Multimodal and Complete Streets Performance Measures in Pasadena, California

To achieve livability and sustainability goals, the transportation professional must look beyond the efficiency of the network for vehicles as the primary metric of performance and use new metrics that recognize the level of complexity in urban land use and transportation systems.

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Introduction

As California cities move into the second decade of the 21st century, they are responding to a series of state mandates that have been adopted in the past several years to address climate change. The greenhouse gas (GHG) reductions mandated by Assembly Bill 32 and the regional targets for GHG reductions inherent in Senate Bill 375 have introduced new dimensions into the realm of transportation management. Similarly, California's adoption of a statewide Complete Streets policy[1] and its new requirement for cities and counties to modify the Circulation Elements of their General Plans to meet the needs of all transportation network users have underpinned the movement toward more walkable, bike-friendly cities. In addition to the state requirements, Pasadena, along with many other cities, adopted the Urban Environmental Accords[2] and the U.S. Council of Mayors Climate Protection Agreement[3] to further a sustainable future.

The net effect of these sustainability goals on the transportation system is to change the perspective from which the system performance is viewed. To achieve the sustainability goals, the transportation professional must look beyond individual intersection operations as the primary metric of performance. New metrics that reflect the sustainability goals are needed and must be balanced across modes. The number and average length of vehicle trips become important measures in relation to GHG production. The condition of the pedestrian and bicycle networks becomes a factor in the performance of a multimodal system. The availability and connectivity of transit service increases in importance, as does the physical proximity of trip origins and destinations. All of these metrics introduce new levels of complexity into the development and measurement of urban transportation strategies that go far beyond the Level of Service (LOS) metric that we are familiar with and use to address performance. Furthermore, these new metrics reflecting livability and sustainability concerns need to co-exist with metrics reflecting the concerns of local residents about mobility in their community.

Pasadena's Department of Transportation has turned increasingly to strategies that manage traffic in the city and has developed programs to protect neighborhoods, manage travel demand, and implement Intelligent Transportation Systems (ITS) capabilities. However, Pasadena has used an approach to assessing transportation impacts for development review and for adopting long-range plans that evaluates two criteria: intersection LOS and changes in traffic volume on street segments. These metrics are largely insensitive to the goals that drive system management activities and have resulted in outcomes that are now increasingly inconsistent with the city's Complete Streets vision. The city's past practice of using LOS encouraged widening of streets and increasing traffic speeds, which has impacted pedestrians and bicyclists. The change in traffic volume criteria highlights increases in traffic on streets as consequences of proposed development and tends to work against infill development, which negates the potential travel and sustainability benefits of allowing new uses to locate in areas well served by non-auto modes.

Having realized that different measures are needed, Pasadena has been redefining the metrics that the city uses to assess transportation performance. This effort

has included identifying appropriate metrics, working with those metrics to understand how they might be used to address an expanded set of goals for the transportation system that embrace livability and sustainability objectives, and undertaking the efforts necessary to have these new metrics adopted as city standards.

New Metrics

Taking advantage of a citywide General (Comprehensive) Plan update, Pasadena has reevaluated current transportation performance measures in the context of how well each helps the city meet its transportation and mobility objectives. With an expanded emphasis on sustainability and public health and a continued focus on livability, the performance measures were also evaluated for their ability to help determine how to balance trade-offs among travel modes and among the mobility needs of different members of the community.

In addition to reflecting new city values and requirements, metrics must be relevant to the set of options actually available. In Pasadena, because of the constraints on the physical roadway network, this means less emphasis on identifying needs for capacity increases or for reducing individual intersection delay through widening roadways. Reflecting the range of options available, the new metrics that the city considered have laid the foundation for a city transportation system with increased emphasis on the following considerations:

- Network performance for travel time reliability, speed management, and queue management;
- Improved transit services;
- Complete Streets that attract walking and bike use; and
- System management that supports multimodal operations.

The city's General Plan establishes the city's commitment to emphasizing quality of travel experience for travelers using all modes while elevating the importance of safety, livability, and sustainability. As the plan covers the full range of issues relating to development and transportation in the city, its performance measures should also reflect interactions among land use, community character, and the multimodal transportation system. To achieve this alignment, the following four categories of measures were considered: accessibility, sustainability, livability, and user experience. Through the process of selecting the new metrics, a strategy was adopted that retains some present measures to provide continuity and adds metrics that respond to community expectations, while also expanding the scope of performance measurement.

The city's General Plan establishes the city's commitment to emphasizing quality of travel experience for travelers using all modes while elevating the importance of safety, livability, and sustainability.

Accessibility, or the ability to reach desired goods or services, is often confused with the transportation metric of mobility, which is much more a measure of physical movement. Enhancing mobility is a purely transportation-related exercise and generally involves the supply side of transportation (e.g., road widening leads to better auto mobility and better LOS). Because the physical network in areas like Pasadena is constrained, supply-side changes often involve trade-offs between modes. Often, better mobility equals better accessibility, but not always.

Cities with high levels of congestion and poor vehicle mobility are often very successful places because of excellent accessibility. Enhancing accessibility involves a multidimensional approach that addresses both transportation and land use. Since accessibility is about connecting people to activities, not just about the trip inherent in that connection, each accessibility question can be answered with a land use solution in addition to a transportation solution. For example, rather than building new street capacity to better connect residents to shopping centers, clustering shops and housing around a transit stop can also achieve better accessibility. Rather than building a new transit line, re-routing an existing transit line to better serve popular destinations can also achieve better accessibility.

Sustainability metrics report on the effectiveness of the city's transportation system for reducing transportation's climate and environmental impacts. Sustainability definitions are generally about long-term actions that preserve the environment for future generations and involve a variety of approaches to transportation that mix elements that are not necessarily within the city's influence (vehicle technology) with those that are (vehicle operating conditions). Sustainability also generally includes an equity component that is often expressed in a triple bottom-line approach (i.e., environment, economy, and equity). Performance measures for sustainability include vehicle miles traveled (VMT) expressed as per household, per employee, or per capita, and indices like the Housing + Transportation Affordability Index.[4]

Livability, while the subject of many different definitions, generally attempts to measure quality of life and opportunities. In that context, livability metrics measure the availability of opportunities for all residents, workers, and visitors. Health and safety measures are typically found in livability metrics. A review of national best practices shows the City and County of San Francisco as being in the forefront of the measurement of livability in urban areas with the Healthy Development Measurement Tool (HDMT), which considers health needs in urban land use plans. The HDMT includes transportation-related metrics such as the Pedestrian Environmental Quality Index (PEQI) and the Bicycle Environmental Quality Index (BEQI), which evaluate the transportation network in terms of design characteristics, volumes, and safety that most affect pedestrian and bicycle travel.

User experience metrics measure how drivers, transit riders, bicyclists, and pedestrians experience the street system. For drivers in urban networks, these include intersection LOS but need to add attributes that reflect people's experiences of the system or network and move attention away from individual intersections and toward corridors. Measures that achieve this shift in focus include driver travel time, average travel speed, reliability of travel time, and safety (collisions).

As user experience metrics move beyond drivers, they need to decrease the emphasis on the efficiency of auto travel relative to other modes to address the manner in which people use and experience the transportation system as a whole from a Complete Streets perspective. The Multi-Modal Level of Service (MMLOS) metrics from NCHRP 616[5] (incorporated in the 2010 *Highway Capacity Manual*) that emphasize quality of travel experience by walk, bike, transit, and car is one method for addressing a more complete user experience perspective. The MMLOS calculation for each mode is based on each mode's users' perceptions of level of service and factors that influence their perceptions.

Pasadena's Approach

In exploring the potential metrics that come from the previously mentioned four areas, the city focused on three areas: (1) development of an accessibility tool/metric, (2) refinement of the existing metric of VMT per household/employee, and (3) integration of the MMLOS approach with the existing intersection LOS and street segment volume metrics. The accessibility and sustainability metrics, because of their scale and the complexity of calculating, were designed to be used as part of the decision-making process for the General Plan. The user experience metric is designed to be used primarily for impact analysis at the project level. In the process of designing the metrics, it became apparent that the livability measures in use elsewhere contained many of the elements necessary to quantify nonmotorized user experience. Rather than define a separate livability metric, the city's approach incorporates livability criteria into the user experience metrics.

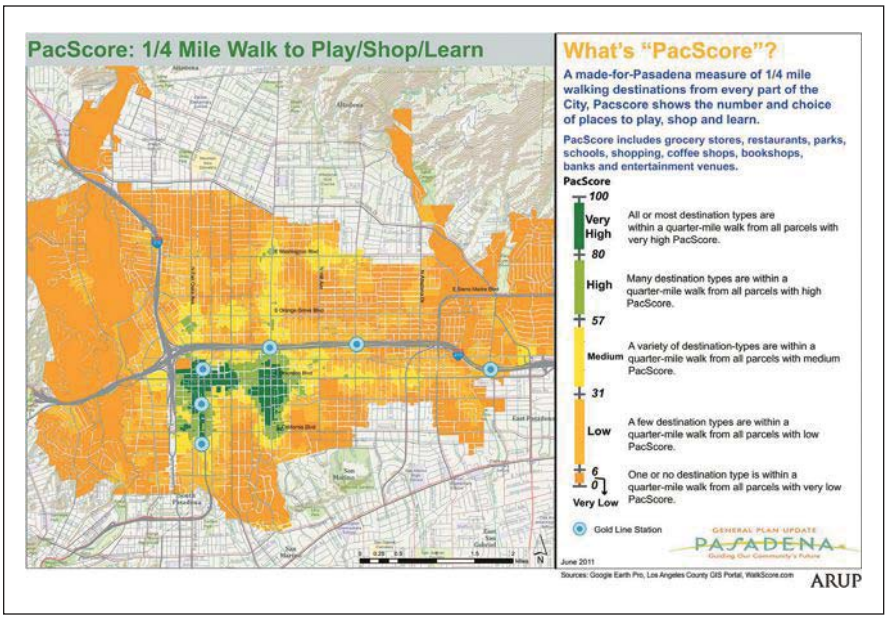

Figure 1. Example of PacScore Results

Accessibility

The city's approach to accessibility draws from the current set of online spatial analysis tools that allow users to identify the accessibility of a location based on its proximity to destinations. Inspired by these tools, the City of Pasadena and its consultant team created its own made-for-Pasadena measure of walk access to places to work, shop, learn, and play. The measure, known as "PacScore" (Pasadena ACessibility Score), incorporates accurate network walk measurements, a rich palette of destinations, and the ability to vary weighting of destination groups and to introduce livability factors such as street trees. These techniques help assess accessibility for different population groups, such as seniors, youth, and low-income or minority populations, and allow for comparisons among parts of a city or region.

PacScore operates on the city's geographic information system (GIS) and draws its destinations from the land use layers. Since it operates at a parcel level, results can be disaggregated to the parcel level or aggregated for larger areas (census blocks/tracts, neighborhoods, other district boundaries) that allow for comparison with other metrics that exist only at the larger scale. The city uses a quarter-mile distance as a surrogate for a 5-minute walk. The primary accessibility metric in PacScore is the number of destinations, weighted by type, that are within a 5-minute walk from a parcel. Pasadena's GIS data includes such attributes as sidewalk presence and width, presence of street trees, and street width. PacScore is designed to recognize these and other attributes and incorporate them into a subjective quality-of-walk metric that is used to modify the distance-based portion of the metric. This is based on the concept that a poor walking environment is equivalent to lengthening the distance walked.

Figure 1 shows a citywide thermal map of accessibility and the PacScore low-medium-high walkability scale.

During the public outreach phase of the General Plan process, PacScore maps were used to convey to residents the accessibility of all existing land uses. The PacScore maps were well received by the public and were easily understood. The maps revealed for residents that existing land uses of varying types and intensities provided similar accessibility. By analyzing the existing familiar land uses, PacScore demonstrated to those participating in the General Plan process the significance of both the density and mix of land use in producing accessible neighborhoods and commercial districts. This concept was critical to helping the community develop future land use alternatives that could achieve high levels of accessibility at densities that were considered compatible

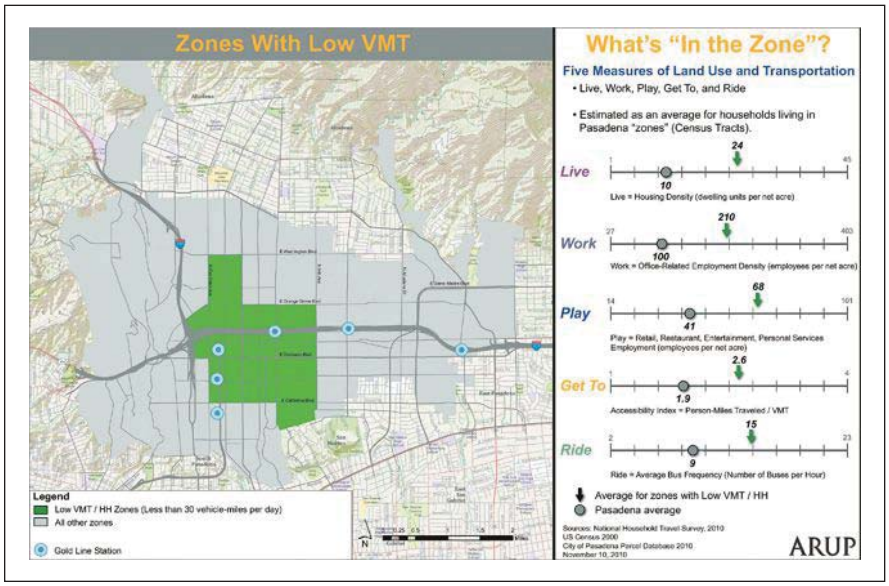

Figure 2. Example of Attributes Linked to VMT Data

Table 1. Expanded Methods for Transportation Impact Analysis

Impact Measure	Current Method of Measurement	Proposed Method of Measurement			
		Auto	Pedestrian	Bicycle	Transit
Intersections	Change in volume to capacity ratio (ICU)	Change in volume to capacity ratio (ICU)	Change in MMLOS at intersections	(addressed in Auto measure)	(Addressed in Auto and Pedestrian measures)
Street Segments	Percentage change in daily and peak traffic volume	Change in MMLOS (Autos)	Change in MMLOS (Pedestrians)	Change in MMLOS (Bicycles)	Change in MMLOS (Transit)

and appropriate in the areas where future growth and land use intensification were being considered.

Sustainability

The city's approach to sustainability focused on VMT per household or per employee. This measure is difficult to forecast in the absence of sophisticated models. The metric operates at a district scale, which is useful for measuring the General Plan performance, but may mask individual project-level impacts. Figure 2 highlights the relationship between land use mix and travel behavior in one part of the city.

Although lower VMT per household supports the sustainability goals through reduced GHG production throughout the day, the reduction in auto trips inherent in reduced VMT per household may not necessarily coincide with a reduction in traffic congestion, particularly if the reduced trips occur outside the peak congestion period on the roadway network. Thus, VMT data alone cannot indicate if overall system goals are being achieved, but it is a strong indicator for the long-term sustainability metric of GHG production. VMT data is also useful as an information tool, illustrating the different travel characteristics of different parts of the city.

As a tool in the General Plan process, graphics like Figure 2 were used to build an understanding of how different mix and development density choices may influence sustainability outcomes. When accessibility and sustainability are combined, greater accessibility through land use planning and coordination of transportation leads to fewer auto trips, reduced per capita vehicle miles traveled, reduced GHG emissions, and lower household transportation costs. Use of the VMT graphics in conjunction with the PacScore maps produced a deeper understanding of the land use–transportation interaction at the city's citizen workshops.

User Experience

As Pasadena researched possible approaches for the user experience metric, it became evident that incorporating the MMLOS approach into the city's current approach, rather than replacing the current approach, would be the most productive. To that end, the city's guidelines for impact analysis are now being updated to reflect the addition of MMLOS components to balance the intersection LOS (ICU) and traffic volume metrics currently used, as shown in Table 1.

The city worked through a series of parallel case studies that used San Francisco's PEQI as a measurement tool and looked at MMLOS under different scenarios. Although both PEQI and MMLOS delivered usable results, the selected approach draws from the MMLOS techniques. The information required in both methods is similar, and although the PEQI technique appears to provide a more rigorous evaluation of existing conditions, the MMLOS technique focuses on a subset of conditions that are applicable in both a measured condition as well as a forecast condition, which was important for evaluating future development at the project level. This latter factor was the deciding one in choosing to incorporate the MMLOS techniques. Many of the livability elements in PEQI and BEQI are incorporated in the MMLOS analyses for pedestrians and bicycles, which allows the user experience metrics to include livability aspects.

While evaluating the continued use of intersection volume to capacity/LOS, the city explored corridor metrics that would communicate information about travel time reliability. The goal was to develop a new measure that would decrease the emphasis on additional vehicle capacity and on reducing individual intersection delay in favor of one that would increase the emphasis on network management and travel time reliability. To achieve this shift in emphasis, the metric must shift in scale, away from individual location-specific

measures to corridor measures. This effort ultimately was shelved, because travel time and travel time reliability are things that can be measured but are extremely difficult to forecast. The city continues to include travel time reliability as one of the metrics used to monitor system operation and guide strategy development for both system speed management and queue management at congested locations. To that end, Pasadena has a pilot project in place for corridor monitoring technology that captures near real-time corridor travel time/speed and queue data.

To achieve a more balanced outcome while continuing to use intersection LOS as a metric, the city elected to introduce a pedestrian intersection LOS measure, again drawing from the MMLOS techniques. By combining the two metrics at a single location, the effects of intersection widening/LOS improvement strategies can be evaluated in the context of their effects on pedestrians at the intersection. Although this strategy does not achieve the goal of moderating the focus on individual intersections during development review, it does create a dynamic in which both pedestrian and vehicle impacts are weighed together.

Conclusions And Next Steps

The use to date of the new metrics, both as part of the city's General Plan Update process and in comparative analyses of improvement projects and proposed developments, is encouraging. The PacScore accessibility metric and the VMT sustainability metric have been used to evaluate the General Plan Land Use alternatives to illustrate the relative merits of different patterns and locations of intensity and mixes of land uses in the city. These two metrics illustrate relative differences and are not being used for impact analysis. The intent is to continue to use these two metrics to provide a broad review of changes in land use and intensity at the specific plan and major project levels. Interest in a broader use of the accessibility metric has been seen from infill developers and neighborhood associations. The user experience metrics (ICU and MMLOS) are being used for assessment of impact of specific projects and plans. However, the new metrics have been used only in comparison with the currently adopted measures. The comparisons show that the proposed measures are effectively addressing the more complex attributes needed for assessing the performance of Complete Streets. Staff is now engaged in a series of parametric evaluations to determine the recommended significance thresholds for the metrics to be used in review of projects and in the environmental impact analysis for the General Plan. Under California statutes, the city council adopts the impact measures and sets the thresholds for significant impact for use in environmental impact analyses.

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References

1. As of January 2011, California cities and counties are required to modify the circulation elements of their general plans to include "a balanced, multimodal transportation network that meets the needs of all users of streets, roads, and highways, defined to include motorists, pedestrians, bicyclists, children, persons with disabilities, seniors, movers of commercial goods, and users of public transportation, in a manner that is suitable to the rural, suburban, or urban context of the general plan."

2. See www.sfenvironment.org/downloads/library/accords.pdf

3. See www.usmayors.org/climateprotection/agreement.htm

4. See http://htaindex.org/

5. Dowling R. et al. *National Highway Cooperative Research Program Report 616: Multimodal Level of Service Analysis for Urban Streets.* Washington, DC: Transportation Research Board, 2008.

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