to develop the variables are likely available across multiple jurisdictions (except when derived from travel surveys). Some variables will be familiar from indicators already reviewed (e.g., Walk Score uses distances to stores and other destinations). The advantage to research-based composite indicators, such as this Meta-Analysis and TELUMI, is that the weights of each variable are based on actual travel behaviors, whereas indicators such as Walk Score may select and weight variables based on past research findings, but the weights are based more on experience and intuition. The drawback of research-based indicators is that they may not always be valid beyond the study population and much work is required to perform the initial research of collecting BE data and travel data and performing the analysis to identify the relationship. Ewing and Cervero's work attempts to allow practitioners to bypass the latter two steps in this process by presenting the weighted average elasticities of each variable. These elasticities could feed into a weighting system if any of these indicators were used to feed into a composite indicator.

Neither TELUMI nor Ewing and Cervero's Meta-Analysis offers any readily usable composite indicator because they will not be repeated on a regular schedule. Rather they are presented as examples of how research can inform the choice of BE indicators and the importance of the relationship between certain BE variables and travel outcomes.

BE variables associated with travel outcomes can feed into indicators that describe an area's support for fewer VMT and more walk and transit trips. It may be in WSDOT's interest to track actual travel behaviors of people who live or work in in an area as well. This would allow WSDOT to refine the understanding of how modifications to the BE affect actual travel and provide a more direct indicator of the target they must meet. Commuting between home and work accounted for only about 15% of person trips in the 2009 NHTS. Because commute trips are fairly regular, however, the commute distances traveled could offer a good indicator of VMT trends. These commute distance are made available at fairly small geographic scales via the U.S. Census Bureau's On The Map application (page 12). It is an online tool that enables users to visualize and create reports on where workers live and work. For a given area, it identifies the number of workers who live and work there, as well as how far they commute to or from work, respectively. It is built on top of a database comprised of origin and destination census blocks, with info on the number and demographics of workers, as well as job types and income categories. A related table identifies the number of workers that commute between each origin-destination census block pair. This would enable the development of many indicators of commute behaviors and jobs/housing balance. However, to protect privacy, the tool is built on synthetic data, which has the same characteristics of the actual data, but is somewhat altered. Use of this tool would require further investigations into how well the synthetic data reflect reality.

Raw Data

Raw data are required for all the report cards and composite indicators discussed in the previous two sections. While ready-made report cards and composite indicators require relatively little effort to access, they are subject to various shortcomings: They may fail to capture the exact desired metric, fail to be updated on a regular schedule, change methodologies over time, not cover the desired extent, not be reported at the desired scale, or not have adequately documented or robust methodologies. Directly accessing raw data to use as an indicator or feed into a custom-made composite indicator may overcome these limitations. Raw BE data identified in the review process generally captures common trip origins and destinations (residential/employment/non-work destinations) and the impedances between the two (distances and transportation infrastructure). Because non-motorized transportation and VMT are influenced by distances, precise locations of these residences, workplaces, and other destinations are important. Therefore parcel-level spatial data would be the ideal raw spatial data to locate these places. Additional non-BE raw data includes the upstream political and public support for non-SOV travel and the downstream actual travel behavior. Each of these raw data types was reviewed.

Residential data

The U.S. Census counts people every decade and provides population counts down to the block level. In the years between Censuses, it releases population estimates based on births, deaths, and migration for geographies as small as counties and incorporated places (i.e., cities and towns). The Washington State Office of Financial Management (OFM) also releases these data on an accelerated schedule and potentially using a more robust methodology. The OFM's official population estimates (page 14) are for geographies as small as cities, towns, and counties. In addition, OFM has a Small Area Estimates Program (SAEP) (page 15), which provides population and housing unit estimates to geographies as small as the census block group (average populations of roughly 1,200 people). The OFM's methodology for the SAEP figures is to make estimates at the block level, then aggregate them to larger geographies. The OFM does not make the block level estimates publically available, but it is possible that they may be available upon request. However, OFM warns that errors may range from 5 to 15 percent for areas of 1,000 people, and may be considerably higher for areas with fewer people.

Employment data

Employment data are readily available at the county level through the Quarterly Census of Employment and Wages published by the Washington State Employment Security Department in cooperation with the federal Bureau of Labor Statistics (page 16). These data provide the number of employees by industry based on the NAICS code. The primary drawback to these readily accessible reports is the coarse geography. The Urban Form Lab has previously applied these county-level employment figures to parcels based on land use codes and improvement square footages, which correspond to the type and number of employees that would be located on a parcel. This type of endeavor at a state-wide level would prove difficult and time consuming. One alternative investigated was the Washington Business Tax and Premiums Database (page 17), which contains a record (with number of employees and address information) for each business that operates in Washington State. It, however, is limited because it appears to be at the firm level. Therefore a business may have one location listed in the database even if its workers are spread across numerous sites. Additionally it is not publically accessible and would require working with the managing agency to access it. An employment database that overcomes both these limitations (imprecise geographies and accessibility issues) is the U.S. Census Bureau's Standard Statistical Establishment List (SSEL) (page 18). Its data are at the business establishment level and contain information on the industry classification and employees. These data are not publically available, but can be accessed by researchers through the Northwest Census Research Data Center.

Destination data

Employment data sources can also be used to identify business establishments that serve as non-work destinations, such as grocery stores, restaurants, and other retail stores. Often the destination data used in the composite tools reviewed here are sourced from proprietary databases, likely due to the fact that most official business databases are not publically accessible. Numerous proprietary destination data sources exist, including Google local, Yahoo local, Yelp, OneSource, Localeze, and ReferenceUSA (page 20). All are national, if not worldwide listings. They are compiled from various sources, including authoritative sources, business owners, user feedback, and verification performed by the provider. The information contained in these business listings vary, but can include the business name, location (x/y), user ratings, reviews, category, NAICS code, and the business website. Some databases appear to be free to use (Google, Yahoo, and Yelp), while others require a subscription (Localeze, ReferenceUSA). The databases that require a fee advertise themselves as more accurate and suitable for research, however, their inaccuracies have been documented (CITE).

Parcel data

Residences, places of employment, and destinations are located on individual parcels, which are the smallest units of land for which statewide data are available. These data are part of the Washington State Parcel Database (page 19), which aggregates parcel data from counties and other parcel data providers across Washington State. The parcel data are in a GIS format where a polygon represents a single parcel. Attributes that have been normalized across all data providers and would be of relevance to VMT include land use and improvement information. Land uses correspond to activities that take place on the parcels, such as residence, employment, recreation, education, etc. Improvements are the built structures on the parcels. Because the parcel data do not contain any information on actual human activities, they would be best for allocating residential and employment populations that are only available at larger scales. They would also be useful for identifying non-commercial destinations that may not be available through business listing, such as parks and churches. Because data are aggregated from various providers, the data are not entirely complete or consistent.

Infrastructure data

Street network datasets are available through various public transportation agencies and private providers. Public agency datasets (page 22) usually only cover the spatial extent of the agency's jurisdiction, and sometimes only include the types of streets that are relevant to the agency. For example, King County maintains a street network dataset that includes all streets in the King County while WSDOT maintains a street network dataset that covers all of all of Washington state but contains only higher level roads (collectors or higher). Proprietary street network data (page 21), on the other hand, are often used for routing and therefore offer complete street network data for just about all of the developed world. The proprietary street network datasets require a license fee and are subject to use restrictions. WSDOT has a license for MultiNet street network data. The Urban Form Lab has a license for StreetMap premium street network data. As is often the case with proprietary datasets, the data appear to be updated frequently but irregularly in an attempt to constantly provide the most up-to-date set of data. The variables for street networks depend on the dataset, but for both public and private datasets, they usually contain length, street classification, speed limit or travel speed, intersections, restricted uses (such as transit-only streets), and address ranges. Detailed data on sidewalks, crosswalks, on-street parking, street width, and traffic volume are not regularly available in any of these datasets. Two additional street network datasets have complete coverage for Washington State and no use restrictions. They are the U.S. TIGER/Lines (page 23) and OpenStreetMap data (page 24). The TIGER/Line data are provided by the U.S. Census Bureau and are used to define census geographies and facilitate census data collection. There are few infrastructure attributes, but the data would likely be fairly accurate and detailed because they were refined from previous versions using information from local government officials and census canvassers. The OpenStreetMap data are user-generated geospatial data. OpenStreetMap may be considered the Wikipedia of cartography. The coverage and features represented in the data are quite extensive, but are depended on users for accuracy and completeness, making it problematic to compare areas or changes over time, as both may be subject to variations in user activity.

Non-SOV political and public support data

Political and public support for non-SOV travel includes pedestrian, bike, and transit transportation plans, advocacy groups, government spending, and other indicators. The Alliance for Biking and Walking 2012 Benchmarking Report presents a thorough range of these indicators and provides transparent data sources. For this reason source data for these indicators are not discussed here. Instead, please see the Alliance for Biking and Walking 2012 Benchmarking Report (discussed on pages A-2 and 1).

Travel behavior data

Detailed travel behaviors at the household and individual level are available from the NHTS and various travel surveys conducted by metropolitan and regional planning organizations. However, the NHTS is conducted only every 7 or so years and only contains representative figures only for the nation or areas where an add-on is collected (in 2009, the year of the most recent survey, no add-ons were completed in Washington State or any jurisdiction in Washington State). MPO and RPO surveys are also conducted intermittently and would not cover rural areas in Washington State. The most regularly collected travel data with complete coverage for Washington State appears to come from the American Community Survey (ACS) (page 26). The ACS collects commute (and other) data from a sample of the population annually in order to provide estimates for various geographic scales for various time periods ranging from one to five years (Figure A-1). As the size of the geography decreases, the frequency of estimates also decreases. The most precise geographic area is the block group, which only has five-year estimates available.

Table 3. **Release Schedule for ACS Data**									
		Year of Data Release							
Data product	**Population threshold**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
		Year(s) of Data Collection							
1-year estimates	65,000+	2005	2006	2007	2008	2009	2010	2011	2012
3-year estimates	20,000+			2005–2007	2006–2008	2007–2009	2008–2010	2009–2011	2010–2012
5-year estimates	All areas*					2005–2009	2006–2010	2007–2011	2008–2012

*Five-year estimates will be available for areas as small as census tracts and block groups.
Source: U.S. Census Bureau.

Figure A-1: Release Schedule for ACS Data. Source:
http://www.census.gov/acs/www/Downloads/handbooks/ACSResearch.pdf

In addition to population-level surveys on travel and commute behaviors, counts of facility users also lend insight into travel patterns. Efforts to reduce per-capita VMT will rely in part in more people using non-motorized modes and public transportation. Therefore trends of non-motorized users and transit ridership on the same facility or system over time offer insight on overall VMT trends. WSDOT's Washington State Bicycle and Pedestrian Documentation Project (page 25) can provide these trends for non-motorized modes. Counts along facilities are taken annually and in 2010 there were 229 count locations in 30 cities. Bus ridership data are reported to and available from the National Transit Database (NTD) (page 27). It includes data for all transit agencies that received grants from the Federal Transit Administration (FTA), 20 of which are located in Washington State. Data are reported at a system level, however, making it difficult to identify specific locations with higher or lower levels of ridership. Ridership by station location may be available directly from the participating transit agencies.

CONCLUSION

This report presents the results of a review of tools that could serve as early indicators for WSDOT's VMT reduction program. The search focused on indicators of (1) political and public support for non-SOV travel, (2) BE characteristics that support fewer VMT, and (3) actual travel behaviors. Twenty three tools were identified and organized into three categories: report cards, composite indicators, and raw data.

Report cards provide a good menu of indicators for political and public support for non-SOV travel and actual travel behaviors. These indicators may be particularly robust because they are based on input from pedestrian and bicycle professionals, advocates, and plans. However, they tend to be reported at large geographic scales and often require collecting information from governments or organizations. It may be difficult to repeat such indicators for the multiple jurisdictions across Washington State.

Composite indicators provide a simple score or rank that communicates the travel opportunities provided by the BE of a place and/or the travel behaviors of a place. A well-known example is Walk Score. The advantage of composite indicators is they present simple, easy-to-read figures. However, there are several drawbacks. Composite indicators are often oriented toward an audience seeking information about a specific location or neighborhood and would require some processing to gather and aggregate at various scales across the state. Bike and transit indicators are limited in scope due to the lack of readily available bike and transit infrastructure data. Composite indicators often they rely on constantly changing open source data and methodologies that are still being refined and may not be well-documented. Finally, the output of a composite indicator may be somewhat arbitrary or based more on intuition than evidence. Due to these drawbacks, composite indicators may not be of greatest value as example metrics that can be improved upon using more authoritative data sources as well as clearly documented and stable methods based on evidence. The ample research on the relationship between the BE and travel could inform these methods.

To investigate the feasibility of improving upon composite indicators, **raw data** that could feed into a custom-made indicator were reviewed. These data included residential data, employment data, destination data, parcel data, infrastructure data, Non-SOV political and public support data, and travel behavior data.

- Residential– The most robust residential data are available through the OFM at areas as small as Census block groups.
- Employment – The most robust employment and business data come from the U.S. Census' Standard Statistical Establishment List (SSEL), which contains a (probably) geocoded record for each business establishment.
- Parcel – The Washington State Parcel Database could be used to allocate data at larger geographic scales to individual parcels and also provide non-commercial destination locations based on state land use codes.

- Infrastructure – The U.S. Census TIGER/Line files likely represent the most authoritative and comprehensive street network coverage for Washington State and would likely be suitable for calculating connectivity variables. Transit service data are available for about half the 30 transit agencies in Washington State. Bike facility and sidewalk data are not readily available across the state.
- Non-SOV political and public support – the Alliance for biking and walking 2012 Benchmarking Report provides a good menu of raw data, which often would have to be collected from a jurisdiction's governing agency
- Travel behavior – The ACS provides rolling estimates of commute behaviors for various geographies and time frames, although the time-frame increases as the geography decreases. System-wide transit ridership is available from the National Transit Database for 20 transit agencies in Washington State. WSDOT conducts single day bike and ped counts annually at various locations across the state.

This report stops short at recommending actual indicators to use for monitoring VMT and public support and BE's that may influence it. The review did, however, bring up several issues for consideration when developing indicators:

- Readability – The indicator should be easy to relate to. Walk Score excels at this because it uses a simple scale of 0-100. Even if a person does not know exactly what a Walk Score of 75 means, they have probably been in school long enough to realize it is about a C, or average score.
- Stability – Will the indicator measure the same thing year after year? An indicator's methodology should be stable. And although data quality will inevitably change over time, it should not change in any systematically biased way (e.g., open source data may be updated more rapidly in areas with more computer-savvy residents). Also worth considering is if the indicator should change if a substantially better data source comes along.
- Ideal score – what would a perfect score look like? Does it even matter as long as WSDOT knows if things are moving in the desired direction?
- Sensitivity – An indicator should be sensitive enough to register changes to the BE.
- Comparability – Could an indicator be compared from one area to the next? Transit Score addresses this by using a log scale, where the addition of one bus in an area served by only two buses would result in a much greater increase than the addition of one bus in an area already served by 20 buses.
- Posterity – will this indicator still be around in 10 years? 1 year?
- Transparency – will WSDOT know if and when source data or methods change significantly?

- Appropriateness – Cities range quite a bit across the state, even within the same county (e.g., Beaux Arts Village vs. Bellevue). Perhaps different indicators should be used for different jurisdictions.
- Buy in – Does WSDOT need to present these indicators to the public? If so, should they work with advocacy groups, local governments, and the public to get buy in for these indicators before moving forward?
- Evidence base – There is plenty of research on the relationship between travel and the BE, which could inform the selection of indicators.
- Feedback loop – Does WSDOT care about "downstream" outcomes of walking, bicycling, and transit use (e.g., collision rates, obesity rates, etc.)? Some of these may feed back into the mode use (i.e. more people may bike if it is safer).
- Population sub-groups – Indicators could be developed for people of certain SES and Demographics: children near schools, old persons near pharmacies and doctor's offices, low income households near public transit and destinations, workers near jobs, etc...
- Data source trade-offs – Official data (consistent, clear methodology, may be out of date), vs. open access, crowd sourced data (updated frequently, unknown reliability), vs. proprietary data ($, unclear methods, 'black box', should be accurate and up-to-date)

This list represents just some of the issues to be considered in the development of indicators. The tools presented in this report suggest many possible indicators, but also provide a scope of the data that are feasible to collect. The final selection will undoubtedly be a compromise between desired metrics and those possible within the constraints of the resources available.

APPENDIX B: DESCIRPTIONS OF VMT INDICATOR TOOLS REVIEWED

Alliance for Biking and Walking 2012 Benchmarking Report

Agency: Alliance for Biking and Walking

Website: www.peoplepoweredmovement.org/site/index.php/site/2012benchmarkingdownload/

Spatial unit: State and large city

Spatial extent: Nationally, includes all 50 states and the 51 largest cities

Variable(s): Report provides myriad benchmarks of data related to walking and bicycling. Benchmarks are organized as either inputs or outcomes. Inputs to walking and bicycling include policies, programs, and advocacy. Outcomes of these inputs include mode share, safety, and public health (Table).

Table B-1: Benchmarks included in the Alliance for Biking and Walking 2012 Benchmarking Report

Type	Category	Benchmark
Input	policy	Funding (per capita and % of trans dollars to bicycling and walking)
		Complete streets policies
		Goals to increase bike and walk
		Goals to increase safety
		Bike/ped master plan
		Bike/ped advisory committee
		Legislation
		Infrastructure (existing and planned miles per square mile)
		Bike-transit integration (1. Bike racks on buses, 2. bike parking at transit stations per capita, 3. Bike access on rail
	program	Adult and youth bike edu course participation per capita
		Bike to work day participation per capita
		Open street (ciclovia) initiative participation per capita
		City/state-sponsored bike ride participation per capita
		Walk and bike to school day participation per capita
	Advocacy	Presence of dedicated bike/ped advocacy organization
		Capacity indicators of advocacy organizations (membership per capita, income per capita, staff levels per capita, contacts per capita)
Outcome	Mode share	Share of bike/ped commuters
		Share of bike/ped trips from all trips
		Demographics of bike/ped commuters (age, gender, ethnicity, income)
	safety	Bike/ped fatalities (number and percent of all traffic fatalities)
		Risk
		Disparities in mode share and fatalities
		Demographics of Bike/ped fatalities (age)
	Public health	Overweight and obesity levels
		Hypertension levels
		Diabetes levels
		Asthma levels
		PA levels

Methodology: Benchmarks compiled from various secondary datasets, as well as a biennial survey of city and state officials. For the survey, the Benchmarking Project team reached out the staff of cities, state departments of transportation, metropolitan planning organizations, and advocacy organizations. Secondary data sets include: American Community Survey (ACS) (2005-2009); American Public Transportation Association (APTA) (2010); Behavioral Risk Factor Surveillance System (BRFSS) (2009); Federal Highway Administration's FMIS (FHWA) (2004-2010); Fatality Analysis Reporting System (FARS) (2005-2009); League of American Bicyclists (LAB) Bicycle Friendly States Program (2011); National Center for Safe Routes to School (2011); National Complete Streets Coalition (2011); National Health Interview Survey (NHIS) (2005); National Health and Nutrition Examination Study (NHANES) (2005-2006); National Household Travel Survey (2001, 2009); National Transportation Enhancements Clearinghouse (2011); Rails-to-Trails Conservancy (2011); Safe Routes to School National Partnership (SRTSNP) State of the State's Report (2011); School Transportation News (2011); U.S. Census (1990, 2000); United States Historical Climatology Network (USHCN); Web-based Injury Statistics Query and Reporting System (WISQARS) (2009)

Update schedule: Every two years. Current report presents 2009/10 data. Full reports previously published in 2007 (2005/06 data) and 2010 (2007/08 data). The Alliance for Biking & Walking will continuously refine methods and consider new data sets as available.

Availability: report available online. Data sources clearly documented and often available to public.

Summary: Provides a good menu of bike and walk indicators for relatively large geographic areas. Could tweak some indicators for use in smaller jurisdictions within Washington State. Report facilitates comparison to other states. Some indicators would require outreach to local governments and advocacy organizations.

2012 Seattle Bicycle Report Card

Agency: Cascade Bicycle Club
Web links: www.cascade.org/pdf/Seattle_Bicycle_Report_Card_2012_web.pdf
Spatial unit: Seattle
Spatial extent: Seattle
Variable(s): various, based on 2007 Seattle bicycle master plan goals
Methodology: Indicators include:

- Downtown bike counts, performed by the City of Seattle
- Bicycle crash rates, based on collisions reported to the Seattle police department and downtown bike counts
- Bike infrastructure (sharrows, lanes, multi-use trails, bike boulevards), reported by the City of Seattle
- Bike funding reported by the City of Seattle
- Innovative infrastructure (bike boxes, bike signals, bike detection, HAWK signals at bike crossings, left turn queue boxes, on-street bike corrals, bicycle scramble intersections, bike share programs)

Update schedule: Unknown, report published in 2009 and 2012. Source data likely available from the city of Seattle and other sources on an annual basis

Availability: report available online

Summary: Limited to City of Seattle and may not continue after 2017, when Master Plan Goals are to be realized, but provides examples of bicycle indicators that could perhaps be collected from other jurisdictions.

Walk Score

Agency: Walk Score

Web links: www.walkscore.com/

Spatial unit: buffer around a point location, also neighborhoods and jurisdictions

Spatial extent: Worldwide

Variable(s): Single composite score of "walkability" on a scale of 0 to 100

Methodology: It appears that there are two versions of Walk Score. An 'original' Walk Score, which seems to be the default value given when an address is typed into the online interface. It also appears to be what is used for neighborhood and city Walk Scores. No detailed documentation of the 'original' Walk Score is available online, but it appears that destinations in 9 categories (grocery, restaurants, shopping, coffee, banks, parks, schools, books, and entertainment) that are less than 1-mile Euclidean distance to a point. Each destination is weighted based on distance and relative importance for walking.

The second version of Walk Score is called 'Street Smart Walk Score.' It is in beta. It uses a similar distance decay scoring system for destinations in the 9 categories. However street network (not Euclidean) distances up to 1.5 miles are used. It also will penalize a Walk Score if the neighborhood has a low intersection density and/or average block length. It is unclear which spatial extent is used for these calculation (buffer size, Euclidean or network). For more on the 'Street Smart' algorithm, see: www.walkscore.com/methodology.shtml.

Both Walk Score versions use a number of data sources, including, business listing data from Google and Localeze, road network data and park data from Open Street Map; school data from Education.com. Walk Score users can also add and delete destinations based on their local knowledge.

Finally, Walk Score also provides Walk Scores for jurisdictions and neighborhoods. A 500ft grid is created, census block-based population estimates are applied to each grid cell, then the Walk Score value at the center of each grid cell is multiplied by the population estimate. To aggregate scores for an area, they divided the sum of weighted Walk Scores by the total population for the points within the area. This essentially gives an average per-capita Walk Score value for the area's population. For details, see www.walkscore.com/rankings/ranking-methodology.shtml.

Updated: Walk Scores would presumably change continuously as the source data are updated. City and neighborhood rankings were published for 2008, 2010, and 2011. No schedule for upcoming rankings is available, although it seems like annual rankings would be logical.

Availability: Online, Walk Score also can provide data to researchers and planners in various formats

Summary: Walk Score is a relatively well known, easy to understand measure of proximity to destinations that people frequently walk to. Street Smart Walk Score uses more accurate measures of proximity and takes into account pedestrian-friendly street network design. The disadvantage to using it as an indicator is that the source data are open source and are updated on a continual basis. Additionally, Walk Score seems to be still developing its methods. In short, Walk Score is constantly changing. It seems that if Walk Score is used as an indicator to track progress over time, it would be important to know exactly what is being measured and make sure it remains consistent over time or report on changes in methods/data. Due to this, if Walk Score is used, it would probably be best to communicate with Walk Score on the feasibility of the project. Fortunately, it seems Walk Score is open to sharing data and working with researchers, see: www.walkscore.com/professional/research.php. Conversely, we could probably access more authoritative source data and develop alternate indicators of walkability.

Bike Score

Agency: Walk Score

Web links: www.walkscore.com/bike-score-methodology.shtml

Spatial unit: City

Spatial extent: Only Seattle (and ~15 more large U.S. cities)

Variable(s): Composite measure of how "good" a location is for bicycling

Methodology: The quality of a location for bicycling is based on four criteria: Bike lanes, hills, destinations and road connectivity, and bike commuting mode share.

Bike lanes are sourced from GIS data provided by city governments. Bike lanes are divided into four categories: on-street bike lanes, off-street trails, cycletracks (separated bike lanes), and residential bikeways (a.k.a. bike friendly streets or greenways). These four categories are collapsed into two: on-street and off-street facilities. For a given location, the length of all bike lanes within 1km is summed. A distance decay function is applied to each segment. Off-street facilities are weighted at 2X as valuable as on-street lanes. This creates a raw value, which is normalized to a score between 0 - 100 based on an average of the highest Bike Lane Scores that were sampled.

Hills are scored based on the steepest grade within a 200-meter radius of the location. Grades ranging from 10% - 2% are converted to scores ranging from 0 - 100. Hill source data is the National Elevation Data set from the USGS.

Destinations and road connectivity are based on a "modified" version of the Street Smart Walk Score, which is based on measures of network distances to a diverse set of amenities and connectivity metrics of average block length and intersection density. No mention of how it has been modified for biking.

Bike commuting mode share data are sourced from the U.S. Census. A 1-km moving window is applied to census tract level commuting data and bicycle mode share from 0 - 10% are converted to a score between 0 - 100.

Update schedule: unknown

Availability: online

Summary: Similar issues to Walk Score. Also some "black box" issues about methodology, for example how was the street smart walk score algorithm modified for bike score and how are raw scores converted to the 0 – 100 scale? The tool currently is only offered in limited areas and is probably limited most by the lack of bike facility data and commuting data for smaller communities.

Transit Score

Agency: Walk Score

Web links: www.walkscore.com/transit-score-methodology.shtml

Spatial unit: point location, also neighborhoods and jurisdictions

Spatial extent: Areas served by transit agencies with public data in the General Transit Feed Specification (GTFS) format (13 out of 30 agencies in Washington, see http://www.citygoround.org/agencies/us/wa/?public=all for a list).

Variable(s): Single composite score of public transit service on a scale of 0 to 100

Methodology: To calculate a raw Transit Score, the value of all of nearby routes is summed. The value of a route is defined as the service level (frequency per week) multiplied by the mode weight (heavy/light rail is weighted 2X, ferry/cable car/other are 1.5X, and bus is 1X) multiplied by a distance penalty. The distance penalty calculates the distance to the nearest stop on a route and then uses the same distance decay function as the Walk Score algorithm.

To normalize measures of transit service and accessibility of transit stops, a logarithmic scale is used. The logic to this is that it matches a rider's experience better: the added utility of one additional bus in a small town may exceed the addition of 10 new routes in downtown Manhattan. The logarithmic scale is based on a perfect score of 100 defined as the average score of the center of five U.S. cities: San Francisco, Chicago, Boston, Portland, and Washington, D.C.

Walk Score also has city-wide transit scores, but only for some cities. It is presumably calculated the same way that citywide Walk Scores are calculated – as a per-capita score.

Update schedule: Unknown, seems like scores would change as source data change. Would also have to determine how often the "perfect 100" score changes based on changes to transit service in the five cities. A change in the perfect 100 score could result in changes to scores in other areas without any changes in transit service.

Availability: Online, Walk Score also can provide data in various formats

Summary: Transit Score is really a measure of transit service (mode and frequency) and accessibility (distance to stop). Drawbacks are the "black box" of the methodology and the limited areas of coverage. As with the other Walk Score tools, it would be worth discussing these issues with the people of Walk Score before proceeding.

One Bus Away Explore Tool

Agency: One Bus Away (?)

Web links: www.onebusaway.org/explore/onebusaway/

Spatial unit: transit service based buffer around a point location

Spatial extent: Currently it seems only the area served by King County Metro. However, "the addition of more transit agencies to the Explore program requires only agency schedule data in the format of the General Transit Feed Spec (GTFS), about one day worth of programming on the part of the developer and adequate server resources."

Variable(s): none specifically, the program allows the user to specify the types of destinations s/he would like to reach via public transit within a certain time frame and with a certain number of transfers and a maximum walk distance from transit stops. For example, a person could look for doctor's offices within a total trip time of 30 minutes from 2:30pm, July 20, 2012, with no transfers and a maximum walk distance of a half mile.

Methodology: The tool functions in two steps. First, an area reachable by transit is calculated by searching for all transit stops reachable from the user-specified starting location in the specified amount of time along with any additional constraints, such as the number of transfers or max walking distance. Second, the reachable area is transformed into a grid with half-mile cells. Local businesses and amenities as specified by the user within the activated grid cells of the reachable area are searched. The beta (current?) version of One Bus Away Explore uses the Yelp online database of reviews, but other local search databases, such as Google Local or Yahoo Local, could be used. Once results have been returned, they are checked against the street network to ensure that there is a path from a nearby stop to the search result and that the total travel time is still under the specified limit.

For a complete description of the tool and methods, see http://wiki.onebusaway.org/bin/download/Main/Research/JPT13-4-OneBusAway-Watkins.pdf

Update schedule: unknown

Availability: Online tool, could be queried for multiple point locations. May be able to work with developers (i.e., kari) to collect data.

Summary: The methods behind this tool could be used to create a measure of public transit service, or destination accessibility via public transit. However, because the tool is based on bus schedules for a specific time of day, this would have to be converted into something less temporally specific, such as an average weekday and weekend service area. Also, when I tried the website, the tool did not work for me, which makes me wonder if this tool is still being funded and maintained.

TELUMI

Agency: Urban Form Lab

Web links: www.wsdot.wa.gov/Research/Reports/600/620.1.htm

Spatial unit: quarter-mile buffer around a 30m X 30m mesh grid

Spatial extent: urban growth areas (UGAs) of the Puget Sound region (King, Pierce, Snohomish, and Kitsap counties)

Variable(s): Transportation efficiency, as a composite index that takes into account the relative effects of each of nine variables on King County bus ridership. Transportation efficiency (TE) is divided into three categories: low, latent, and high. Low TE corresponds to few transportation options beyond SOV travel. High TE values correspond to many convenient transportation options, including transit, non-motorized, and other non-SOV travel options. Latent TE indicates that travel options remain limited, but that land-use conditions in these zones are favorable enough to permit easy and effective increases in future travel options—either via transportation system investments, demand management or other programmatic actions, or land-use changes.

Methodology: A literature review identified nine variables related to travel behavior. These nine variables were measured in the Puget Sound region and often transformed into categorical variables based on the results of a Delphi process. The variables were correlated to King County bus ridership to identify how each related to actual non-SOV travel as a proxy for transportation efficiency. Based on this statistical analysis, a composite map layer that represented transportation efficiency was developed. The nine variables were measured within a quarter-mile buffer of each 30m x 30m cell:

- Residential density, measured as average net residential density
- Employment density, measured as average net employment density
- Neighborhood center, measured as presence of restaurant, retail, and grocery within 50m of one another
- Shopping traffic, measured as total number of shopping trips based on ITE trip generation manual
- School traffic, measured as total number of school trips based on ITE trip generation manual
- Average block size, measured as average street block size in a quarter-mile buffer
- Percentage of parking at grade, measured as average percentage of unimproved area of commercial parcels
- Slope, measured as average percentage of slope
- Affordable housing, measured as the net percentage of area of residential parcels with the assessed property value per residential unit below the average for King County

Update schedule: None, published in 2005

Availability: Urban Form Lab

Summary: Composite measure requires a lot of data and data processing. Could use a 'lite' version for a statewide indicator. Unclear if relationship between these variables and KC bus ridership can be extrapolated to rest of state.

Travel and the Built Environment: A Meta-Analysis

Agency: Journal of the American Planning Association article by Reid Ewing and Robert Cervero

Web links: http://www.tandfonline.com/doi/abs/10.1080/01944361003766766

Spatial unit: not applicable, summarizes studies for which the outcome variable is individuals' travel behavior

Spatial extent: not applicable, summarizes studies conducted in various areas worldwide (although most were conducted in the U.S.)

Variable(s): Provides weighted average elasticities of travel (Walking, transit, and VMT) for built environment variables organized into 5 D's:

1. Density: Household/population density, Job density, and Commercial Floor Area Ratio (FAR)
2. Land use mix: Jobs/housing balance and Distance to a store
3. Design: Intersection/street density and Percent 4-way intersections
4. Destination accessibility: Job accessibility by auto, Job accessibility by transit, Job within one mile, and Distance to downtown
5. Distance to transit: Distance to nearest transit stop

Methodology: Reviewed academic literature for studies on the effect of the built environment on individual-level travel behavior while controlling for demographics and SESr. Found 50 studies that fit criteria. From these 50 studies, found 13 common variables (included in 3 or more studies) that were then organized into 5 D's: density, diversity, design, destination accessibility, and distance to transit (other D's that affect travel are also demand management and demographics). From these studies, the effect size of each variable was calculated as the average weighted elasticity of a travel outcome (walking, transit use, or VMT). An elasticity is the ratio of the percentage change in one variable associated with the percentage change in another variable. For outcomes measured as continuous variables, such as numbers of walk trips, an elasticity can be interpreted as the percent change in the outcome variable when a specified independent variable increases by 1%. For outcomes measured as categorical variables, such as the choice of walking over other modes, an elasticity can be interpreted as the percent change in the probability of choosing that alternative (or the percent change in that alternative's market share) when the specified independent variable increases by 1%.

Update schedule: None, published in 2010

Availability: Published in the Journal of the American Planning Association (JAPA)

Summary: Provides a framework for organizing BE variables that are related to VMT, as well as example BE variables that could be used as indicators. Added benefit of offering an insight into the effect of these common BE variables on actual travel behavior, which could be used as a rough guide of the importance of each variable.

On the Map

Agency: U.S. Census Bureau

Web links: http://lehd.did.census.gov/led/datatools/onthemap.html

Spatial unit: Census block

Spatial extent: Nation

Variable(s): Various relating to workers, jobs, and commute patterns. See methodology section.

Methodology: On the Map is an online mapping tool that allows users to visualize where workers live and work (i.e., commute patterns). The underlying data are contained in three datasets:

1. OD – one record for each home/work census block pair, fields include the home/work census block IDs, total number of jobs (i.e., people that live/work in the home/work census block pair), number of jobs by age groups (<29, 30-54, >55), number of jobs by income (<$1250/month, $1251-$3333/month, >$3333/month), number of jobs by industry category (good producing; trade, transportation and utilities; and all other service industries)
2. RAC – residential census blocks. Fields include total jobs (people that live in the census block and work), jobs by age, income, industry (20 categories), race, ethnicity, education, and gender.
3. WAC – Work census blocks. Fields include total jobs (people that live in the census block and work), jobs by age, income, industry (20 categories), race, ethnicity, education, and gender.

For complete metadata, see http://lehd.did.census.gov/led/onthemap/LODES6/LODESTechDoc6.0.pdf.

The employment data contained in these datasets are derived from several sources:

- Unemployment Insurance (UI) Wage Records reported by employers and maintained by each state for the purpose of administering its unemployment insurance system provide information on employees and jobs (relationship between employee and firm). These data are provided for "UI-covered employment," which typically includes private-sector employment as well as state and local government.
- The Office of Personnel Management (OPM) provides information on employees and jobs for most Federal employees (although there are exceptions).
- The Quarterly Census for Employment and Wages (QCEW) provides information on firm structure and establishment location. These data are collected by each state under an agreement with the Bureau of Labor Statistics (BLS).
- Age, earnings, and industry profiles are compiled by the Census Bureau from a state's records and are supplemented with other Census Bureau source data.

The states assign employer locations, while workers' residence locations are assigned by the U.S. Census Bureau using data from multiple federal agencies. To protect confidentiality, synthetic data are generated using a calibrated Bayesian modeling approach. For details, see

http://lehd.did.census.gov/led/datatools/onthemap.php?name=ConfidentialityProtection

Update schedule: unknown, but appears to be annual, most recent data are for 2010

Availability: mapping tool online, source data available for download

Summary: This tool could provide a detailed indicator of commute distances and employment density. However, it uses synthetic data, which may not accurately reflect reality at a fine spatial scale. The utility of synthetic data should be investigated before proceeding with this tool.

April 1 Official Population Estimates

Agency: Office of Financial Management (OFM)

Web links: www.ofm.wa.gov/pop/april1/default.asp

Spatial unit: cities, towns, and counties

Spatial extent: Washington State

Variable(s): Official population, used for state program administration and allocation of state revenues.

Methodology: The city, town, and unincorporated county population estimates are based on housing data collected each year from local governments by OFM. Household size is estimated based on models or supplementary data sets. The population figures from city, town, and unincorporated areas of counties are summed to get a county estimate. This estimate is then averaged with two other county estimates: one based on births, deaths, migration, and Medicare data; the other an allocation of the estimated state population based on "symptomatic" factors including share of school enrollment, voter and auto registration, out-of-state driver's licenses, and natural increase. Adjustments are then made to city, town, and unincorporated county populations based on the average county population.

Definition of population: "The figures include all persons usually residing in an area including military personnel and dependents, persons living in correctional institutions, and persons living in nursing homes or other care facilities. College students are considered residents of the place where they live while attending school. Seasonal populations, such as vacationers or migrant farm workers, are considered residents of the place they consider their usual residence. Persons with no usual residence are counted where they are on April 1."

For a complete description of methods, see: http://www.ofm.wa.gov/pop/april1/overview.pdf

Update schedule: Annually on April 1 (April fool's day, coincidence?), data made available July 1.

Availability: available for download online

Summary: Can be used for making per-capita measures or jurisdiction-level estimates of population density. Nice because the numbers are official. Clear methodology. Data program probably won't go away anytime soon. Would prefer a finer spatial resolution (see next tool).

Small Area Estimates Program (SAEP)

Agency: Office of Financial Management (OFM)

Web links: http://www.ofm.wa.gov/pop/smallarea/default.asp

Spatial unit: Various small areas, defined as geographic areas below the level of the state (often U.S. Census Bureau geographies). The finest resolution available online is the census block group (average population of ~1,200).

Spatial extent: Washington State

Variable(s): population, housing units (occupied and unoccupied)

Methodology: The SAEP takes OFM April 1 city and county population and housing estimates and distributes these to census blocks, then re-aggregates the counts to various small area geographies.

To allocate April 1 population estimates to census blocks, OFM first allocates group quarters populations, then housing units, then household population. Group quarters populations come from the OFM's annual population and housing survey. State agencies such as the Dept. of Corrections, Dept. of Social and Health Services, and military facilities also report populations to the OFM. Each facility is geocoded to a census block. Housing units come from an annually updated master dataset consisting of new units and demolitions by structure type (single family, multi-family, mobile homes, and specials) used in the April 1 estimates. Housing units are allocated to census blocks within each SAEP tabulation area by year according to one of three data sources: 1) geocoded housing units, 2) postal delivery statistics, and 3) block-level Census 2010 housing unit counts. The data source used depends on availability. The geocoded housing unit dataset is apparently the Washington State Parcel database (See page 19). Finally, household population is based on the total housing units, an occupancy rate, and an estimate of persons per household.

The error for areas of about 1,000 in population may range from 5 to 15 percent. Variances for smaller areas may be considerably higher.

For more on methods, see: http://www.ofm.wa.gov/pop/smallarea/docs/saep_user_guide.pdf

Update schedule: Annually in the fall, typically October.

Availability: available for download online, smallest geographies are the census block group.

Summary: Can be used for making per-capita measures or census block group-level estimates of population density. Since these data are based on aggregated census block figures, it may be possible to access those data upon request for a finer spatial resolution. Nice data source because the numbers are based on official figures, are at a fine resolution, have a clearly documented methodology, likely won't go away anytime soon, and are updated annually.

Quarterly Census of Employment and Wages

Agency: Washington State Employment Security Department in cooperation with the federal Bureau of Labor Statistics

Web links: https://fortress.wa.gov/esd/employmentdata/reports-publications/industry-reports/quarterly-census-of-employment-and-wages

Spatial unit: county

Spatial extent: Washington State

Variable(s): firms, employees, and wages for each industry sector (NAICS code)

Methodology: Information collected quarterly about employment, total wages and taxable wages from unemployment-tax forms filed by employers. Therefore only includes industries covered by unemployment insurance. Quarterly surveys of employers who have more than one worksite in the state are also conducted and integrated into the data.

Updated: Quarterly, with averages published annually

Availability: online

Summary: County employment figures can be distributed to parcels in the Washington State Parcel Database with the development of a industry code to land use code crosswalk and some understanding of the employee space utilization rate (square foot per employee). See the UFL's work on King County employee density estimates.

The Washington Business Tax and Premiums Database

Agency: Joint effort between Washington State Department of Revenue, Washington State Employment Security Office, Washington State Department of Labor & Industries, and Washington State Office of Financial Management.

Web links: www.ofm.wa.gov/economy/business_tax/description_and_methodology.pdf

Spatial unit: Business firm, which would need to be geocoded, but may be troublesome for firms with multiple establishments.

Spatial extent: Washington State

Variable(s): Many variables related to taxes and insurance. Variables of interest include employment and firm open and close dates.

Methodology: Data reported to various agencies are merged at the individual taxpayer level using the Washington State Unified Business Identifier (UBI) numbers. A UBI is an identifier assigned to every business registering with any department in the State of Washington.

The database includes all Washington Businesses. This definition includes any business that is located or has nexus in Washington State and reports to any of the participating agencies. Businesses must report to at least one agency if any of the following conditions are satisfied: annual gross incomes over $28,000, collects retail sales tax, has employees.

Update schedule: Annually, began in 2003.

Availability: Data on individual businesses are confidential, and therefore cannot be disclosed. Perhaps an exception would be made for another state agency?

Summary: Probably not the best choice due to the unit being a firm, not a business establishment and the restricted nature of the dataset.

Standard Statistical Establishment List (SSEL)

Agency: U.S. Census Bureau

Web links: www.census.gov/econ/overview/mu0600.html

Spatial unit: Business establishment, defined as a single physical location where business is conducted. Presumably data are geocoded, or at least contain address and/or are linked to larger census geographies.

Spatial extent: Nation (24 million unique establishments)

Variable(s): business location, organization type (e.g., subsidiary or parent), industry classification, and operating data (e.g., receipts and employment)

Methodology: Dataset includes all establishments of all domestic businesses (except private households and governments) and organizational units of multi-establishment businesses. Database pulls info from various sources, including administrative data, Census data, and survey data. Information for single establishments and Employer Identification Numbers (EINs) is updated continuously; including employment and payroll data based on payroll tax records, and receipts data based on income tax records from the IRS. Information for establishments of multi-unit companies is updated annually based on responses to the company organization survey and annual survey of manufactures. Other routine economic census surveys are also used to update the database.

The Standard Statistical Establishment List (SSEL) feeds into the Longitudinal Business Database (LBD), which can be used to track economic activity over time. For more info, see http://www.census.gov/ces/dataproducts/datasets/lbd.html

Update schedule: Continuously, data released annually, latest release is 2009

Availability: Available from the Northwest Census Research Data Center (http://depts.washington.edu/nwcrdc/getting-stared), researchers must apply to use the data

Summary: Seems like the best bet for authoritative business listings. Website claims the data "Provide the most complete, current, and consistent source of establishment- based information about U.S. businesses."

Washington State Parcel Database

Agency: UW Washington Geographic Information Service (WAGIS)

Web links: http://depts.washington.edu/wagis/projects/parcels/

Spatial unit: parcel (tax lot)

Spatial extent: Washington State, source data come from counties and other parcel producers.

Variable(s): Contains 71 common, normalized variables, the most pertinent being: date of data acquisition, state land use, improvement type, improvement square feet, improvement year built, and parcel size. For a complete list, see: http://depts.washington.edu/wagis/projects/parcels/techdocs/attributes.php. It is not clear how many jurisdictions have complete data for each normalized variable.

Methodology: WAGIS collects data from parcel producers in the state of Washington, normalizes common attributes, and aggregates GIS parcel data into a common spatial dataset. For details, see: http://depts.washington.edu/wagis/projects/parcels/techdocs/.

Database is not entirely complete and consistent due to issues with license agreements, technical hurdles, and varying county data. The primary spatial data issue for the 2010 database is the lack of GIS data in Asotin and Whitman counties. In these two counties, "pseudo-parcels" were developed to serve as placeholders. They are described as, "Cartoon parcels randomly located within a mile of their true location, although some are randomly distributed throughout the county when no legal description or parcel id number could be used to geographically locate the pseudo-parcel. Parcel acres from county tax rolls were used to determine the pseudo-parcel size."

Update schedule: No schedule posted, but based on current trends, every 1-2 years. Data were released for 2007, 2009, and 2010; a 2012 version is in the works. Efforts

Availability: available by request

Summary: Finest spatial resolution data, which could be used for spatially allocating variables that are only available at a coarser resolution. Could also be used directly to estimate household density, employment density, and identify destinations based on land use codes and improvements. However, data may be inconsistent and incomplete, but quality should improve over the years.

Proprietary Destination Data Sources

Agency: various providers, including Google local, Yahoo local, Yelp, OneSource, Localeze, and ReferenceUSA. ReferenceUSA claims to be the premier source of business and residential information for research.

Web links: See for example: www.referenceusa.com/Home, or www.localeze.com/how-localeze-works/local-search-platforms.aspx, or http://developer.yahoo.com/local/

Spatial unit: business listing address location (usually geocoded)

Spatial extent: National, maybe worldwide

Variable(s): depends on business listing database. Could include business name, location (x/y), rating, reviews, category, NAICS code, website

Methodology: Depends on listing. Usually tends to be a mix of authoritative sources, business owners, user feedback, and verification performed by data provider.

Update schedule: Continuously updated.

Availability: Some databases are available for a fee (ReferenceUSA) and some appear to be free (Google, Yahoo). UW has access to ReferenceUSA database, but can only download 50 records at a time. For context there are 3,712 grocery store/supermarkets listed in Washington State. Connecting to local business listing databases that are designed to integrate into mapping apps, such as Google local or Yahoo local, may require some developer skills. Mike may know more…

Summary: Provide most up-to-date data. However, none of these databases are going to be completely accurate or comprehensive and their shortcomings have been documented in some journal articles.

Street Network – Proprietary Data Sets

Agency: various private companies including ESRI and TomTom.

Web links: for example, see http://www.esri.com/data/streetmap

Spatial unit: street segment

Spatial extent: Varies depending on license agreement, but likely available for most of the developed world.

Variable(s): Depends on dataset, but most would likely include length, hierarchy, estimated travel speed, intersections, restricted uses (such as pedestrians), and address ranges. Can be used to develop street design variables that are related to walking and reduced VMT (e.g., block length, intersection density). Can be used to measure network-based distances or buffers. Can be used for geocoding destination addresses.

Methodology: Unknown

Update schedule: Varies. Navteq seems to release two or three versions a year

Availability: Require a license for use. Licenses for WA state data can cost upwards of $2k per year. WSDOT has a license for MultiNet (by TomTom) street network data.

Summary: Not recommended due to costly license fees, unless WSDOT can use their MultiNet data for the project.

Street Network – Public Agency Data Sets

Agency: various public transportation agencies

Web links: For example, see www.wsdot.wa.gov/MapsData/Tools/FunctionalClass/

Spatial unit: street segment

Spatial extent: Varies, usually coverage for the agency's jurisdiction only.

Variable(s): Depends on dataset, but most would likely include length, functional class, speed limit, intersections, and address ranges. Can be used to develop street design variables that are related to walking and reduced VMT (e.g., block length, intersection density). Can be used to measure network-based distances or buffers. Can be used for geocoding destination addresses.

Methodology: Unknown.

Update schedule: Varies

Availability: Most Public agency data, such as WSDOT and King County Street Networks are readily available or available upon request. However, WSDOT maintains a dataset of higher-level streets (collectors on up through interstates) only. Would have to collect data from each jurisdiction to gather a complete coverage of WA state.

Summary: Could be the best source of public agency implemented changes to the street network, but would be difficult, if not impossible, to gather data for complete coverage of the state. Would also have issues along jurisdictional boundaries where street networks do not connect and may overlap.

TIGER/Line Shapefiles

Agency: U.S. Census Bureau

Web links: www.census.gov/geo/www/tiger/tgrshp2011/tgrshp2011.html

Spatial unit: various, including street segment and census block.

Spatial extent: nation

Variable(s): Geographic ID, address range, street name. For a complete list, see appendix A of the technical documentation (www.census.gov/geo/www/tiger/tgrshp2011/documentation.html)

Methodology: Based on past Census geographies with updates from the 2010 census received from local government agencies and Census Bureau canvassers with handheld GPS devices. For complete info, see chapter 2 of the technical documentation (www.census.gov/geo/www/tiger/tgrshp2011/documentation.html)

Update schedule: Annual

Availability: online

Summary: Free and dataset that probably has sufficient coverage. May not be detailed for places where people do not live and does not contain very detailed street network attributes. Probably does not contain pedestrian paths or trails.

OpenStreetMap

Agency: OpenStreetMap.org

Web links: http://wiki.openstreetmap.org/wiki/Main_Page

Spatial unit: Any map feature imaginable, including street segments, amenities, historic points, buildings, etc. For a complete list, see http://wiki.openstreetmap.org/wiki/Map_Features

Spatial extent: world

Variable(s): various depending on map feature

Relation to VMT: street network variables, could be used for geocoding addresses of destinations.

Methodology: Registered users may add or remove geographic features in a wiki setting.

Update schedule: Weekly

Availability: online, can be downloaded and converted to various formats, see http://wiki.openstreetmap.org/wiki/Downloading_data

Summary: Free dataset. User generated data means that quality and detail may vary from area to area. Need to investigate the Open Database License (http://wiki.openstreetmap.org/wiki/Open_Database_License), particularly the share alike obligation.

Washington State Bicycle and Pedestrian Documentation Project

Agency: WSDOT

Web links: www.wsdot.wa.gov/bike/Count.htm

Spatial unit: Facility count location and time

Spatial extent: "Counts will be assembled from all over Washington State, but focused on several cities including: Bainbridge Island, Bellevue, Bellingham, Bothell, Bremerton, Burien, Ellensburg, Everett, Ferndale, Issaquah, Kelso, Kent, Kirkland, Longview, Lynden, Mercer Island, Mountlake Terrace, Oak Harbor, Olympia, Redmond, Renton, Richland, Seattle, Shoreline, Spokane, Tacoma, Tukwila, Vancouver, Walla Walla, Wenatchee and Yakima."

Variable(s): Type of facility, setting (rural, suburban, urban), scenic quality, surrounding land uses, quality of connecting facilities, length of facility, access from neighborhood, network quality, ADT of adjacent road, posted traffic speed, average distance between crossings, ADT on cross streets, ped/bike crossing facilities, facility condition, topography, AM and PM bike, ped, and other counts.

Methodology: The documentation project uses a very traditional method involving placing volunteer observers at specific locations to record bicycle or pedestrian movements. Observers use tally sheets to record numbers consistently. In addition, city and state staff conduct a quality control effort to cross check many of these count locations.

Update schedule: Data collection occurs annually in the early fall. Data exist for 2008, 2009, and 2010. Count locations and volunteers have steadily increased in the three years to 229 count locations in 30 cities in 2010. There were 73 consistent AM locations and 66 consistent PM locations from 2008 to 2009. There were 128consistent AM locations and 117 consistent PM locations from 2009 to 2010. There were 64 consistent AM locations and 61 consistent PM locations from 2008 to 2010.

Availability: WSDOT

Summary: Obvious limitations extrapolating trends at single-day count locations to larger bike/ped trends, but could provide at least a "snapshot."

American Community Survey (ACS)

Agency: U.S. Census Bureau

Web links: www.census.gov/acs/www/

Spatial unit: various geographies as small as the Census Block Group

Spatial extent: Nation

Variable(s): Topics include demographic characteristics, economic characteristics, social characteristics, housing characteristics, financial characteristics and commute characteristics. Commute characteristics include place of work, type of work, usual travel mode to work, and time and duration trip to work.

Methodology: Tabulations for geographies are prepared based on accumulated responses to a survey questionnaire. Depending on the population size of a geographic area, tabulations will be based on the responses accumulated for 1-year, 3-year, or 5-year periods. ACS data are currently based on an annual sample that is approximately 1-in-40 housing units (with some variations), administered as 12 independent monthly samples, and data products are produced for geographic areas once enough responses have been accumulated. Data for geographic areas with populations of 65,000 and more are summarized and produced annually based on the accumulated responses from the previous calendar year's data collection. Areas with populations of 20,000 and more are summarized and produced annually based on the accumulated responses to the previous 3 years of data collection. All size areas (down to block groups) are summarized with data produced annually based on the accumulated responses to the previous 5 years of data collection. When comparing smaller areas with larger areas, researchers must use consistent collection periods for comparison purposes. For example, when analyzing census tract characteristics for a major metropolitan area, data users should use the 5-year estimates for both the tract-level data (the only option) and the metropolitan area.

For details on tabulations and other issues relating to research use, see: http://www.census.gov/acs/www/Downloads/handbooks/ACSResearch.pdf

Update schedule: Annual

Availability: Online download

Summary: Best source of data for consistently tracking trends over time. However, all figures are estimates and therefore contain a margin of error. Figures for smaller geographies will represent a 3- or 5-year time period, thus making it difficult to see recent changes in behavior.

National Transit Database (NTD) Program

Agency: Federal Transit Administration (FTA)

Web links: www.ntdprogram.gov/ntdprogram/

Spatial unit: transportation agency service area. Service area varies by mode and is generally a buffer around transit stops (see www.ntdprogram.gov/ntdprogram/Glossary.htm#G428). Service area geospatial data does not appear to be available.

Spatial extent: Service area of 20 public transportation agencies (Table B-)

Table B-2: Washington transportation agencies with NTD data

Transportation Agency	Primary City Served
Whatcom Transportation Authority	Bellingham
Kitsap Transit	Bremerton
Skagit Transit	Burlington
Asotin County PTBA	Clarkston
Everett Transit	Everett
Snohomish County Public Transportation Benefit Area Corporation	Everett
RiverCities Transit	Longview
Intercity Transit	Olympia
Ben Franklin Transit	Richland
Central Puget Sound Regional Transit Authority	Seattle
City of Seattle - Seattle Center Monorail Transit	Seattle
King County Department of Transportation - Metro Transit Division	Seattle
Washington State Ferries	Seattle
King County Ferry District	Seattle
Spokane Transit Authority	Spokane
Pierce County Transportation Benefit Area Authority	Tacoma
Pierce County Ferry Operations	University Place
Clark County Public Transportation Benefit Area Authority	Vancouver
Link Transit	Wenatchee
Yakima Transit	Yakima

Variable(s): numerous, those of interest pertain to system-wide ridership and levels of service, including service area square mileage, service area population, service miles, service hours, service days, unlinked passenger trips, and passenger miles,

Methodology: Transit agencies that are recipients or beneficiaries of grants from the Federal Transit Administration (FTA) are required by statute to submit data to the NTD. Reporting agencies must comply with rules and regulations for reporting each piece of information, resulting in consistent and comparable variables.

Update schedule: Annually, most recent is 2010 data, which were made available in April, 2012

Availability: online for download (http://www.ntdprogram.gov/ntdprogram/data.htm)

Summary: non-spatial and coarsely defined geography service area. However, data are consistent and comparable. More detailed data, including transit stop-level ridership and stop locations may be available from individual agencies.