Operations and Congestions Management

Contents

Bicycle/Pedestrian

Pedestrian Level of Service (PLOS)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Bicycle/Pedestrian	

Indicator Overview

Description

This indicator measures the comfort/safety and the ease of mobility of pedestrian facilities. Factors in the calculation may include level of exposure and delay for/during crossing.

Human and Environmental Drivers

Physical: improvements that reduce pedestrian-vehicle and pedestrian-bike interaction will have a more favorable PLOS. In addition separate bike paths; decreasing crosswalk signal delay times/ implementing pedestrian signal prioritization, creating higher quality pedestrian path conditions can provide better PLOS. Higher number of auto lanes (3 vs 2) and smaller building setbacks, building oriented toward the street degrade PLOS.

Application

In the Basin

No current in-basin use.

External uses

New York State Association of Metropolitan Planning Organization uses "Pedestrian Level of Service" metrics to evaluate speed/density relationships, personal body shape and dimensions, and the very idea of a pedestrian level of service and how to distinguish between levels (New York State Association of Metropolitan Planning Organizations 2006a).

Chicago Metropolitan Agency for Planning in its Congestion Management Process report, looks to increasing walkability of the city my tracking PLOS through its "Soles and Spokes Planning Process" (Chicago Metropolitan Agency for Planning 2013).

Literature or Guidance Documents

New York State Association of Metropolitan Planning Organizations recommends using the Pedestrian Level of Service measure to assess the network and condition of pedestrian infrastructure and progress forward accordingly (New York State Association of Metropolitan Planning Organizations 2006a).

Relationship with Goal

Congestion: This measure relates to congestion because PLOS takes into account the flow/ mobility of pedestrian traffic and decreases vehicle trips by incentivizing and encouraging walking through safer and more fluid connections.

Operations: This measure relates to operations because PLOS can determine whether or not the pedestrian infrastructure capacity is appropriate for the volume of pedestrians.

Variations of the Measure / Alternatives to the measures

Pedestrian Facility Continuity, which measures the connectivity of pedestrian infrastructure in an area.

References

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2013)

(Florida Department of Transportation 2014)

(New York State Association of Metropolitan Planning Organizations 2006a)

(Toru Hagiwara et. al. 2005)

(Transportation for America 2015)

(Victoria Transport Policy Institute 2017a)

("Who We Are" n.d.)

Bicycle Level of Service (BLOS)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Bicycle/Pedestrian	

Indicator Overview

Description

This indicator measures the comfort/safety and the ease of mobility of bicycle facilities. This measure can be used by practitioners to predict a bicyclists' perceptions of a specific roadway perceptions of a specific roadway environment, and to evaluate the environment, and to evaluate the capability of a variety of roadways to accommodate both motorists and bicyclists using geometric and operational characteristics such as lane width, vehicle speed, and traffic volume.

Human and Environmental Drivers

Physical: Number of right hand side driveways, higher vehicle volumes and speeds negatively impacts BLOS. Pavement in good repair, greater bike lane/shoulder widths and length between signalized intersections improves BLOS.

Application

In the Basin

No current in-basin use.

External uses

New York State Association of Metropolitan Planning uses a this measure to evaluate roadways so that they may support bicycling (New York State Association of Metropolitan Planning Organizations 2006a).

Chicago Metropolitan Agency for Planning in its Congestion Management Process report, looks to increasing bikeability of the city through utilization of this measure. (Chicago Metropolitan Agency for Planning 2013).

Tennessee Department of Transportation in its 25-year plan, uses the “Bicycling Level of Service” to analyze facilities for bicycles statewide to determine how safe and/or suitable they were for bicycle travel (Tennessee Department of Transportation 2016).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Congestion: This measure relates to congestion because BLOS takes into account the comfort and safety of cyclists and decreases vehicle trips by incentivizing and encouraging biking through safer and more direct connections.

Operations: This measure relates to operations because BLOS can determine whether or not the bicycle infrastructure capacity is appropriate for the type of roadway.

Variations of the Measure / Alternatives to the measures

Bicycle Facility Continuity, which measures the connectivity of bicycle infrastructure in an area as well as Trail Maintenance and Management which measures the quality of trails throughout the area

References

(Bixhaku & Malenkovska 2013)

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2013)

(Elias 2010)

(New York State Association of Metropolitan Planning Organizations 2006a)

(Tennessee Department of Transportation 2016)

(“Who We Are” n.d.)

Bicycle Facility Capacity

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory**: Bicycle/Pedestrian	

Indicator Overview

Description

This indicator measures the physical capacity as well as the demand for creating bicycle facilities.

Human and Environmental Drivers

Environmental: People transitioning from motorized transportation to bicycling facilities will positively combat environmental issues through increasing biking as a mode of transportation. This can lead to a decrease in roadway congestion which leads to a decrease in GHG emissions. Identifying locations for bicycle facilities can be limited due to geographic conditions.

Economic: It is economically efficient to install more bike paths, because they cost less to maintain. When people switch from automobile to bike, there may be fewer automobiles on the roadway which can decrease the need for road repairs.

Human: If adequate facilities are created and maintained, the social and physical human benefit from creating bicycle facilities can benefit people and the community.

Application

In the Basin

No current in-basin use.

External uses

The San Francisco County Transportation Authority works towards maximizing "Bicycle Capacity" in its 2013 Congestion Management Plan. They reported completion of 217 facility projects consisting of routes, paths, and lanes. (San Francisco County Transportation Authority 2013a).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Operations: This measure relates to the operations goal because it speaks to the integration, maintenance, and sustainability of bicycle facilities.

Congestion: This measure relates to the congestion goal because it deals directly with redirecting automobile congestion by way of transforming automobile users into bicycle users.

Connectivity: This measure relates to the connectivity goal under because it helps define where new projects should be built. The new facilities recommended may then close gaps in the network or create new connections.

Variations of the Measure / Alternatives to the measures

Bicycle Demand/Capacity.

References

(Dill & Carr 2003)

(San Francisco County Transportation Authority 2013a)

(Victoria Transport Policy Institute 2017b)

Level of Traffic Stress (LTS)

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Bicycle/Pedestrian

Indicator Overview

Description

"Level of Traffic Stress" measures the level of safety a person feels when using bicycling as a means of getting from one place to the next via bicycle, ranked on a scale from 1 to 4, 1 being the most comfortable to ride and 4 being the least comfortable.
LTS 1 - Comfortable for all cyclists from children to seniors, experienced to inexperienced, commuters or leisure riders.
LTS2 - Comfortable for a majority of adult riders, but not largely suited for children.
LTS3 – General comfort level for most adult riders. Surrounding traffic speeds higher, but manageable.
LTS4 – Reserved for only experienced riders who are comfortable riding directly next to traffic.

Human and Environmental Drivers

Physical/Human: Increasing shoulder width increases potential ridership, decreases LTS. Integrating specific bicycle signage and roadway markers (i.e. painted bicycle lanes, bicycle route signs, bikes may use full lane etc.) decreases LTS. Decreasing total number of vehicles on the road decreases LTS. Adding separated bike paths, buffers, or physical protection decreases LTS. Surveys of cyclists show that physical barrier use for protected paths also increase perception of safety and reduce traffic stress.

Application

In the Basin

No current in-basin use.

External uses

City of Berkeley monitors "Bicycle Level of Stress" by integrating mapping technology with open data sources such as Bicycle Preference Surveys to provide details of all roads in Berkeley and the Level of Traffic Stress presented by each one. (City of Berkeley n.d.)
City of Portland uses "Bicycle Level of Traffic Stress" in its Multimodal Analysis of Transportation as a tool to identify key locations which can then be dually monitored by MMLOS. (Oregon Department of Transportation 2017)
City of Austin uses "Bicycle Level of Traffic Stress" with an LTS of 2 in their 2014 Bicycle Plan as a threshold for the completion of their own bicycle network. (Austin Transportation Department 2014)
City of Edmonton in Canada analyzes "Bicycle Level of Stress" by sending out questionnaires to over 1,000 cyclists in the area and asking them to pick which path they felt they would most likely take (based on comfort levels, time/distance, and available bicycle parking at a destination). (J. D. Hunt & J. E. Abraham 2006)

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Operations: This measure relates to the operations goal because it analyzes type of bicycle infrastructure and use to provide valuable data on existing infrastructure and considerations for improvements to existing and new infrastructure.
Active Transportation: This measure relates to the active transportation goal because it analyzes perceived bicycle safety while travelling in order to increase overall ridership and promote active transportation.
Safety: this measure relates to safety because traffic stress is the perceived sense of danger associated with riding in or adjacent to vehicle traffic; studies have shown that traffic stress is one of the greatest deterrents to bicycling.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Austin Transportation Department 2014)

(City of Berkeley n.d.)

(J. D. Hunt & J. E. Abraham 2006)

(Oregon Department of Transportation 2017)

Active Transportation Utilization

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Bicycle/Pedestrian	

Indicator Overview

Description

This indicator measures the number of bicyclists that pass a certain checkpoint or checkpoints along a bicycle facility (bike lane, path, shared-use path, etc.) and the number of pedestrians that pass a certain checkpoint or checkpoints along a sidewalk or shared-use path. Some agencies may only track the highest activity locations taking into consideration seasonal variation in active transportation facility usage. High volumes and physical appeal of a facility correlate to greater active transportation connectivity as well as nearby popular uses and can be an indicator of bicycle and pedestrian congestion if volumes are exceeding the capacity of the bike and pedestrian facilities.

Human and Environmental Drivers

Environmental: consideration to type of facility and location are important to increasing bicycle and pedestrian volumes. Implementing protected bike lanes or separated bike paths that offer protection from automobiles provide safer facilities and increase perception of safety can increase bicycle and pedestrian volumes; car parking fees increase bicycle and walking volumes. Having a good dense network of facilities coupled with mixed use developments that include services within a 20 to 30-minute walk or 3-mile bike ride increase bicycle and pedestrian volumes. Shorter blocks and grid street pattern increase connectivity/directness increasing pedestrian and bicycle volumes. Proximity and availability to transit increase pedestrian volumes; visually interesting and attractive landscaping and buildings increase pedestrian and bicycle volumes. Designated pathways should include well maintained roadways, pothole free and clear of snow and debris. Facilities need to include good lighting to increase bicycle and pedestrian volumes. Adequate supporting infrastructure such as showers, locker rooms, secure and convenient bicycle parking at destinations, especially places of employment, increases bicycle and pedestrian volumes. shorter blocks and grid street pattern increase connectivity/directness increasing pedestrian volume; proximity/ availability of transit increase pedestrian volumes; visually interesting and attractive landscaping and buildings increase pedestrian volume.

Adverse weather conditions may lower bicycle and pedestrian volumes along with physical conditions of the environment such as hilly topography. Facilities adjacent to roadways with higher number of cars per capita and high volumes of turning movements, high bicycle theft rates all lower bicycle and pedestrian volumes. Busy streets with parallel parking have lower bicycle volumes due to safety concerns of doors opening/ hitting cars.

Human: perceived level of risk on busy roadways without protection decreases bicycle and pedestrian volumes.
NOTE: less experienced bicyclists are more concerned with safety and separation from auto traffic while experienced bicyclists are more concerned with factors related to travel time and support facilities.

Application

In the Basin

No current in-basin use.

External uses

The San Francisco County Transportation Authority aims to encourage active transportation through funding of pedestrian and bicycle safety strategies. These include encouraging active transportation during peak congestion hours which ultimately resulted in a 10% reduction of auto trips (San Francisco County Transportation Authority 2013b).
The San Francisco County Transportation Authority works towards maximizing active transportation in its 2013 Congestion Management Plan by completing 217 facility projects in January of 2013 consisting of bicycle and pedestrian routes, paths, and lanes (San Francisco County Transportation Authority 2013a).
The Mid-Ohio Metropolitan Transportation Plan for 2016-2040 includes an Active Transportation Plan which focuses on 12 corridors it felt most pertained to the active transportation goals and required the most improvement (Mid-Ohio Regional Planning Commission 2016).

Literature or Guidance Documents

N/A

Relationship with Goal

Operations: This measure relates to operations because it quantifies active transportation infrastructure utilization and will help agencies determine if and how much infrastructure is needed.
Congestion: This measure relates to bicycle and pedestrian congestion because bicycle and pedestrian volumes will determine if certain bicycle and pedestrian facilities/ routes are exceeding capacity and thus, congested as well as by finding means of

mitigation for automobile traffic.This measure is relative to auto congestion as well. Areas with high auto congestion may be good candidates for bicycle and pedestrian improvements.
Variations of the Measure / Alternatives to the measures
Bicycle volume, Annual Bicycle and Pedestrian Highest Activity Locations, Seasonal Variation in Active Transportation Facility Usage, and Pedestrian volume.
References
(Bixhaku & Malenkovska 2013) (“Counts” n.d.) (Kurt 2008) (Madison Metropolitan Planning Area 2011) (Mid-Ohio Regional Planning Commission 2016) (Polly Trottenberg 2014) (San Francisco County Transportation Authority 2013a) (San Francisco County Transportation Authority 2013b) (Transportation Research Board 2014)

Emerging Technology

Number of Charging Stations with Educational Signage or Information

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Emerging Technology

Indicator Overview

Description

This indicator measures the accessibility of current charging station locations ensuring that signs are easily readable by all populations.

Human and Environmental Drivers

Human: By creating clear universal signage, common across the scope of PEV charging stations, there is an increase in use due to the fact that universal terms are easily identifiable and understood by all.
Environmental: Creating physically consistent signs decreases confusion and increases awareness of electric vehicle stations.

Application

In the Basin

No current in-basin use.

External uses

No external uses identified.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Emerging Technology: This measure relates to the emerging technology goal because it constructs an analysis around adequate sign and symbiology implementation for new PEV charging stations.
Operations: This measure relates to the operations goal because it deals with universal implementation and maintenance of signs.
Air Quality: This measure relates to the air quality goal because it encourages accessibility of environmentally friendly automobiles.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(U.S. Department of Energy n.d.)

(U.S. Department of Energy 2014a)

Number of Events Providing Electric Vehicle Materials	
Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Emerging Technology	
Indicator Overview	
Description	
This indicator measures the number of events wherein the public is able to gather more knowledge about the benefits of electric vehicles.	
Human and Environmental Drivers	
Economic: Providing materials to satisfy information regarding public knowledge may increase the overall use of EV automobiles. Long term, the impact on consumers of purchasing electric vehicles will result in a decrease in fuel spending. **Environmental:** Direct interaction with the public relative to the education of residents regarding the benefits to general air quality may increase the number of EVs purchased and can decrease. **Human:** Direct interaction with the public increases public regard for agency action. This regard in turn increases likelihood of compliance with the desired goals of the agency. The greater the interaction and initial material benefits (small as they may be), the greater the response from the public.	
Application	
In the Basin	
No current in-basin use.	
External uses	
No external uses identified.	
Literature or Guidance Documents	
No literature or guidance documents identified.	
Relationship with Goal	
Emerging Technology: This measure relates to the emerging technology goal because it educates the general public on the benefits of new electric vehicle technology. **Automobiles**: This measure relates to the automobiles goal because it looks for ways to educate the public on new viable forms of automobile transportation. **Air Quality:** This measure pertains to the air quality goal because as more people become aware and begin purchasing non-gasoline based vehicles, there will be an air quality improvement. **Operations:** This measure relates to the operations goal because it deals with how a certain agency will include updating their on-going work priorities to include providing information to the public.	
Variations of the Measure / Alternatives to the measures	
No variations identified.	
References	
(California Plug-in Electric Vehicle Collaborative 2016b) (California Plug-in Electric Vehicle Collaborative 2017) (International Energy Agency 2016) (Tahoe-Truckee PEV Readiness Plan)	

Number of Jurisdictions and Utility Companies with Policies, Design Standards, Plans, Incentives, etc. Directly Addressing Electric Vehicles in a Supportive Way (at least every four years)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Emerging Technology	

Indicator Overview

Description

This indicator measures the number of jurisdictions and utility companies that produce plans, standards for plug-in electric vehicles (PEV), and provide education and outreach on electric vehicles. It identifies the different means of communication with the public and how to encourage residents towards plug-in electric vehicles.

Human and Environmental Drivers

Economic: Increasing users of PEVs would reduce consumer spending on fuel. Increase in public knowledge of financial benefits would increase purchase of electric vehicles. Incentives provided by federal, state, regional, and manufacturer in PEV purchasing including rebates, tax credits, and HOV/carpool stickers increase purchasing.
Environmental: Policy implementation encouraging use of PEVs increases air quality. For every "electric vehicle mile travelled" (EVMT) there is a parallel detraction of "gasolne vehicle mile travelled" (GVMT). Designing, planning, and incentivizing cities so that they are compliant with the needs of PEVs would increase public support of PEVs and increase purchase and use.
Human: By effectively communicating the benefits of utilizing PEVs over gasoline based cars between an agency and the local and regional population, people will better understand the benefits of the government goals and be encouraged to partner with an agency in the overall pursuance of PEVs.

Application

In the Basin

No current in-basin use.

External uses

No external uses identified.

Literature or Guidance Documents

No literature or guidance documents.

Relationship with Goal

Emerging Technology: This measure relates to the emerging technology goal because it encourages incorporating new technologies which can evolve into common practice.
Operations: This measure relates to the operations goal because it encourages agencies and regional organizations to raise public awareness and acceptance of PEVs through design, incentives, planning, and policy.
Air Quality: This measure relates to the air quality goal because its end goal results in air quality improvements through agency policy integration to encourage electric vehicles.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Bay Area Air Quality Management District 2013)

(California Plug-in Electric Vehicle Collaborative n.d.)

(Melaina 2003)

(Southwest Energy Efficiency Project n.d.)

(Tesla 2017)

Number of Training Events On Electric Vehicles	
Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Emerging Technology	
Indicator Overview	
Description	
This indicator measures the potential benefit of educating/training the public in the ways of electric vehicle production. This means to educate the public on how an electric vehicle functions, how to manage these new vehicles, and the benefit that ultimately comes from using them.	
Human and Environmental Drivers	
Human: Increasing knowledge in how to operate and possible rebates on acquiring a vehicle will increase acceptance by the consumer. Increasing knowledge on the cost effectiveness of electric vehicles will increase acceptance. Increasing positive environmental benefit understanding will increase acceptance. Increasing acceptance will increase comfortability which will ultimately lead towards larger scale purchasing of electric vehicles. **Environmental:** As knowledge grows, so may acquisition of EVs and recognition of the environmental benefits of EV use **Economic:** Possible additional cost of material production and hosting events by an agency. However, ultimately economically beneficial for the consumer in the long run. Additionally, media coverage through social media sites such as Facebook and Instagram that host direct links to sites with more information are cost efficient and effective ways to reach out to the public with electric vehicle based knowledge.	
Application	
In the Basin	
No current in-basin use.	
External uses	
No external uses identified.	
Literature or Guidance Documents	
No literature or guidance documents identified.	
Relationship with Goal	
Emerging Technology: This measure relates to the emerging technology goal because it educates the general public on the function and benefits of new electric vehicle technology. **Automobiles:** This measure relates to the automobiles goal because it looks for ways to educate the public on automobile transportation that is better for the overall environment. **Air Quality:** This measure pertains to the air quality goal because as more people become aware, comfortable with, in support of and purchase non-gasoline based vehicles, there will be an air quality improvement.	
Variations of the Measure / Alternatives to the measures	
No variations identified.	
References	
(California Plug-in Electric Vehicle Collaborative 2016) (Office of Energy Efficiency and Renewable Energy 2016) (SAE International n.d.) (Stern 2000) (U.S. Department of Energy 2014b)	

Crowdsourcing Data Collection

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Emerging Technology

Indicator Overview

Description

This indicator measures the potential benefit of gathering information at real-time speeds from publicly sourced data sites to more efficiently and quickly handle potential problems in the area.

Human and Environmental Drivers

Human: Increasing accessibility of the public to voice their opinions and concerns increases the resident's positive outlook of where they live. Increase of collection and real-time crash data (or roadway locations where there is high crash potential/dangerous road conditions) decreases the total amount of crashes which increase overall person safety on the condition that improvements are in fact made and enforcement is increased. Increase in users with crowdsource data applications increases the ability to better manage operations and congestion by integrating real time updates of roadway problems.

Economic: Increasing knowledge of high priority projects derived from largely noticed roadway problems identified by the public will decrease economic revenue spent on projects for underutilized systems.

Application

In the Basin

No current in-basin use.

External uses

No external uses.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Emerging Technology: This measure relates to the emerging technology goal because it works with modern day smart phone technology to best translate user provided information for more efficient problem solving.

Operations: This measure relates to the operations goal because it is the responsibility of the agency to implement and maintain an effective, well-maintained system for communications so that users are aware of problems and can then make more efficient travel decisions.

Resident Quality of Life: This measure relates to resident quality of life because crowd sourcing information can be used to improve incident response which can improve travel times for users of the roadway, reducing travel times to minimums has a direct relationship to quality of life.

Safety: This measure relates to the safety goal because dangerous road conditions can be identified faster reducing response times and even be linked with providing alternative routes to avoid.

Systems Connectivity: This measure relates to the system connectivity goal because people may be able to provide real time information about potential transit delays or incidents, delays due to congestion, bicycle and pedestrian facility issues, etc.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Alta Planning and Design 2017)

(Kanhere 2011)

(Misra et al. 2014)

Parking

Parking Utilization

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory**: Parking	

Indicator Overview

Description

This indicator measures the utilization of available automobile parking spaces. Adjacent and nearby land uses affect percentage of parking utilized. Efforts to minimize the amount of parking provided, manage parking turnover through parking pricing can encourage use of transit and active transportation. A variation of this measure is the Number of Communities Adopting Reduced Parking Standards.

Human and Environmental Drivers

Environmental: Increased availability and cheap access to parking would negatively impact environmental air quality as it would encourage automobile transportation. Minimizing amount of parking would decrease the quantity of automobile users because parking options would be scarce. Accessing demand and providing the minimum number of parking spaces, coupled with pricing strategies increase total parking utilization. Decreasing automobile usage by way of minimizing parking will positively impact air quality as well as water quality which is prone to harmful run off from parking areas.

Economic/Human: Short term, implementation of minimal parking standards could result in a shortage based on current demand for parking. Providing other alternatives to driving such as frequent transit and connected path networks that are visible can alleviate some of the shortage. Long term, (should transit and active transportation become more viable, convenient, and practical options) implementation of minimal parking would result in lower levels of automobile traffic, but utilization of the available parking nonetheless.

Application

In the Basin

TRPA currently uses “East Shore Parking Counts (Summer, Weekday/Weekend)" to measure the level of parking utilization in areas typically measured as highly utilized. (Tahoe Regional Planning Agency 2010).

During the summer of 2017 additional counts will be taken at Zephyr Cove and Emerald Bay

Placer County and USFS initiate studies to capture parking demand and utilization. conducting parking counts at Zephyr Cove and Emerald Bay this summer.

External uses

The Mid-Ohio Regional Planning Commission’s Metropolitan Transportation Plan for 2016 to 2040 uses “Parking Utilization” to look outside of densely populated city centers where parking may be hard to find and encourages bicycling the last few miles to work (Mid-Ohio Regional Transportation Plan 2016).

The Mid-Ohio Regional Planning Commission’s 2012 Transportation Plan includes factors of implementing restricted parking in order to increase water quality (Mid-Ohio Regional Planning Commission 2011).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Operation: This measure relates to the operations goal because it deals directly with the establishment of parking in new and current developments.

Congestion: This measure relates to the congestion goal because it measures the potential utilization of parking to ensure parking is provided and managed for the demand, optimally there will not be a surplus of parking which can lead to automobile congestion by encouraging driving.

Environment: This measure relates to the environmental water and air quality goals because the impacts of parking utilization directly affect the surrounding atmosphere and water.

Variations of the Measure / Alternatives to the measures

Number of Communities Adopting Reduced Parking Standards.

References

(Albanese & Matlack 1999)

(Donald Shoup 1999)

(Kendall Banfield 1997)

(Mid-Ohio Regional Planning Commission 2011)

(Mid-Ohio Regional Planning Commission 2016)

(Willson 1995)

Roadway Operations

Traffic Volumes

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Roadway Operations	

Indicator Overview

Description

This indicator measures traffic volumes which are the total number of vehicles that pass through a specific location during a specified time period. Two methods are available for conducting traffic volume counts: (1) manual and (2) automatic. Manual counts are typically used to gather data for determination of vehicle classification, turning movements, direction of travel, pedestrian movements, or vehicle occupancy. Automatic counts are typically used to gather data for determination of vehicle hourly patterns, daily or seasonal variations and growth trends, or annual traffic estimates such as level of service. Volumes are often used for determining signal timing.

Human and Environmental Drivers

Environmental: Decrease in total traffic volumes (by non-electric) automobiles improves air quality; decrease in traffic volumes may also decrease congestion.

Human: Decrease in traffic volumes may decrease overall travel time which increases the total amount of time for other activities.

Application

In the Basin

TRPA currently uses "Traffic Volumes at Highway 50 and Park Avenue" (Threshold Standard) as a means of measuring traffic volumes in the Tahoe Region (Tahoe Regional Planning Agency 2010).

External uses

The Metropolitan Transportation Commission uses "Traffic Volumes" to analyze various metrics determining, for example, that the traffic volume in the Bay Area counties has generally increased over the past decade (Metropolitan Transportation Commission n.d.).

The Chicago Metropolitan Agency for Planning in the 2014 Annual Atlas uses "Annual Average Daily Traffic Volumes" to measure traffic volumes in the area (Chicago Metropolitan Agency for Planning 2015).

Chicago Metropolitan Agency for Planning's *Go To 2040 Plan* uses "Traffic Volumes" to looks for ways to mitigate areas of high traffic volumes by conducting studies and improvements on roadways such as a 5 mile stretch of Milwaukee Avenue through the Village of Niles (Chicago Metropolitan Agency for Planning 2010).

The Chicago Metropolitan Agency for Planning in its Congestion Management Process Document analyzes "Traffic Volumes" (by day and by class) and reports them directly into the Illinois Roadway Information System (http://gis.dot.illinois.gov/gist2/) (Chicago Metropolitan Agency for Planning 2013).

Literature or Guidance Documents

Iowa State University Traffic volume studies are conducted to determine the number, movements, and classifications of roadway vehicles at a given location. This data can help identify critical flow time periods tha may require timing adjustments and determine the influence of large vehicles on signal operations and traffic flow.

Relationship with Goal

Congestion: This measure relates to the congestion goal because it monitors traffic volumes and triggers changes to roadway conditions and signal timing that can improve congestion.

Operations: This measure relates of the operations goal because the data collected can inform needed improvements to maximize the efficiency of roadway operations.

Connectivity: This measure relates to the connectivity goal because it can inform where additional roadway facilities are needed or improvements to non-auto travel options should be implemented.

Variations of the Measure / Alternatives to the measures

a) Annual average daily traffic (AADT) counts represent the average 24-hour traffic volume at a given location averaged over a full 365-day year. AADT volume counts have the following uses (Iowa St):
b) Measuring or evaluating the present demand for service by the roadway or facility
c) Developing the major or arterial roadway system
d) Locating areas where new facilities or improvements to existing facilities are needed

• programming capital improvements

References

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2013)

(Chicago Metropolitan Agency for Planning 2015)

(Metropolitan Transportation Commission n.d.)

Number of Complete Street Projects

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Roadway Operations

Indicator Overview

Description

Measures the total number of complete street projects and the importance of time, funding, and infrastructure management.

Human and Environmental Drivers

Economic: Delays in completion of projects typically result in an increase in costs of completing the project. Correctly estimating total costs around a project is important for maintaining transparency and honesty between agency and the general public as well as not running the risk of an increase in delay of a project due to the lack of funding.
Environmental: Completion of new road projects results in a direct loss of habitat when constructed in a greenfield area. Completion of bicycle and pedestrian road projects in the name of increasing potential utility of alternate transportation increases environmental air quality in the long run.
Human: Delay in construction of complete street projects results in discontent among residents. Completion of projects within a timely manner increases visitor experience and resident quality of life by implementing projects which ultimately increase functionality, aesthetics, and safety.

Application

In the Basin

TRPA monitors the "Number of Complete Street Projects" through its EIP Tracker, reflected in the Lake Tahoe Info website. (Tahoe Regional Planning Agency 2017)

External uses

Mid-Ohio Regional Planning Commission uses "Number of Complete Street Projects" which are broken down and assessed based on the level of successful implementation. (Mid-Ohio Regional Planning Commission 2012).
Southern Nevada's Regional Transportation Commission's uses "Complete Street Projects" in one way that ensures that they do not obstruct the function of other modes of transportation. (Southern Nevada Regional Transportation Commission 2017).
The Carson Area Metropolitan Planning Agency's uses "Number of Complete Street Projects" to outline an entire section of their document dedicated to the functional completion of street projects.(Carson Area Metropolitan Planning Organization 2016)

Literature or Guidance Documents

The Nevada Department of Transportation recommends creating a live update of roadway projects in a designated planning area, analyzing each section of production. This implementation of an updated project report system is available in the Road Projects division on the website (Nevada Department of Transportation n.d.).

Relationship with Goal

Operations: This measure relates to the operations goal because it tracks the completion of road projects.
Systems: This measure relates to the systems portion of the connectivity goal because complete streets are built for all modes, potentially closing gaps for specific modes in the transportation system.
Visitor Experience: This measure relates to the visitor experience goal because completion of projects increases functionality, safety, and positive user experience.
Resident Quality of Life: This measure relates to the resident quality of life goal because completion of projects increases functionality and safety for residents no matter which mode is chosen for travel.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Carnegie Mellon University n.d.)

(Carson Area Metropolitan Planning Organization 2016)

(Kaliba et al. 2009)

(Mid-Ohio Regional Planning Commission 2011)

(Mid-Ohio Regional Planning Commission 2012)

(Mid-Ohio Regional Planning Commission 2016)

(Nevada Department of Transportation n.d.)

(Southern Nevada Regional Transportation Commission 2017)

(Spellerberg 1998)

(Tahoe Regional Planning Agency 2017)

(Texas Department of Transportation 2017)

Vehicle Hours Travelled

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Roadway Operations

Indicator Overview

Description

This indicator measures the average hours travelled by vehicle in an area, the origin and destination determining hours traveled, and the direct impact of an increase in miles traveled by non-electric vehicles and emissions.

Human and Environmental Drivers

Environmental: As traffic congestion increases, vehicle hours travelled increases. As vehicle hours travelled increases, the amount of emissions increases which ultimately decreases air quality.

Technology: Finding ways to source real time data (in a safe manner) on traffic congestion can real time information to redirect certain vehicles or increase awareness of heavy congestion in an effort to encourage those to avoid the trafficked area.

Human: Increase in vehicle hours travelled decreases the amount of time spent in places of significance to a person (such as home or work) and thus decreases overall quality of life.

Physical: Design infrastructure and permitted land uses such as affordable housing in such a way as to combat sprawling city characteristics which increase vehicle hours travelled. Travelling at peak traffic hours increases vehicle hours travelled due to congestion.

Application

In the Basin

No current in-basin use.

External uses

Denver Regional Council of Governments in its 2035 Regional Transportation Plan tracks "Vehicle Hours Travelled" in addition to vehicle miles traveled to better understand how the public experiences congestion (Denver Regional Council of Governments 2011)

California Department of Transportation uses "Vehicle Hours Travelled" by analyzing different scenarios involving a conglomeration of multiple modes of transportation and how they will impact vehicle hours traveled in the years to come (California Department of Transportation 2016).

Literature or Guidance Documents

No literature or guidance documents.

Relationship with Goal

Air Quality: This measure relates to air quality because vehicle hours travelled is a large determinant of fuel efficiency which is directly correlated to emissions and air quality.

Quality of Life: This measure relates to the quality of life goal because decreasing the total number of hours spent in a vehicle increases the overall time spent elsewhere improving quality of life.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(California Department of Transportation 2016)

(Chao Chen et al. 2001)

(Denver Regional Council of Governments 2011)

(Downs 2001)

(Ewing, Reid et al. n.d.)

Vehicle Trips

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Roadway Operations

Indicator Overview

Description

This indicator measures the impact of vehicle trips based on the start of the engine of a car to the end, based not in miles or hours traveled, but simply on a "per trip" scale.

Human and Environmental Drivers

Environment: An increase in total vehicle trips will concurrently result in an increase in pollution of the air and water quality. Research indicates where there is a greater increase in dwelling in low density, suburban areas, there is a greater increase in congestion. The greater increase in congestion due to a higher number of vehicle trips directly results in higher harmful emissions. For the average resident, higher living area density decreases vehicle trips per household.
Economic: The amount of vehicle trips increases costs for both the driver due to an increase in car maintenance and fuel cost, and also the agency responsible for road maintenance as the roads inevitably receive greater wear per vehicle trip.

Application

In the Basin

No current in-basin use.

External uses

City of Pasadena analyzes "Vehicle Trips Per Capita" under its accessibility and environmental performance measure based on a per service population metric (City of Pasadena Department of Transportation 2014).
Transportation for America analyzes "Vehicle Trips" to assess system performance (Transportation for America 2015).
Denver Regional Council of Governments uses "Vehicle Trips" measures in reference to travel demand and finding ways to mitigate the impact that these two impose on one another (Denver Regional Council of Governments 2011).
California Department of Transportation uses "Single Occupancy Vehicle Trips" between regions as a scenario comparison for the year 2040 (California Department of Transportation 2016).

Literature or Guidance Documents

Transportation for America recommends using vehicle trips with relevance to public health and environment measures in terms of fuel use per vehicle trip (Transportation for America 2015).

Relationship with Goal

Environment: This measure relates to the environmental goal because automobiles use has an impact on greenhouse gas emissions.
Automobile: This measure relates to the automobile goal because it looks at reducing the total number of vehicle trips.
Congestion: This measure relates to the congestion goal because by reducing the total number of vehicle trips, congestion may be reduced as well.

Variations of the Measure / Alternatives to the measures

No variation identified.

References

(California Department of Transportation 2016)

(City of Pasadena Department of Transportation 2014)

(Denver Regional Council of Governments 2011)

(Federal Highway Administration 2016)

(Institute of Transportation Engineers 2004)

(Sacramento Area Council of Governments 2016a)

(Transportation for America 2015)

Roadway Congestion Management

Delay

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Roadway Congestion Management	

Indicator Overview

Description

This indicator measures the extra travel time drivers spend on a trip due to congestion. Delay can be defined in several ways, including when travel speeds go below a certain threshold based on road classification, a roadway's level of service grade, or travel during peak times on certain roadways. Total delay measures time spent in both congested delay and all other delays where the travel speed drops below the posted speed limit. Variations of this measure include Vehicle Hours of Delay, Average Delay, Delay per Household, Delay for freeways, Person Hours of Delay, Delay per Commuter, and Time Spent in Congestion (Congested Delay and Total Delay).

Human and Environmental Drivers

Environmental: Increasing accessibility to services (the number of activities that can be reached within a given travel time) decreases the likelihood of decreasing delay; providing transit options along commute routes (and other heavily traveled routes) increases transit mode share and may decrease person delay; implementing complete streets projects (multimodal streets) may reduce delay; basing new roadway construction and focusing active transportation improvements near mixed use development and areas with estimated population growth can improve roadway utilization and decrease delay; more mixed-use development increases the number of amenities in close proximity which decreases vehicle mode share which can decrease delay.

Human: Telecommuting, compressed work week, and flexible work schedules decrease travel during peak hours which can decrease delay.

Application

In the Basin

TRPA measures delay and is required in the Code to measure LOS which is based on delay. This must occur every two years and phase our land-use allocation if LOS is not in attainment.

External uses

California Department of Transportation
Caltrans currently addresses congestion relief through active traffic management, supported by the Traffic Management Cen ters, as well as issuing projects designed to reduce delay. (California Department of Transportation 2016).

Florida Department of Transportation's 2016 MAP-21 Performance Report uses "Vehicle Hours of Delay" to visualize delay during peak traffic periods which currently illustrates a general decline in vehicle delay over the years (Florida Department of Transportation 2016a).

Florida Department of Transportation Performance and Production Review measures "Delay" and equates in terms of costs of time and money (Florida Transportation Commission 2016).

Oregon Department of Transportation reports "Delay" in terms of travel delay per capita per year and uses visual representations comparing goals for reductions in delay and actual reductions in delay (Oregon Department of Transportation 2015).

New York State Association of Metropolitan Planning calculates "Volume Based Delay" by taking actual travel time and subtracting free flow travel time (New York State Association of Metropolitan Planning Organizations 2006a).

Oregon Metro uses "Delay" by looking for ways to combat the economic challenges imposed on freight by congestion traffic and volume based delays (Metro 2014).

San Francisco Metropolitan Transportation Commission uses "Time Spent in Congestion" in its Vital Signs Network to produce infographics which report helpful visuals showing where delay is occurring (?) (Metropolitan Transportation Commission n.d.).

San Diego Association of Governments annual hours of "delay" per capita is collected to help monitor their Regional Comprehensive Plan (San Diego Association of Governments 2015).

Chicago Metropolitan Agency for Planning's "Go To 2040" uses "Delay" as a measure to outline means of financing freight system capital improvements as a way to decrease delays (Chicago Metropolitan Agency for Planning 2010).

Chicago's Management measures "Delay" in terms of how much congestion is caused from wait revolving around waiting for trains (Chicago Metropolitan Agency for Planning 2016).

Chicago's Congestion Management Process Documentation uses "Delay" as a performance measurement and determined that design, operation, and maintenance (or lack thereof) of traffic control devices extremely impacts delay in the surrounding areas (Chicago Metropolitan Agency for Planning 2013).

Madison Metropolitan Planning Area measures "Delay" on urban roadways and assigns specific monitors to certain performance details including delay of both urban roadways and freeways (Madison Metropolitan Planning Area 2011).

Maricopa Association of Governments measure "Delay" in terms of mobility based on travel time (primarily vehicle hours of delay) (Maricopa Association of Governments 2008).
Washoe Regional Transportation Commission uses a "Travel Demand Model" to determine expected delays based on factors such as population growth and expected travel times. (Washoe Regional Transportation Commission 2013).
Southern Nevada Regional Transportation Commission's Access 2040 Plan analyzes "Freight and Commute Delay" alongside detrimental emissions that directly impact air quality and health (Southern Nevada Regional Transportation Commission 2017).
Denver Regional Council of Governments uses "Vehicle and Person Hours Spent in Delay" in its 2015 Annual Report to return logical, readable information on the total amount of delay in the region. (Denver Regional Council of Governments 2016).
Mid-Ohio Regional Planning Commission uses "Delay" to evaluate projects. They calculate delay scores on a scale from 0-20 based on how effective a project is. For example, the agency scored one project in a high truck volume area as above average in its successes due to the amount of delay the project should be mitigating (Mid-Ohio Regional Planning Commission 2012).
Mid-Ohio Regional Planning Commission correlates "Delay" to the ability of the area to attract new businesses and retain/expand current businesses (Mid-Ohio Regional Planning Commission 2011).
Mid-Ohio Regional Planning Commission looks to mitigating "Delay" by allowing buses to merge onto freeway shoulders as a means of mitigating freeway and transit delays. It also plans for handling potential future delay problems in a "worst case scenario" to be prepared for any problem that could arise (Mid-Ohio Regional Planning Commission 2016).
Riverside County Transportation Commission analyzes "Delay" in its 2011 Congestion Management Process document by using a HCM-Based software to consider delay and closely approximate LOS (Riverside County Transportation Commission 2011).

Literature or Guidance Documents

New York State Associations of Metropolitan Planning Organizations recommends the "Vehicle Hours of Delay" measure to assess the duration of congestion (New York State Association of Metropolitan Planning Organizations 2006b).

Relationship with Goal

Congestion: This measure relates to congestion because it measures the time of delay that traveler's experience during their trips due to congestion and other factors.
Operations: This measure relates to operations because delay is an indicator that roadways may not have the capacity to accommodate the volume of vehicles using the roadway.

Variations of the Measure / Alternatives to the measures

Vehicle Hours of Delay, Average Delay, Delay per Household, Delay per Commuter, Person Hours of Delay, Delay for Freeways, and Time Spent in Delay (Congestion Delay and Total Delay).

References

(California Department of Transportation 2016)

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2013)

(Chicago Metropolitan Agency for Planning 2016)

(Denver Regional Council of Governments 2011)

(Denver Regional Council of Governments 2016)

(Florida Department of Transportation 2016a)

(Florida Transportation Commission 2016)

(Garry 2013)

(Hymel 2014)

(Madison Metropolitan Planning Area 2011)

(Maricopa Association of Governments 2008)

(Metro 2014)

(Metropolitan Transportation Commission n.d.)

(Metropolitan Transportation Commission n.d.)

(Mid-Ohio Regional Planning Commission 2011)

(Mid-Ohio Regional Planning Commission 2012)

(Mid-Ohio Regional Planning Commission 2016)

(New York State Association of Metropolitan Planning Organizations 2006a)

(Oregon Department of Transportation 2015)

(Riverside County Transportation Commission 2011)

(Sacramento Area Council of Governments 2016a)

(San Diego Association of Governments 2015)

(Southern Nevada Regional Transportation Commission 2017)

(Washoe Regional Transportation Commission 2013)

Vehicle Occupancy

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Roadway Congestion Management

Indicator Overview

Description

This indicator measures the available seats during peak times of traffic. By looking at strategies like ride matching that can fill those empty seats with passengers heading to similar locations (also driving alone), it is possible to decrease overall congestion.

Human and Environmental Drivers

Environmental: As vehicle numbers on the road increase, traffic congestion may increase. As traffic congestion increases, the amount of emissions increases for non clean fuel vehicles which can degrade air quality. By utilizing all the seats in a vehicle, maximizing it's capacity, minimizes the total number of single rider vehicles on the road.

Technology: Developing technology that can crowdsource information regarding availability of riders to carpool increases vehicle occupancy.

Application

In the Basin

No current in-basin use.

External uses

No external uses identified.

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Automobile: This measure relates to the automobile goal because it looks at ways of minimizing automobile congestion through maximizing seat utility.

Congestion: This measure relates to the congestion goal because the whole point of looking to occupy the total number of vacancies in vehicles is to maximize capacity and minimize the total level of congestion.

Air Quality: This measure relates to air quality because by increasing vehicle occupancy, the number of vehicles on the road may decrease alongside the amount of harmful emissions entering the atmosphere.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Arizona Department of Transportation 1989)

(Fehr and Peers 2017)

(Giuliano et al. 1990)

(Ned Levine & Martin Wachs 1996)

Congestion Index

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Roadway Congestion Management

Indicator Overview

Description

The “Congestion Index” measures is based on a buffer time index (BTI) which is the measure of the amount of time, over and above the average travel time, that a driver would need to budget to ensure on-time arrival at the desired destination, with a 95 percent confidence rateBTI is expressed as a fraction of the average travel time – the lower the BTI, the more reliable the trip.. EX: a driver with a 20-minute commute that has a 0.5 BTI would need to allocate 10 extra minutes to ensure an on-time arrival. Variations of this measure include Congestion Cost per Commuter Average Delay and Congestion Measure.

Human and Environmental Drivers

Environmental: Improving traffic signal synchronization increases travel time reliability; transit signal priority and queue jumps increases travel time reliability; establishing regional traffic/ weather incident management plans increases travel time reliability; providing real-time traffic information to drivers increases travel time reliability.

Application

In the Basin

No current in-basin use.

External uses

San Francisco Metropolitan Transportation Commission uses the “Time Spent in Congestion” and “Miles Traveled in Congestion” measures to understand congestion in the area (Metropolitan Transportation Commission n.d.).
Santa Cruz County Regional Transportation Commission uses the “Problem of Congestion” measure to determine methods to mitigate greenhouse gas emissions as a part of the byproduct of congestion on major roadways (Santa Cruz County Regional Transportation Commission 2014).

Literature or Guidance Documents

California Department of Transportation recommends the use of the “Travel Time Reliability” measure to assess transportation system performance for all modes in California (California Department of Transportation 2015).

Relationship with Goal

Congestion: This measures congestion because it quantifies the amount of extra time drivers should expect to add to their commute due to traffic delays/ congestion.

Variations of the Measure / Alternatives to the measures

Congestion Index, Travel Time Reliability, and Congestion Cost per Commuter.

References

(Metropolitan Transportation Commission 2016)

(Santa Cruz County Regional Transportation Commission 2014)

Vehicle Speed

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Roadway Congestion Management

Indicator Overview

Description

This indicator measures the generally consistent speed throughout an area and how that impacts time, cost efficiency, and safety. Two variations of this measure are the average speed of vehicles for the duration of the entire day and during peak traffic.

Human and Environmental Drivers

Environmental: Maintaining a constant vehicle speed increases fuel efficiency. Increase in fuel efficiency minimizes impacts on the environment. Conversely, non-constant speeds, relative to issues of traffic congestion, produce harmful effects on the air quality due to a decrease in fuel efficiency.
Technology: Finding ways to source real time data (in a safe manner of course) on traffic congestion can mitigate non-constant flows of traffic during peak hours and increase the average vehicle speed through efforts of preventing automobile users to take roads where congestion is already happening.
Human: Relative to time spent in congested traffic, means of implementing new forms of regulation (such as HOV lane laws) may increase time that people spend in their place of work or home rather than stuck in heavily congested traffic. Constant speeds also create a safer environment for motorists, cyclists, and pedestrians.
Economic: Maintaining constant vehicular speed (without excessive amounts of deceleration and acceleration) is more economically efficient for the driver as it requires less fuel consumption.

Application

In the Basin

No current in-basin use.

External uses

San Francisco County Transportation Authority uses the "Vehicle Speed" measure as something to monitor in order to further engage walking and bicycling within the region (implying that the slower speeds ensure and increase in bicyclists and pedestrians) (San Francisco County Transportation Authority 2013b).
Denver Regional Council of Governments analyzes "Vehicle Speeds" at peak congestion hours, determining that during peak congestion hours, the average vehicle speed is only 28 miles per hour (Denver Regional Council of Governments 2011).

Literature or Guidance Documents

N/A

Relationship with Goal

Automobile: This measure relates to the automobile goal because it aggregates vehicle speed in order to find an average.
Air Quality: This measure relates to air quality because vehicle speed is a large determinant of fuel efficiency which is directly correlated to emissions and thus air quality.

Variations of the Measure / Alternatives to the measures

Average Speed of Vehicles During Free Flow Hours and Average Speed of Vehicles During Peak Period of Traffic.

References

(Ahn et al. 2002)

(Atlanta Regional Commission 2015)

(Chang & Morlok 2005)

(Denver Regional Council of Governments 2011)

(Denver Regional Council of Governments 2016)

(Jorgos Zoto, Richard J. La, Masoud Hamedi, and Ali Haghani n.d.)

(Makkar 2016)

(San Francisco County Transportation Authority 2013b)

Roadway Level of Service (LOS)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Roadway Congestion Management	

Indicator Overview

Description

“Roadway Level of Service” measures how efficiently roadways are used based on automobile volume/capacity ratio. Roadways are categorized as under-utilized (roadways that too large for their demand), optimally-utilized (*roadways that regularly flow and are the right size for the amount for traffic, and produce very little delay for the motorist*), over-utilized (roadways used above the optimal capacity = congestion). LOS is a qualitative measure used to determine the operational conditions of roadways as it relates to automobiles. LOS considers traffic flow, traffic speed, mobility, comfort, and safety. Roadways are given an LOS grade ranging from A (No delay) to F (Excessive delay). Similar measures include: roadways with severe congestion, lane miles of roads congested for 3 hours or longer, and number of under-utilized, optimally-utilized, and over-utilized roadways. Roadway LOS only measures delay from the perception of the motorist. Roadway LOS must also be balanced with pedestrian, bicyclists, and transit level of service to provide equitable access for all users.

Human and Environmental Drivers

Environmental: Improving traffic signal synchronization increases travel time reliability; transit signal priority and queue jumps increases travel time reliability; establishing regional traffic/ weather incident management plans increases travel time reliability; providing real-time traffic information to drivers increases travel time reliability; increased travel speed increases LOS; decreased congestion/ travel time increases LOS; low volume to capacity ratio increases LOS; traffic signal synchronization increases LOS; lower peak hour factor (peak hour volume/ volume during the peak 15 minutes of flow) increases LOS.

Application

In the Basin

TRPA currently uses "Roadway Segment Level of Service" and "Intersection Level of Service" to monitor the level of roadway service to vehicles in the area. Maintaining high levels of service in these areas will ultimately lead to vehicle efficiency (Tahoe Regional Planning Agency n.d.)

External uses

Santa Cruz County Regional Transportation Commission analyzes “Road Level of Service” by tracking the impact of congestion on the utility and maintenance of residential roads (Santa Cruz County Regional Transportation Commission 2014).

San Francisco Metropolitan Transportation Commission uses a “Pavement Condition Index” to analyze the Roadway Level of Service of residential roads as well as highways (Metropolitan Transportation Commission 2016)

New York State Association of Metropolitan Planning Organizations indicates “Level of Service on Roads” largely as a determinant of utility and volume-to-capacity measurement (New York State Association of Metropolitan Planning Organizations 2006a).

Sacramento Area Council of Governments speaks to “Roadway Level of Service” in a way that indicates that due to the high cost of road maintenance, typically accrued from heavy vehicle usage on a specific roadway, slight congestion during peak hours is not something to be concerned with, but rather something to welcome (Sacramento Area Council of Governments 2016a).

Gunnison Valley 2040 Regional Transportation Plan uses “Roadway Level of Service” to measure the impacts of congestion on roadways (Gunnison Valley Transportation Planning Region 2015).

Riverside County Transportation Commission “Highway and Roadway Level of Service” match up with the requirements outlined in AB 1963, aiming towards utility of multimodal vehicles (Riverside County Transportation Commission 2011).

Literature or Guidance Documents

New York State Association of Metropolitan Planning Organizations recommends the use of the “Roadway Level of Service” measure to assess roadway congestion (New York State Association of Metropolitan Planning Organizations 2006b).

In its analysis of metrics to replace LOS in CEQA as part of California SB 743, the **Governor’s Office of Planning and Research** described the recent critiques of LOS “for working against modern state goals, such as emissions reduction, development of multimodal transportation networks, infill development, and even optimization of the roadway network for motor vehicles.”

Relationship with Goal

Congestion: This measure relates to congestion because roadway traffic flow/ congestion is considered when assigning LOS grades to roadways.

Operation: This measure relates to RLOS because RLOS can determine whether or not the roadway infrastructure capacity is appropriate for the volume of vehicles using the roadway.

Variations of the Measure / Alternatives to the measures
Under-utilized, Over-Utilized, and Optimally-Utilized Roadways; Trail Maintenance and Management; Roadways with Severe Congestion; and Lanes Miles with Road Congestion for 3 Hours or Longer.

References

(Denver Regional Council of Governments 2016)

(Gunnison Valley Transportation Planning Region 2015)

(Hillsborough Metropolitan Planning Organization 2014)

(Metropolitan Transportation Commission 2016)

(New York State Association of Metropolitan Planning Organizations 2006a)

(OPR 2013)

(Riverside County Transportation Commission 2011)

(Sacramento Area Council of Governments 2016a)

(Sacramento Area Council of Governments 2016b)

(Santa Cruz County Regional Transportation Commission 2014)

Volume-to-Capacity Ratio

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** Roadway Congestion Management	

Indicator Overview

Description

"Volume-to-Capacity Ratio" measures mobility and quality of a specific section of transportation facilities relative to travel, directly comparing supply and demand. Volume here is understood to represent modes of transportation and capacity is understood to represent available roadways, rail lines, and things of the like.

Human and Environmental Drivers

Human: As the ratio of volume to capacity stray from a value of 0.5 (on a scale measured from 0 to 1), the rate of potential vehicular accidents increases. This is in reference to both capacity outweighing volume and volume outweighing capacity, but primarily when volume exceeds capacity.

Environmental: As the volume begins to outweigh the capacity, environmental air quality decreases due to congestion.
Economic: Volume failing to meet capacity results in a decrease in utility of initial and continual development funds. Capacity failing to meet volume results in a decrease in utility of resident funds (relative to costs of car maintenance, fuel, etc.)

Application

In the Basin

No current in-basin use.

External uses

California Rural Counties Task Force analyzes "Volume/Capacity Ratios" in terms of "Peak Hour Travel" specifically analyzing traffic flows during times of high traffic volumes (California Rural Counties Task Force 2015b).

New York State Association of Metropolitan Planning Organizations states that the "Volume-to-Capacity" measure is an older version of the measurement of utility currently deemed "Level of Service" (New York State Association of Metropolitan Planning Organizations 2006b).

Literature or Guidance Documents

New York State Association of Metropolitan Planning Organizations recommends the "Volume-to-Capacity Ratio" measure to assess congestion (New York State Association of Metropolitan Planning Organizations 2006b).

Relationship with Goal

Operations: This measure relates to the operations goal because is deals with the management of roadways in directly analyzing and managing their supply and demand.

Congestion: This measure relates to the congestion goal because it manages automobile and transit based traffic to ensure capacities are being met and not over or under achieved.

Safety: This measure related to the safety goal because it measures the demand to supply and in that measurement, any mishaps have the potential to increase the probability of accidents.

Connectivity: This measure relates to the automobile goal because it seeks to adequately evaluate the volume need against capacity need, focusing on means of constructing proper connectors.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(AECOM 2013)

(Calfee & Winston 1998)

(California Rural Counties Task Force 2015b)

(New York State Association of Metropolitan Planning Organizations 2006a)

(Zhou & Sisiopiku 1997)

System Operations

Travel Time Index (TTI)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** System Operations	

Indicator Overview

Description

This indicator measures the ratio of travel time in the peak traffic period to travel time in free-flow traffic conditions. Specifically, it is the free flow travel time plus the delay due to peak traffic condition, divided by the free flow travel time. A higher index is associated with greater delay in peak traffic condition (i.e. more congestion). Example: A value of 1.3 indicates a 20-minute free-flow trip requires 26 minutes during the peak period.This measure quantifies congestion during peak traffic conditions.

Human and Environmental Drivers

Environmental: Increasing accessibility to amenities (the number of activities that can be reached within a given travel time) decreases TTI; providing transit options along commute routes (and other heavily traveled routes) increases transit mode share and decreases TTI; implementing complete streets projects (multimodal streets) reduces TTI; basing new roadway construction on the areas land use development and estimated population growth improves roadway utilization and decreases TTI; More mixed-use development increases the number of amenities in close proximity which decreases vehicle mode share which decreases TTI; increased housing and employer balance decreases commute distances and increases multimodal mode share which decreases TTI; increased fuel prices decreases VMT which decreases TTI.

Human: Telecommuting, compressed work week, and flexible work schedules decrease travel during peak hours which decreases TTI.

Application

In the Basin

No current in-basin use.

External uses

Florida Department of Transportation uses the “Travel Time Index” to measure and track the congestion level of major roadways (Florida Transportation Commission 2016).

New York State Association of Metropolitan Planning Organizations uses the “Travel Time Index” to take travel time measurements of transportation in the area (New York State Association of Metropolitan Planning Organizations 2006a).

Chicago Metropolitan Agency of Planning uses the “Travel Time Index” to measure peak period travel time flows against free-flowing times of travel on highways (Chicago Metropolitan Agency for Planning 2013).

Madison Metropolitan Planning Area uses the “Travel Time Index” in order to track and analyze the speed of vehicles in both urban and highway areas (Madison Metropolitan Planning Area 2011).

Texas Transportation Institute uses the “Travel Time Index”; they have concluded that the lowest indicator of TTI is for those who work at home however, public transit has the greatest propensity to produce a lower TTI in larger urban areas (Texas Transportation Institute 2010a).

Literature or Guidance Documents

New York State Association of Metropolitan Planning Organizations recommends the use of the Travel Time Index measure to assess the needed time to travel along selected routes (New York State Association of Metropolitan Planning Organizations 2006b).

Relationship with Goal

Congestion: This measure is related to congestion because it quantifies that extra amount of time a driver will spend traveling in peak traffic conditions caused by congestion compared to free-flow traffic conditions.

Operations: This measure relates to operations because a greater travel time index is associated with roadways that are over-capacity at peak traffic periods. This measure can help identify optimal condtions to better maximize the capacity of roadways.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2013)

(Chicago Metropolitan Agency for Planning 2016)

(Florida Department of Transportation 2016b)

(Garry 2013)

(Hymel 2014)

(Madison Metropolitan Planning Area 2011)

(New York State Association of Metropolitan Planning Organizations 2006a)

(Sacramento Area Council of Governments 2016a)

(Texas Transportation Institute 2010a)

(Texas Transportation Institute 2010a)

(Texas Transportation Institute 2015)

(Texas Transportation Institute 2015)

Planning Time Index (PTI)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** System Operations	

Indicator Overview

Description

This indicator measures the ratio of the 95th percent peak period travel time to the free flow travel time. A value of 2.50 means that for a 30 minute trip in light traffic, 75 minutes should be planned. This measure is computed for the AM peak period (6:00 a.m. to 9:00 a.m.) and PM peak period (4:00 p.m. to 7:00 p.m.) on weekdays. Averages across urban areas, road sections, and time periods are weighted by Vehicle Miles Traveled using volume estimates derived from FHWA's HPMS.

Human and Environmental Drivers

Environmental: Number of vehicles on the road, timing of vehicles on the road, availabilty of alternative modes of travel, timing of traffic lights.

Application

In the Basin

Not current in-basin use.

External uses

USDOT - FHWA uses TTI as one of the measures in the annual Urban Congestion Report.

Florida Department of Transportation uses “Planning Time Index” as an indicator for the 95th percentile of travel time index in its Anual Fiscal Year Report (Florida Department of Transportation 2016b).

Chicago Metropolitan Agency of Planning uses the “Planning Time Index” to determine the travel time reliability of their roadways relative particularly to congestion (Chicago Metropolitan Agency for Planning 2013).

Southern Nevada Regional Transportation Commission measures the “Extra Planning Time Necessary” to ensure a proper arrival time, relative to travel time reliability (Southern Nevada Regional Transportation Commission 2017).

Texas Transportation Institute uses “Planning Time Index” in their Urban Mobility Scorecard; they calculate the ratio of travel time or the worst day of the month compared to the time required to make the same trip at free-flow speeds (Texas Transportation Institute 2015).

Literature or Guidance Documents

No literature or guidance documents.

Relationship with Goal

Congestion: This measure is related to congestion because it quantifies that extra amount of time a driver will spend traveling in peak traffic conditions caused by congestion compared to free-flow traffic conditions.

Operations: This measure relates to operations because a greater travel time index is associated with roadways that are over-capacity at peak traffic periods. This measure can help identify optimal conditions to better maximize the capacity of roadways.

Variations of the Measure / Alternatives to the measures

Similar to the TTI, the “Planning Time Index” is the ratio of the 95th percentile travel time as compared to the free-flow travel time. The measure is computed during the AM and PM peak periods as defined in the TTI, and averages across urban areas, road sections, and time periods are weighted by VMT using volume estimates derived from FHWA's HPMS"; the Commuter Stress Index is the same as the Travel Time Index except it is based only on the peak direction of travel. This would be more like the traditional commuter experience of inbound in the morning and outbound in the evening.

References

(Chicago Metropolitan Agency for Planning 2013)

(Federal Highway Administration 2015)

(Florida Department of Transportation 2016b)

(Madison Metropolitan Planning Area 2011)

(Southern Nevada Regional Transportation Commission 2017)

(Texas Transportation Institute 2015)

Mode Share

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** System Operations	

Indicator Overview

Description

This indicator measures the mode of choice for travel. Land-use patterns, land-use policies and funding decisions influence the amount of non-auto travel. Neighborhoods and commercial centers that are designed for transit, walking, and biking, provide community benefits such as easy access to goods and services, savings in transportation costs, and improved health and wellbeing. Reducing reliance on automobile transportation reduces pollutants in the form of oil and particulates in the environment. This measure has many variations with the general goal of measuring the share of trips taken by various transportation modes (walk, bike, transit, SOV, carpool, etc.). For example, alternatives to Single-Occupancy Vehicle (SOV) mode share measures the percent of trips made in a specified region using transportation modes other than SOV; this includes: carpooling/ ridesharing, transit, biking, and walking. Variations of the mode share measure include measuring percent of trips made by a specific mode (bike, walk, transit, SOV), duration of time spent using various modes during weekday commute, percent of trips made by each mode based on commute and non-commute trips, percent of trips made by each mode based on socio-economic areas (LIHM vs. Non-LIHM areas).

Human and Environmental Drivers

Economic: Implementing congestion pricing for SOV to enter central business cores during peak hours, or to use high-occupancy toll (HOT) lanes can increase transit mode share; implementing variable area-wide per-mile charges to SOV in congested areas or variable tolls at freeway on and off ramps decreases SOV mode share; eliminating free employee parking lowers SOV mode share; implementing a parking tax on drivers using commercial parking lots decreases SOV mode share; employers providing parking cash-out programs allows employers to charge employees for parking and give them a pay increase to offset the cost of parking, this increases non-SOV mode share because some employees will change their mode to receive the pay increase; unbundling parking costs from housing increases non-SOV mode shares; employers providing free or subsidized transit passes, vanpool vehicles, or shuttle services to employees reduces SOV mode share; guaranteed-ride-home services from employers provide a set amount of free taxi rides to employers for unexpected trips home (work late, emergency errand, etc.) and reduces SOV mode share; employer ridematching services increases carpool mode share.

Physical: Providing high capacity transit can increase transit mode share; mixed use and transit oriented development reduces SOV mode share; imposing parking space maximums for developments can increase transit mode share; park-and-ride lots can increase carpooling mode share; implementing HOV lanes decreases SOV mode share; marketing TDM, transit options, and incentive program may decrease SOV mode share; mixed use development with high residential density near employers/ commercial centers increases non-SOV mode shares; employers providing free or subsidized transit passes, vanpool vehicles, or shuttle services to employees may reduce SOV mode share.

Application

In the Basin

TRPA seeks to increase non-auto mode share and is a primary goal of transportation planning and programs at Tahoe because of the economic, human health, and environmental benefits created when residents and tourists use alternative modes of transportation. Transportation policies and programs in Tahoe aim to provide a successful multi-modal transportation system that appeals to all users of the transportation system, supports mobility needs, and decreases dependency on the private automobile.

External uses

California Department of Transportation uses “Mode Share” as a performance measure by recognizing a doubling of mode share since 2000 and aims to triple cycling and double the amount of walking statewide by 2020. (California Department of Transportation 2016).

Oregon Metro applies “Mode Share” as a performance measure and aims to triple bicycling, walking, and transit ridership in a demonstration of compliance with the travel reductions required by Oregon’s state Transportation Planning Rule (Metro 2014).

Sacramento Area Council of Governments uses “Mode Share” and seeks to increase multi-modal/alternative/increase the choice of travel means throughout the region (Sacramento Area Council of Governments 2016b).

Sacramento Area Council of Governments looks to “Mode Share” as a key implementation tool in decreasing congestion as well as increasing investments into multi-modal systems (Sacramento Area Council of Governments 2016a).

San Francisco’s Metropolitan Transportation Commission’s Vital Signs Monitoring Report shows infographics of “Travel by Mode” and currently illustrates a general decrease in transit ridership (Metropolitan Transportation Commission n.d.).

San Diego Association of Governments provides infographics relative to “Modes of Travel” (San Diego Association of Governments 2015).

Chicago Metropolitan Agency for Planning uses “Mode of Travel” to recognize that the primary mode of travel in the area is single-occupant automobile driving, but aims to include a variety of mode share options to transportation (Chicago Metropolitan Agency for Planning 2010).
Washoe Regional Transportation Commission uses “Mode Share” to illustrate the need to integrate shared use bike paths and walkways (Washoe Regional Transportation Commission 2013).
Southern Nevada Regional Transportation Commission refers to “Mode Share” as “Mode Split” in its Access 2040 Plan. The Plan aims to enhance multimodal connectivity (Southern Nevada Regional Transportation Commission 2017).
Santa Barbara County Regional Transportation Commission has an explicit “Journey-to-Work by Mode Share” section which details the possibilities for mode share travel in the surrounding area. It is used specifically to gauge if and how residents are using alternative modes of transportation (Santa Cruz County Regional Transportation Commission 2014).
Denver Regional Council of Governments uses “Mode Share” by specifically outlining a goal of increasing non-SOV mode share by 35% by the year 2040 in its Metro Vision Plan (Denver Regional Council of Governments 2011).
California Rural Counties Task Force uses “Mode Share” on a county by county basis (California Rural Counties Task Force 2015a).
San Francisco County Transportation Authority analyzes “Mode Share” by setting a goal of reaching 20% bicycle mode share in the city by the year 2020 (San Francisco County Transportation Authority 2013a).
Transportation for America uses “Mode Shift/Mode Split” as a recommended system performance measure (Transportation for America 2015).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Congestion: This measure relates to congestion because decreasing SOV mode share can reduce congestion and maximize use of roadways when multiple riders are in one single vehicle.
Operations: This measure relates to operations because it determines the amount of trips made by each travel mode and can inform whether or not certain modes need more infrastructure to accommodate the number of trips/ users.

Variations of the Measure / Alternatives to the measures

Percent of Bike/Walking Trips to All Trips, Bike and Walk Mode Share in LHM and Non-LHM areas, LHM and Non-LHM Area Transit Mode Share, Drive Alone Mode Share, Transit Mode Share, Alternatives to SOV Mode Share, Commute Mode Share, Commute Mode Choice, Weekday Tours by Mode Commute Mode Share, and Non-Commute Mode Share

References

(Association of bay Area Governments & Metropolitan Transportation Commission 2013)

(California Department of Transportation 2016)

(California Rural Counties Task Force 2015a)

(California Rural Counties Task Force 2015c)

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2014)

(Denver Regional Council of Governments 2011)

(Metro 2014)

(Metropolitan Transportation Commission n.d.)

(Sacramento Area Council of Governments 2016a)

(Sacramento Area Council of Governments 2016b)

(San Diego Association of Governments 2015)

(San Francisco County Transportation Authority 2013b)

(Santa Barbara County Association of Governments 2016)

(Seattle Department of Transportation 2008)

(Southern Nevada Regional Transportation Commission 2017)

(Texas Transportation Institute 2013)

(Transportation for America 2015)

(Washoe Regional Transportation Commission 2013)

Person Miles Traveled (PMT)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** System Operations	

Indicator Overview

Description

This indicator measures the distance traveled by individuals by any mode, excluding bicycle and walking (e.g. If one person travels 5 miles by any mode, this would result in five person miles traveled. If three people travel five miles in the same car, this would result in fifteen person miles traveled).

Human and Environmental Drivers

Human: Social and recreational purposes account for the largest number of annual PMT by american households, followed by work commutes. Social/ recreational trips account for the largest number of daily person miles traveled, followed by family/personal errands. The majority of PMT are made by private vehicle, followed by transit..

Application

In the Basin

No current in-basin use.

External uses

Denver Regional Council of Governments uses "Person Miles Traveled" in its Annual Report on Traffic to help measure current and future congestion in and around the area (Denver Regional Council of Governments 2011).

Literature or Guidance Documents

No literature or guidance documents.

Relationship with Goal

Congestion: This measure quantifies the usage of a certain geographic area/ corridor. This measure of usage can be used to determine the capacity needed to ensure efficient travel within the specified area/ corridor. Thus, this measure is a tool to improve congestion.

Operations: This measure relates to operations because it quantifies the person hours spent traveling by various modes which can determine the need for more infrastructure based on the mode.

Quality of Life: This measure relates to quality of life because it measures the amount of miles traveled by trip type. Shorter trips generally allow for more time spent doing activities whether for work or play.

Variations of the Measure / Alternatives to the measures

Person Miles Travelled on Transit and Person Miles Travelled (No Transit).

References

(Denver Regional Council of Governments 2011)

(Denver Regional Council of Governments 2016)

(Federal Highway Administration 2009)

("Table 2-4 Annual Person-Trips and Person-Miles Traveled by Mode: 1995, 2001, and 2009" 2015)

(Tennessee Department of Transportation 2016)

("Transportation Research Thesaurus" 2017)

(U.S. Department of Transportation n.d.)

Person Hours Traveled (PHT)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** System Operations	

Indicator Overview

Description

This indicator measures the time spent traveling by individuals, regardless of mode but excluding time spent traveling by transit.(e.g. If one person travels for two hours by any mode other than transit, this would result in two person hours traveled. If three people travel for 2 hours in the same car, this would result in six person hours traveled). A variation of this measure is Percent of Population Engaging in more than 20 minutes of daily transportation-related physical activity.

Human and Environmental Drivers

Environmental: Smaller MSAs have less PHT.

Human: People spend most of their weekday travel time on work-related activities, personal care, caring for or helping household members, caring for or helping non-household members, socializing and leisure, and education-related activities. People spend most of their weekend and holiday travel time on socializing and leisure, using government services and civic obligations, consumer purchases, personal care, and caring for and helping household members.

Application

In the Basin

No current in-basin use.

External uses

Denver Regional Council of Governments uses "Person Hours Traveled" in its Annual Report on Traffic to help measure current and future congestion in and around the area (Denver Regional Council of Governments 2011).

Literature or Guidance Documents

Relationship with Goal

Congestion: This measure quantifies the usage of a certain geographic area/ corridor. This measure of usage can be used to determine the capacity needed to ensure efficient travel within the specified area/ corridor. Thus, this measure is a tool to improve congestion.

Operations: This measure relates to operations because it quantifies the person hours spent traveling by various modes which can determine the need for more infrastructure based on the mode.

Quality of Life: This measure relates to quality of life because it measures the amount of time spent traveling by trip type. Shorter trips generally allow for more time spent doing activities whether for daily errands, work or play.

Variations of the Measure / Alternatives to the measures

Person Hours Traveled (No Transit).

References

(Denver Regional Council of Governments 2011)

(Denver Regional Council of Governments 2016)

(Federal Highway Administration 2009)

("Table 2-3: Average Weekday and Weekend Time Spent Traveling by Persons Engaged in Selected Activities: 2013" 2015)

("Transportation Research Thesaurus" 2017)

Person Trips

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** System Operations	

Indicator Overview

Description

This indicator measures the number of trips made by individuals in a specified geographic area/ corridor regardless of mode. This can also be measured using Trips per Capita based on mode.

Human and Environmental Drivers

Human: Social and recreational purposes account for the largest number of annual personal trips by american household, followed by work commutes. Family/ personal errands accounted for the most daily person trips, followed by social/ recreational trips. The majority of person trips are made by private vehicle, followed by transit, walking, and bicycling.

Application

In the Basin

No current in-basin use.

External uses

Sacramento Area Council of Governments uses "Person Trips" to measure how many trips are taken by alternate mode of transportation (i.e. transit, bike, walk, etc.) as well as how many person trips are taken during weekday commute times (Sacramento Area Council of Governments 2016b).

Sacramento Area Council of Governments analyzes the amount of "Weekday Person Trips" that occur by mode of transit, walk, or bicycle (Sacramento Area Council of Governments 2016a).

Literature or Guidance Documents

No literature or guidance documents.

Relationship with Goal

Congestion: This measure quantifies the usage of a certain geographic area/ corridor. This measure of usage can be used to determine the capacity needed to ensure efficient travel within the specified area/ corridor. Thus, this measure is a tool to improve congestion.

Variations of the Measure / Alternatives to the measures

Transit Trips per Person; Transit, Walk, and Bike Trips per Capita; Weekday Person Trips by Transit, Walk, and Bike Modes; and Weekday Non-Commute Trips by Mode.

References

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2013)

(Federal Highway Administration 2009)

(Federal Highway Administration 2011)

(Sacramento Area Council of Governments 2016a)

(Sacramento Area Council of Governments 2016b)

("Table 2-4 Annual Person-Trips and Person-Miles Traveled by Mode: 1995, 2001, and 2009" 2015)

Multi-Modal Service Quality (MMLOS) (includes mobility and travel time reliability)

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory:** System Operations	

Indicator Overview

Description

This indicator measures mode-specific and blended LOS for transit, automobile, pedestrian, and bicycle. This measure factors in mode accommodation, comfort, availability, mobility, and reliability. Considers the travel times and costs by modes and the variability in travel times by modes.Varioations of this measure are multi-Modal Travel Mobility, and Multi-Modal Travel Reliability.

Human and Environmental Drivers

General:

Environmental: Improving traffic signal synchronization inreases travel time reliability; transit signal priority and queue jumps increases travel time reliability; establishing regional traffic/ weather incident management plans increases travel time reliability; providing real-time traffic information to drivers increases travel time reliability.

Transit LOS:

Environmental: Greater transit frequency increases TLOS; including bus stop amenities (lighting, benches, shelter from weather) increases TLOS; longer boarding times create longer delays at transit stops which decreases TLOS; higher passenger loads decrease TLOS; transit prioroity lanes increase TLOS.

Bike LOS:

Environmental: Number of right hand side driveways negatively impacts BLOS; vehicle volume negatively impacts BLOS; vehicle speed negatively impacts BLOS; pavement in good repair positively impacts BLOS; greater bike lane/shoulder width increases BLOS; street parking occupancy decreses BLOS; increased segement length (length between light signal intersections) improves BLOS.

Pedestrian LOS:

Environmental: Reducing pedestrian-vehicle and pedestrian-bike interaction increases PLOS; seperate bike paths increases PLOS; wider sidewalks increases PLOS; high-visibility crossing facilities (e.g. white zebra-stripe crosswalks) increase PLOS; more turning traffic decreases PLOS; ADA-approved curb cuts improve PLOS; decreasing crosswalk signal delay times/ implementing pedestrian signal prioritization improves PLOS; greater roadway width decreases PLOS; higher number of auto lanes decreases PLOS; smaller building setbacks/ building oriented toward the street increases PLOS; short block lengths increase PLOS; greater intersection density/street connectivity increases PLOS; amount of sidewalks in good repar increases PLOS; wider crosswalks increases PLOS; greater vehicle volumes decrease PLOS; higher vehicle speeds decrease PLOS; presence of barriers between pedestrians and vehicles (trees, bollards, etc.) increases PLOS; greater distance between vehicles and pedestrians increases PLOS; flat topagraphy increases PLOS; increased signage and maps improves PLOS; presence of shade trees and awnings improve PLOS; street lights improve PLOS

Auto LOS:

Environmental: Increased travel speed increases ALOS; decreased congestion/ travel time increases ALOS; low volume to capacity ratio increases ALOS; traffic signal synchronization increases ALOS; lower peak hour factor (peak hour volume/ volume during the peak 15 minutes of flow) increases ALOS.

Application

In the Basin

No current in-basin use.

External uses

California Department of Transportation uses “Multimodal Transportation Modes” as a substantial source of travel for residents (California Department of Transportation 2016).

California Department of Transportation speaks to “Multimodal Transportation” as the future of increasing mobility throughout the state (California Department of Transportation 2010)

Community Design and Architecture based out of Oakland, CA analyzes the interconnectivity of different modes of transportation and outlines “Multimodal Usage” for different modes such as measuring pedestrian proximity to transit systems and the potential lack of automobile accessibility (Community Design and Architecture n.d.)

City of Aspen, Colorado uses “Multimodal Quality” by creating a TDM and MMLOS Interactive Tool that helps users analyze potential problems that may arise in their plan due to the potential increase in volume that the bridge entering the city may or may not have the capacity to carry (City of Aspen n.d.)

The City of Bellevue Washington's Department of Planning and Community Development outlines a design strategy for a "Grand Connection" Plan which clearly states the city's "commitment to multi-modal transportation, connectivity, and enhanced quality of life" (City of Bellevue 2016).

Fehr and Peers focuses on "Multimodal Safety" as well as the interconnectivity of transit, pedestrian, bicycle, automobile, and goods traffic and the balanced use of them all through the creation of a matrix of uses on horizontal axis and modal priorities (Fehr and Peers n.d.)

San Francisco Municipal Transportation Agency aids "Multimodal Level of Service" by installing Green Wave monitors for their bicycle and transit networks to ensure minimal red lights and timely arrivals for those choosing to use alternate modes of transportation (San Francisco Municipal Transportation Agency 2015).

Literature or Guidance Documents

California Department of Transportation recommends the use of the "Multi-modal Travel Mobility", Multi-modal Travel Reliability", and "Multi-modal Service Quality (MMLOS)" measures to assess how reliable the mobility of all modes is (California Department of Transportation 2010).

Relationship with Goal

Congestion: This measure relates to congestion because MMLOS takes into account the flow/ mobility of all modes of traffic.

Operations: This measure relates to operations because MMLOS can determine whether or not the infrastructure of all modes has the capacity to accomodate the volume of users for each mode.

Variations of the Measure / Alternatives to the measures

Multi-Modal Travel Mobility, Multimodal Travel Reliability, and Multi-Modal Service Quality

References

(Bixhaku & Malenkovska 2013)

(California Department of Transportation 2010)

(California Department of Transportation 2016)

(Community Design and Architecture n.d.)

(Elias 2010)

(Hillsborough Metropolitan Planning Organization 2014)

(Metropolitan Transportation Commission 2016)

(San Francisco Municipal Transportation Agency 2015)

(Santa Cruz County Regional Transportation Commission 2014)

("Table 2-4 Annual Person-Trips and Person-Miles Traveled by Mode: 1995, 2001, and 2009" 2015)

(Toru Hagiwara et. al. 2005)

(Transportation for America 2015)

(Transportation Research Board 2013)

(Victoria Transport Policy Institute 2017a)

(Victoria Transport Policy Institute 2017b)

("Who We Are" n.d.)

Travel Time

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: System Operations

Indicator Overview

Description

This indicator measures the duration of a trip from one point to the next dependent upon volume of vehicles on the road, opportunities for alternatives, and potential congestion caused. Several variations of this measure are the Disadvantaged Population Average Trip Time vs. Regional Average Time as well as Travel Time for Freight and Passenger Cars.

Human and Environmental Drivers

Environmental: Increase in travel time results in an increase in vehicle hours traveled. Increase in vehicle hours traveled results in an increase in harmful emissions, assuming a substantial amount of electric or alternative fuel based vehicles are not in use.
Economic: Increase in travel time increases costs on the user primarily. Increase in travel time increases willingness of people to pay to decrease travel time (up to $30 based on San Diego I-15 study). Increase in price increases inequality of wealth distribution thus disadvantaging lower income travelers.
Human: An increase in travel time variability increases the probability of disutility. Increase in variability increases the cost to the user. Live and work proximity can reduce time spent commuting, can make alternative modes of transportation more appealing such as biking, walking and transit.

Application

In the Basin

No current in-basin use.

External uses

Texas Transportation Institute analyzes the initial use of "Total Travel Time" as a performance measure in an effort to reduce congestion (Texas Transportation Institute 2010b).
Transportation for America's claims that certain DOTs and MPOs are beginning to replace LOS measurements with variables of "Travel Time" (Transportation for America 2015).
City of Pasadena's Department of Transportation uses "Auto Travel Time" for significant arterials that are set to be determined by the city's Dynamic Traffic Assessment Model (City of Pasadena Department of Transportation 2014).
2012 Metropolitan Plan for Mid-Ohio seeks to improve neighborhood stability by weighing disadvantaged neighborhoods "Average Travel Time" against the regional average Travel Time (Mid-Ohio Regional Planning Commission 2011).
Mid-Ohio Regional Transportation Commission 2016 to 2040 Columbus Area Metropolitan Transportation Plan analyzes the "Accessibility to Jobs" based on Travel Time, ways to minimize the necessity of a buffer for Travel Time expectancy, and many other factors relevant to measuring Travel Time (Mid-Ohio Regional Planning Commission 2016).
Denver Regional Council of Governments uses "Travel Time Variables" relative to the difference of travelling during peak hours of traffic and free flow hours between the year 2015 and the set goal year of 2040 (Denver Regional Council of Governments 2016).
Santa Barbara County Association of Governments uses "Travel Time" in terms of economic vitality for the region (Santa Barbara County Association of Governments 2016).
San Mateo County analyzes "Travel Time Variances" between different modes of transportation during different hours of the day and the week (City/County Association of Governments of San Mateo County 2015).
Maricopa Association of Governments analyzes many variations of "Travel Time" such as the relationship between the throughput of vehicles in regards to peak Travel Time (Maricopa Association of Governments 2008).
San Diego Forward Plan analyzes "Travel Time" in a variety of means throughout key corridor regions and regions deemed less susceptible to high congestion as well (San Diego Association of Governments 2015).
Carson Area for Transportation Planning is primarily concerned with discovering the means for which to shorten (or at the very least maintain) "Travel Times" throughout the region (Carson Area Metropolitan Planning Organization 2016).
New York State Association of Metropolitan Planning Organizations adds "Travel Time" measures to its list of key performance measures (New York State Association of Metropolitan Planning Organizations 2006b).
2040 Transportation Plan for the State of California deals with "Travel Time" in terms of ensuring that Travel Times will be reduced through the implementation of alternate modes of transportation such as the introduction of the nation's first high-speed rail system spanning from the Bay Area to Southern California regions around Los Angeles (California Department of Transportation 2016).

Literature or Guidance Documents

Texas Transportation Institute emphasizes the use of communication in order to adequately reduce the total travel time (Texas Transportation Institute 2010b).
Transportation for America recommends using travel time for freight and passenger cars as key performance measure (Transportation for America 2015).

Maricopa Association of Governments recommends using travel time determinants for several different agencies. For example, the Washington State Department of Transportation is using travel time as a guide for aiding general purpose traffic as well as HOV traffic and freight (Maricopa Association of Governments 2008).

New York State Association of Metropolitan Planning goes through a list of options, each uniquely their own, and breaks down the elements of travel time and their impact on a variety of transportation planning performance concerns (New York State Association of Metropolitan Planning Organizations 2006b).

Relationship with Goal

Automobile: This measure relates to the automobile goal because it analyzes invidual travel time which is typically taken by car.

Congestion: This measure relates to the congestion goal because it seeks to develop means (be it through minimizing road traffic or creating alternate options to the primary mode of vehicular travel) to decrease congestion.

Operations: This measure relates to the operations goal because it necessitates management of different kinds of travel to decrease travel time.

Variations of the Measure / Alternatives to the measures

Percentage of Travel Time in Delayed Conditions, Travel Demand Model Established Travel Times, Travel Time for Freight and Passenger Cars, Automobile Travel Time, Travel Time During Peak Hours, Total Travel Time, Transit Travel Time, Travel Time at Peak Hours (Alternative Modes), Average Vehicle Trip Time for Low Income Communities, and Disadvantaged Population Average Travel Time vs. Regional Average Travel Time.

References

(Brownstone et al. 2003)

(California Department of Transportation 2016)

(Carson Area Metropolitan Planning Organization 2016)

(City of Pasadena Department of Transportation 2014)

(City/County Association of Governments of San Mateo County 2015)

(Denver Regional Council of Governments 2016)

(Jabali et al. 2012)

(Maricopa Association of Governments 2008)*

(Mid-Ohio Regional Planning Commission 2011)

(Mid-Ohio Regional Planning Commission 2012)

(Mid-Ohio Regional Planning Commission 2016)

(New York State Association of Metropolitan Planning Organizations 2006b)*

(Noland & Polak 2002)

(Roy et al. 2004)

(San Diego Association of Governments 2015)

(Santa Barbara County Association of Governments 2016)

(Texas Transportation Institute 2010b)*

(Transportation for America 2015)*

Transit

Miles of Dedicated Transit Lanes

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory**: Transit	

Indicator Overview

Description

"Miles of Dedicated Transit Lanes" measures the current amount of (and potential for) roadways dedicated to purely transit. Lanes dedicated purely to transit have proven to garner greater success rates than those with dual lanes for buses and automobiles.

Human and Environmental Drivers

Economic: Transit Lanes dedicated to buses decreases costs in comparison to light rail systems. Creation of dedicated transit lanes increases initial costs per mile of implementation. Maintenance of buses increase costs. **Environmental:** Integration of Transit Dedicated Lanes decreases total air pollution by allowing traffic of automobiles and buses to run more fluidly. This also decreases air pollution by creating a functional and efficient transit system that is competitive with other modes and more prone to utilization, thus decreasing the total number of single-occupancy rider automobiles on the road. Dedicated Transit Lanes increases ridership. Dual integrated Transit and Automobile Lanes decreases ridership.

Application

In the Basin

No current in-basin use.

External uses

San Francisco County Transportation Authority uses the "Miles of Dedicated Transit Lanes" for one particular lane in order to remove problems with automobile traffic that the system was otherwise facing (San Francisco County Transportation Authority 2013b).

Literature or Guidance Documents

No literature or guidance documents.

Relationship with Goal

Operation: This measure relates to the operation goals because it deals directly with the establishment of lanes dedicated to transit (measured on a per mile basis).

Congestion: This measure relates to the congestion goal because lanes dedicated to buses can decrease total congestion because they increase overall transit efficiency, which encourages people to forgo their cars in favor of transit. **Connectivity**: This measure deals directly with the transit connectivity goal because it analyzes the potential benefits of integrating lanes dedicated to transit.

Variations of the Measure / Alternatives to the measures

Miles of Protected Transitways.

References

(Center for Clean Air Policy 2012)

(Clift 2017)

(Lorne Matalon 2016)

(San Francisco County Transportation Authority 2013b)

(Transportation Research Board Washington D.C. 2003)

Park and Ride Utilization

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory**: Transit	

Indicator Overview

Description

"Park and Ride Utilization" measures current level of transit stations with the option to park an automobile and take transit elsewhere as well as the potential for implementation of park and ride operative systems.

Human and Environmental Drivers

Environmental: By reducing the distance a single-occupant vehicle has to travel and thus decreasing overall congestion, total emissions are reduced which increases air quality. It is important to recognize that the most efficient use of park and ride systems is by implementing stations on the edge of highly urbanized areas. The more dense an area that the park and ride system is located, the less optimal it becomes.

Human: Park and Ride systems increase mobility by offering a convenient hub for users to drop off their cars and board transit. This system solves the first-last mile connection issue many transit networks face.

Economic: Allowing users a way to utilize transit looks to saving costs potentially on parking in a more expensive, meter-based, urban destination as well as money that would be spent on gas for a certain automobile. However, these two are conditionally dependent on the total distance traveled by the user in both the transit based transportation as well as automobile.

Application

In the Basin

No current in-basin use.

External uses

Denver Regional Council of Governments uses the "Utilization of Park-n-Ride Systems" measure within the Denver Region during 2015 and the projected year of 2040 (Denver Regional Council of Governments 2016).

Literature or Guidance Documents

No literature or guidance documents.

Relationship with Goal

Automobile: This measure relates to the automobile goal of connectivity because it looks for ways of mitigating total VMT by automobiles.

Transit: This measure relates to the transit goal because it looks into a dual integrating system of replacing portions of automobile travel with travel via transit.

Operations: This measure relates to the operations goal because it focuses on analysis as to where transit systems are most optimal followed by the crucial step of implementation.

Congestion: This measure related to the congestion goal because park and ride systems are well known practical ways of minimizing vehicular traffic.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Denver Regional Council of Governments 2016)

(Parkhurst 1999)

(Parkhurst 2000)

(San Francisco Bay Area Rapid Transit District 2017)

(TRANSLink 2017)

Transit Running Time/Headway Consistency

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory**: Transit	

Indicator Overview

Description

"Transit Running Time/Headway Consistency" measures the frequency of transit and the impacts that has on ridership. Economic and environmental factors additionally play into the headway analysis. A variation of transit running time/headway consistency is stop frequency.

Human and Environmental Drivers

Larger vs. Shorter Headways: A shorter headway signifies a more frequent transit service, which is both more costly and complicated to operate. Conversely, a large headway signifies a less frequent transit system and higher wait times and fewer trip options for passengers. Less frequent transit routes are cheaper to operate and require fewer capital assets, but riders are more attracted to routes that operate at high frequencies because there are more trip options and shorter wait times. In the long run, shorter headways, though they do require more consistent timing and investment, result in higher levels of utility by residents. This in turn results in movement away from automobile usage and towards transit usage, meaning improved air quality and monetary savings for the user.

Human: Longer wait times deter passengers and decrease overall transit use. Shorter headways are more convenient for users because higher frequencies on transit routes increases the total number of potential trips and limits wait time between buses.

Application

In the Basin

No current in-basin use.

External uses

Tahoe Transportation District emphasizes the importance of maintaining "Consistent Transit Headways" in order to maintain constant utility (Tahoe Transportation District 2017).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Air Quality: This measure relates to the air quality goal because it deduces the means for which air quality will be improved through transit usage in the long run.

Transit: This measure relates to the transit goal because it addresses transit efficiency.

Operations: This measure relates to the operations goal because it manages the consistency of transit systems in the area to ensure that they are running in a timely manner.

Variations of the Measure / Alternatives to the measures

Location Efficiency.

References

(Alta Planning and Design 2017)

(Dennis Romero 2005)

(Guihaire & Hao 2008)

(Strathman et al. 1999)

(Tahoe Transportation District 2017)

(Taylor et al. 2009)

Transit Speed

Measure at a Glance	
Category: Operations and Congestion Management **Subcategory**: Transit	

Indicator Overview

Description

Transit Speed" measures the optimal speed for tansit based transportation and the different factors which may affect transit speed/efficiency.

Human and Environmental Drivers

Environmental: Maintaining a consistent speed mediates the amount of harmful emissions entering the atmosphere.
Economic: Maximizing speed can increase headways. Increasing headways will maximize utility of the provided fleet, provided that the fleet is not over utilized and there would then be a need for a substantial amount of reconstruction of the fleet. It is important to identify that by maximizing speed, it is meant primarily to maximize speed optimal to fuel efficiency and user need rather than simply running the vehicles as quick as possible.

Application

In the Basin

No current in-basin use.

External uses

San Francisco County Transportation Authority uses the "Transit Speed" measure in a variety of means all relating to the idea of maintaining consistency in transit utility (San Francisco County Transportation Authority 2013a).
San Francisco County Transportation Authority uses the "Speed of Transit Operating Systems" measure to understand the impact on operating costs. (San Francisco County Transportation Authority 2013b).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Transit: This measure relates to the transit goal because it handles the appropriate speed for transit transportation.
Air Quality: This measure relates to the air quality goal because transit speed correlates to cost and fuel efficiency and thus the quality of air.

Variations of the Measure / Alternatives to the measures

Transit Speed Variability and Average Transit Time

References

(American Public Transportation Association 2013)

(Estrada et al. 2011)

(Ke et al. 2011)

(Los Angeles County Metropolitan Transportation Authority 2010)

(San Francisco County Transportation Authority 2013a)

(San Francisco County Transportation Authority 2013b)

Transit On-Time Performance

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Transit

Indicator Overview

Description

This indicator measures the frequency with which transit arrives or leaves a time point as scheduled. This measure relates to congestion because transit is often late due to heavy traffic on routes.

Human and Environmental Drivers

Transit signal priority coupled with automatic vehicle locator (AVL) systems improves on-time performance for transit; queue-jumper lanes improve on-time performance for transit; traffic signal synchronization improves on-time transit performance; passenger overloading decreases on-time performance for transit; increased bus capacity and/or frequency decreases passenger overloading which decreases boarding times which improves on-time performance for transit; transit-only lanes improve on-time performance for transit; reducing roadway congestion improves on-time performance for transit (see Time Spent in Congestion), reducing SOV mode share increases on-time performance for transit (see Alternatives to SOV Mode Share).

Application

In the Basin

No current in-basin use.

External uses

New York State Association of Metropolitan Planning Organizations uses the “Congestion Impact” measure on transit on-Time Performance (New York State Association of Metropolitan Planning Organizations 2006a).
Transportation for America has a category of recommended system performance measure under which “Transit On-Time Performance” falls (Transportation for America 2015).
Maricopa Association of Governments analyzes “Transit On-Time Performance” and the impacts of On-Time Performance in several different parts and determines the needs for improvements accordingly (Maricopa Association of Governments 2008).
Madison Metropolitan Planning Area uses the “Transit On-Time Performance” measure by seeking to track transit based on schedule versus the actual time (Madison Metropolitan Planning Area 2011).
Chicago Metropolitan Agency of Planning uses the “System Reliability” measure to understand the reliability of the transit network in the area (Chicago Metropolitan Agency for Planning 2013).
Carson Area Metropolitan Planning Organization uses the “Transit Performance” measure to understand on-time performance, which was able to run consistently 96.5% of the time (Carson Area Metropolitan Planning Organization 2016).

Literature or Guidance Documents

New York State Association of Metropolitan Planning Organizations recommends the use of the Transit On-time Performance measure to assess transit travel reliability (New York State Association of Metropolitan Planning Organizations 2006b).

Relationship with Goal

Congestion: This measure quantifies the frequency at which transit is performing on-time. This relates to congestion because improved congestion management practices will improve on-time performance for transit.

Variations of the Measure / Alternatives to the measures

No variations identified.

References

(Carson Area Metropolitan Planning Organization 2016)

(Chicago Metropolitan Agency for Planning 2010)

(Chicago Metropolitan Agency for Planning 2013)

(Chicago Metropolitan Agency for Planning 2016)

(Garry 2013)

(Hymel 2014)

(Madison Metropolitan Planning Area 2011)

(Madison Metropolitan Planning Area 2011)

(Maricopa Association of Governments 2008)

(Metro 2014)

(New York State Association of Metropolitan Planning Organizations 2006a)

(Sacramento Area Council of Governments 2016a)

(Seattle Department of Transportation 2008)

(Southern Nevada Regional Transportation Commission 2017)

(Transportation for America 2015)

(Washoe Regional Transportation Commission 2013)

Transit Cost Recovery

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Transit

Indicator Overview

Description

“Transit Cost Recovery” measures the revenue obtained by the transit services, also known as farebox recovery. Factors of this measure are listed below:

Transit Passengers per Revenue Hour: Measures the number of transit users per operation (revenue) hour of the transit service (i.e. productivity). Productivity measures the effectiveness of the transit service and gives transit providers insight with regards to if they should alter the frequency, routes, or service cost of their transit service.

Transit Cost per Revenue Mile: Measures the total operating cost that the transit provider must pay per operation (revenue) mile. This is related to the operations goal because transit providers must adjust their services to maintain healthy operation costs and adequate revenues to ensure continuous operation and improvement of the transit service.

Transit Cost per Revenue Hour: Measures the total operating cost that the transit provider must pay per operation (revenue) hour. This is related to the operations goal because transit providers must adjust their services to maintain healthy operation costs and adequate revenues to ensure continuous operation and improvement of the transit service.

Transit Farebox Recovery Rate: Measures the ratio of operating costs that are covered by the fares paid by passengers to use the transit service. This relates to the operations goal because transit service providers use this measure to adjust their services to ensure their farebox recovery rate is high.

Subsidy per Passenger: Measures the total operating cost that the transit provider must pay per passenger. This is related to the operations goal because transit providers must adjust their services to maintain low operation costs to obtain adequate revenues that will ensure continuous operation and improvement of the transit service.

Passenger Revenue: Measures the fare paid by each transit passenger and the revenue obtained from these passengers. Passenger revenue includes the base fare, zone premiums, express service premiums, and extra cost of transfers. This is related to the operations goal because transit providers must adjust their services to maintain low operation costs to obtain adequate revenues that will ensure continuous operation and improvement of the transit service.

Human and Environmental Drivers

General: Ridership increases do not directly relate to farebox recovery however generally the overall goal of a public transit system is to provide an option to the automobile. Several factors do however have a dirct relationship to ridership. Increase in population may not lead to an increase in ridership if population grows outward (sprawl, low density, suburban) due to lack of transit service coverage; If population growth is focused on major corridors/ high density areas, transit ridership will increase; total population can have a positive effect on transit ridership (note: population growth vs. total population). Decreases may occur in ridership if transit fares are increased too much. Management strategies such as reducing parking availability in central business districts/ downtown areas can increase transit ridership; increasing housing and employment density may increase transit ridership (note: ridership eventually plateaus once density reaches about 20-30 people per acre); increases in public funding for transit services increases transit ridership by increasing public awareness of the facilities and providing funding for necessary transit facilities; providing special discounts to certain demographics (e.g. students, seniors, etc.) without expanding the service increases transit ridership; improved service information, on-street service, station safety, customer service, safety, cleanliness, and service marketing all increase transit ridership; use of real-time transit information (Intelligent Transportation Systems (ITS)) increases ridership.

Transit Cost per Revenue Mile: Higher fuel costs increase cost per revenue mile, replacing bus fleet with fuel efficient/ hybrid buses reduces cost per revenue mile; lower maintenance/ repair costs decrease cost per revenue mile.

Transit Cost per Revenue Hour: Higher fuel costs increase cost per revenue hour, replacing bus fleet with fuel efficient/ hybrid buses reduces cost per revenue hour; lower maintenance/ repair costs decrease cost per revenue hour.

Transit Farebox Recovery: Higher fuel costs decrease farebox recovery rate, replacing bus fleet with fuel efficient/ hybrid buses increases farebox recovery rate; lower maintenance/ repair costs increase farebox recovery;

Subsidy per Passenger: Higher fuel costs increase cost per passenger, replacing bus fleet with fuel efficient/ hybrid buses reduces cost per passenger; lower maintenance/ repair costs decrease cost per passenger.

Passenger Revenue: Higher fuel costs increase cost per passenger, replacing bus fleet with fuel efficient/ hybrid buses reduces cost per passenger; lower maintenance/ repair costs decrease cost per passenger; differentiated fares better reflects the cost of the service and increases passenger revenue; flat fares are simpler to administer and my increase ridership and passenger revenue; electronic fare collection increases ease of use for passenger and may increase ridership and passenger revenue.

Application

In the Basin

TRPA uses "Transit Cost Per Revenue Mile", "Transit Cost Per Revenue Hour", and "Transit Farebox Recovery Rate" to measure the level of transit cost recovery within the basin (Tahoe Regional Planning Agency 2014)

External uses
Riverside County Transportation Commission locates the "Costs for Transit" measure under transit performance costs of operating and maintaining transit vehicles per revenue hour (Riverside County Transportation Commission 2011) **California Counties Rural Task Force** uses the "Operating Costs" measure for both travel distance and time as well as farebox revenue operations (California Rural Counties Task Force 2015a). **California Counties Rural Task Force** uses the "Cost-Benefit Analysis" measure to understand different factors around transit such as safety and congestion (California Rural Counties Task Force 2015b). **San Diego Association of Governments** provides a list in the appendix of its transportation plan listing many different "Types of Transit Costs" (San Diego Association of Governments 2015). **Sacramento Area Council of Governments** lists that the "Cost of Operation and Maintenance for Transit Vehicles" consumes about 67% of transportation investment (Sacramento Area Council of Governments 2016a). **Tennessee Department of Transportation's** 25 Year Plan includes analysis of "Transit Costs" of $132 million to provide federal transit funding, non-motorized accommodations, grant funds to local municipalities, and fund TDM programs across the state.(Tennessee Department of Transportation 2016). **The Carson Area Metropolitan Planning Organization** uses the "Transit Performance Measure by Cost" measure to understand factors such as the cost per trip of each transit vehicle (Carson Area Metropolitan Planning Organization 2016).
Literature or Guidance Documents
No literature or guidance documents identified.
Relationship with Goal
Operations: This measure relates to operations because it informs transit providers of the revenue/ costs that are associated with their transit service. This data is critical when determining how to adjust services and pricing to improve the quality and profitability of the service. **Congestion:** This measure relates to congestion because transit ridership and greater transit cost recovery can reduce congestion.
Variations of the Measure / Alternatives to the measures
Transit Passengers per Vehicle Revenue Hour, Transit Passengers per Vehicle Revenue Mile, Transit Passenger Miles per Vehicle Revenue Hour, Cost per Revenue Hour/Mile/Trip for Transit, Farebox Recovery for Transit, and Benefit/Cost Ratio of Transportation Investments.
References
(American Public Transportation Association 2017) (Armbruster 2010) (California Rural Counties Task Force 2015a) (California Rural Counties Task Force 2015b) (Carson Area Metropolitan Planning Organization 2016) (Chicago Metropolitan Agency for Planning 2013) (Fleishman 2010) (Maryland Transit Administration 2010) (Metropolitan Transportation Commission n.d.) (Nevada Department of Transportation n.d.) (Riverside County Transportation Commission 2011) (Sacramento Area Council of Governments 2016a) (Sacramento Area Council of Governments 2016b) (San Diego Association of Governments 2015)

(Taylor & Fink 2003)

(Tennessee Department of Transportation 2016)

(Transit Cooperative Research Program 1998)

(Transportation Research Board 2003)

Transit Vehicle Availability

Measure at a Glance	Evaluation Factors
Category: Operations and Congestion Management **Subcategory:** Transit	**Performance Measure Type**: **Required by**: **Used by:** **SMART Amenable (TRPA/TMPO):** **Reporting Readiness**: **Composite/Index Measure**: **Relationship with Goal:** **Existing Tahoe Measure:**

Indicator Overview

Description

This indicator measures the number of vehicles that a transit agency has available for use during revenue hours. A variation of this measure is the Transit Vehicles Operating at Maximum Service. This is a measurement of operations because transit providers must use this data to ensure they are supplying the appropriate number of vehicles to provide their service to the public.

Human and Environmental Drivers

Human: Transit service demand is a large determinant of the amount of transit vehicles that will be operating in the given area.

Economic: Transit Vehicle Availability can be affected based on the amount of funding available for repairs, maintenance, and regular operation.

Application

In the Basin

TRPA currently uses the "Transit Vehicles Available at Maximum Service" and "Transit Vehicles Operating at Maximum Service" measures to monitor the total level of transit vehicle availability (Tahoe Regional Planning Agency 2014).

External uses

Nevada Department of Transportation uses the "Availability of Transit" measure throughout all urban areas, with larger urbanized areas such as Las Vegas and Reno having their own specific public transit systems designed through the Metropolitan Planning Organizations (Nevada Department of Transportation n.d.).

Literature or Guidance Documents

No literature or guidance documents identified.

Relationship with Goal

Operations: Transit providers use this measure to gauge whether they need to increase or decrease the total number of transit vehicles available to increase quality and profitability of their service.

Variations of the Measure / Alternatives to the measures

Transit Vehicles Available at Maximum Service and Transit Vehicles Operating at Maximum Service.

References

(American Public Transportation Association 2017)

(Nevada Department of Transportation n.d.)

(Transportation Research Board 2013)

Transit Level of Service (TLOS)

Measure at a Glance

Category: Operations and Congestion Management
Subcategory: Transit

Indicator Overview

Description

This indicator measures the comfort, safety, ease of mobility, and frequency of transit services. This measure relates to transit connectivity and safety as this measure factors in transit service connectivity and transit safety.

Human and Environmental Drivers

Environmental: Greater transit frequency increases TLOS; bus stop amenities (lighting, benches, shelter from weather) increases TLOS; longer boarding times create longer delays at transit stops which decreases TLOS; higher passenger loads decrease TLOS; transit prioroity lanes increase TLOS.

Application

In the Basin

No current in-basin use.

External uses

California Department of Transportation on providing transit service through the "First Mile-Last Mile" measure which focuses on constructing valuable transit facilities (California Department of Transportation 2016).
Tennessee Department of Transportation uses "Transit Level of Service" by analyzing the potential increase in want/need for transit services in its 25 Year Transportation Plan (Tennessee Department of Transportation 2016).
New York State Association of Metropolitan Planning Organizations uses the "Rural Transit Provider Statistics" measure to understand the number of providers and counties served by the transit service (New York State Association of Metropolitan Planning Organizations 2006a).
Madison Metropolitan Planning Area uses the "Potential Operating Deficiencies" measure to understand transportation operations, specifically their shortcomings. (Madison Metropolitan Planning Area 2011).
Los Angeles County Metropolitan Transportation Authority establishes a set of "Level of Service" standards alongside transit system performance indicators (Los Angeles County Metropolitan Transportation Authority 2010).
San Francisco Transit Authority looks to expanding transit services and new vehicles as a way to increase the "Transit Level of Service" (San Francisco County Transportation Authority 2013b).
San Francisco Transit Authority's Congestion Management Plan dedicates an entire chapter of the document to "Level of Service Management" specific to transit by increasing LOS through potential congestion relief (San Francisco County Transportation Authority 2013a).
Transportation for America determines "Performance Level of Service" for transit by reviewing the number of passenger trips per year (Transportation for America 2015).

Literature or Guidance Documents

New York State Association of Metropolitan Organizations recommends the "Transit Level of Service" measure to assess transit travel conditions (New York State Association of Metropolitan Planning Organizations 2006a).

Relationship with Goal

Connectivity: This measure directly relates to transit connectivity because it considers transit service as a connection for residents between different locations.
Safety: This measure directly relates to safety because transit passenger safety and comfort are factors used to measure TLOS.

Variations of the Measure / Alternatives to the measures

Transit Accessibility: Housing/Jobs within .5 Miles of Transit Stop, Transit Demand/Capacity Ratio, and Transit Frequency Measure.

References

(California Department of Transportation 2016)

(Los Angeles County Metropolitan Transportation Authority 2010)

(Madison Metropolitan Planning Area 2011)

(New York State Association of Metropolitan Planning Organizations 2006a)

(San Francisco County Transportation Authority 2013a)

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(Tennessee Department of Transportation 2016)

(Transportation for America 2015)

(Transportation Research Board 2013)

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