OR 217 Interchange Management Study: A La Carte Planning for an Unpredictable Fiscal Future

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ABSTRACT

The OR 217 corridor in Portland, Oregon had been studied twice in the past decade. However, with the total cost of recommended improvements totaling $1 billion and any one project costing at least $50 million, nothing had been implemented and there was no hope that anything could be in the foreseeable future. Tired of waiting, the Oregon Department of Transportation (ODOT) was asked by the public to do something to improve conditions in the corridor now. With the funding outlook unchanged, the objective of this study was to identify and evaluate effective, fundable projects that could feasibly be constructed today to improve reliability, mobility, and safety.

The project team identified, screened, and evaluated nearly 40 improvement alternatives. The result was a menu of projects widely supported by elected stakeholders that included targeted locations for shoulder widening, provision of traveler information, variable speed systems, and ramp management improvements that were able to provide benefits at affordable costs. The first set of improvements has already been funded and will be constructed within the next year.

This project represents a departure from the typical transportation corridor plan. The types of projects recommended were non-traditional, as were the types of benefits. It is considered an early example of applied least cost planning principles and heavily incorporates system operations expertise into the planning process. By focusing on projects that fit within funding limitations and minimize the creation of impermeable surface, it also supported the Environmental and Economic branches of the Transportation Sustainability Triple Bottom Line.

INTRODUCTION

OR 217 is a seven-mile limited access freeway that bypasses the city center of the Portland Metropolitan area by connecting Interstate 5 (I-5) and US 26 (see Figure 1). It is the primary access for three major activity generators (Washington Square Regional Center, Beaverton Regional Center, and Tigard Town Center) and carries up to 120,000 vehicles per day, yet the facility is one of the least reliable freeways in the Portland area.

Along OR 217 there are numerous safety and mobility problems, including recurring bottlenecks, high crash rates, and unreliable travel times. Factors that lead to these problems include peak period demands that exceed capacity, lack of shoulders, and short weaving areas that create erratic changes in traffic. Most interchanges are well under one mile apart, which does not allow adequate space for the weaving that occurs between vehicles entering and exiting the freeway. There have been nearly 200 crashes a year along OR 217, with 70% being rear-end collisions and over 50% occurring during the a.m. and p.m. peak periods.

Previous studies addressed these mobility and safety problems with costly capital projects such as widening to six lanes, braiding ramps, and adding collector-distributor roadways. These high-cost improvements total nearly $1 billion for the corridor, and are generally over $100 million at key interchanges. Given past and projected funding levels for transportation improvements, no projects had been implemented in the corridor and there was no expectation that needed funding would be available soon.

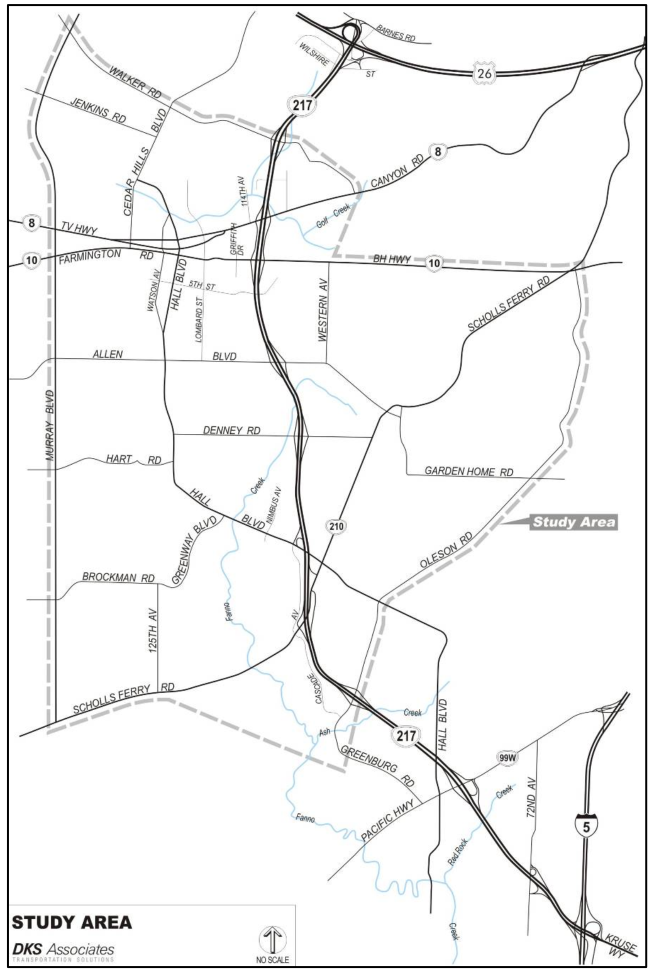

Figure 1: OR 217 Study Area

Tired of waiting, ODOT was asked by the public to do something to improve conditions in the corridor now. Therefore, the objective of this study was to identify and evaluate lower cost, fundable projects that could feasibly be constructed for OR 217 today to increase reliability, mobility, and safety.

APPROACH

The OR 217 Interchange Management Study was divided into two phases: Phase I being the concept exploration component, and Phase II being the refined feasibility study.

Phase I

Phase I began with a full day workshop attended by representatives from public agencies (ODOT, Washington County, City of Tigard, City of Beaverton, and Metro), as well as several consulting technical experts in freeway design, freeway operations, and water resources. A background information packet was developed prior to the workshop, incorporating data and analysis describing the study area from readily available sources and past studies. The packet included information such as general roadway characteristics, traffic volumes, traffic operations, speed-flow charts, crash data, and interchange characteristics.

Using the background information, the workshop served as a brainstorming session to create a list of possible projects with potential to address reliability, mobility, and safety issues along OR 217. It was established at the outset of the workshop that improvement concepts would be focused only on motor vehicle travel in the OR 217 corridor, and that the complimentary needs for pedestrian and bicycle improvements and transit were to be investigated as part of another upcoming study. Nearly 40 project concepts were developed as a result of the workshop, which were assigned into one of four categories:

- System Management Projects
- Ramp Management Projects with Associated Street Improvements
- Surface Street Improvement Projects
- Highway Interchange Modernization Projects

For each of the projects developed at the workshop, an initial analysis was completed which involved a planning-level cost estimate and an investigation of the potential benefits each project could create. Given that projects were still in the conceptual stage, analysis of potential benefits was limited at a cursory level, such as travel demand model applications and use of ranges of benefits documented in case studies or technical publications. It was also assumed that to comply with the low cost criteria, projects must be constructible for no more than $25 million (although projects under $10 million were preferred). The analysis was then reviewed with the Technical Advisory Committee, with the results presented to elected officials representing the area served by OR 217. The general findings for each project type are summarized below.

System Management Projects

Systems management projects worked to optimize existing infrastructure. Projects such as targeted shoulder widening, traveler information, and variable speed systems, were explored. These options were typically some of the lowest cost projects, while maintaining a potential to improve safety and reliability on OR 217.

Ramp Management Projects with Associated Street Improvements

These projects targeted improving operations on OR 217 by reducing conflict areas through the closure of ramps or interchanges with complementary off-highway street improvements. As more ramps were closed, benefits to OR 217 increased, but so did the negative impacts of increased diverted traffic onto nearby surface streets and reduced access. The key to these projects was to identify options that balanced the benefit to OR 217 with the impact to adjacent surface streets. Select ramp management projects did show potential to improve safety, reliability, and mobility within low cost parameters.

Surface Street Improvement Projects

The surface street improvement projects focused on increased capacity on surface streets to improve conditions on OR 217 by providing attractive alternative routes. While each of these projects reduced delay on the surface streets, the benefit to OR 217 was typically localized and minimal.

Highway Interchange Modernization Projects

The highway interchange modernization projects explored practical design solutions for many of the same types of capacity-enhancing projects that had previously been identified. Cost savings were gained through innovative designs, limiting improvements to one side of the freeway or interchange, and seeking opportunities to deviate from State design standards. However, no acceptable concepts identified were expected to reduce costs enough to make them affordable in the near term. This was partially due to significant flooding and stormwater management problems in the area that would require costly mitigation for any increases in impervious surface area.

Based on the initial analysis, elected officials determined that select strategies from the systems management projects and the ramp management projects with associated street improvements best fulfilled the study criteria (low cost with reliability and safety benefits). This select group of projects were termed “Best in Class” and forwarded for further technical analysis.

Systems Management Projects

- Targeted Shoulder Widening
- Traveler Information
- Variable Speed System

Ramp Management Projects with Associated Street Improvements

- Wilshire Street full interchange closure
- Denney Road full interchange closure
- Wilshire Street + Walker Road full interchange closures
- Wilshire Street + Walker Road + Denney Road full interchange closures

Phase II

Phase II focused on a refined assessment of the Best in Class strategies. The refined analysis included a higher degree of cost estimate certainty, as well as surface street traffic analysis for each of the ramp closure options. For the systems management strategies, additional system needs and requirements were further explored to serve as a preliminary concept of operations.

The building blocks of public savings in crash and delay reduction used for preliminary project benefit assessment were obtained from ODOT. Table 1 shows the assumed costs for incidents and delay time that were applied to the estimates of delay and crash reductions associated with each project. Savings achievable from reducing crashes and delay are a direct benefit the public. These savings do not go to ODOT.

Table 1: Cost of Crashes and Delay

Crash Type or Vehicle Delay	Cost of Single Crash	Cost of Delay per Hour[1]
Property Damage Only	$15,000	--
Minor Injury	$47,900	--
Severe Injury or Fatality	$840,000	--
Passenger vehicle delay	--	$20
Commercial vehicle delay	--	$31

RESULTS

All of the projects that progressed to Phase II offer high benefits on comparatively low costs by optimizing the performance of existing infrastructure. These strategies each offer reliability and safety benefits to OR 217, and in general, individual projects could be implemented for less than $10 million. The degree of benefit varies based on the strategy.

Targeted Shoulder Widening

Narrow shoulders hinder the performance of a freeway. They slow emergency responders from getting to incident scenes, provide no space for stopped vehicles to avoid blocking traffic, and allow no space for errant vehicles to avoid secondary rear-end collisions. A Portland State University study determined that if all Portland area delay-causing incident durations increased by one minute, the extra cost to the public would be approximately $1.4 million.[2]

In several locations along OR 217 the outside shoulder is less than a lane wide (sometimes as narrow as three to four feet wide). When an incident occurs in one of these sections, the through capacity on the freeway is significantly reduced. In a two-lane section, a one-lane blockage actually results in a 65% reduction to capacity, not 50%.[3] Figure 2 shows that having an adequate shoulder can restore lost capacity during an incident by 35 to 45%.

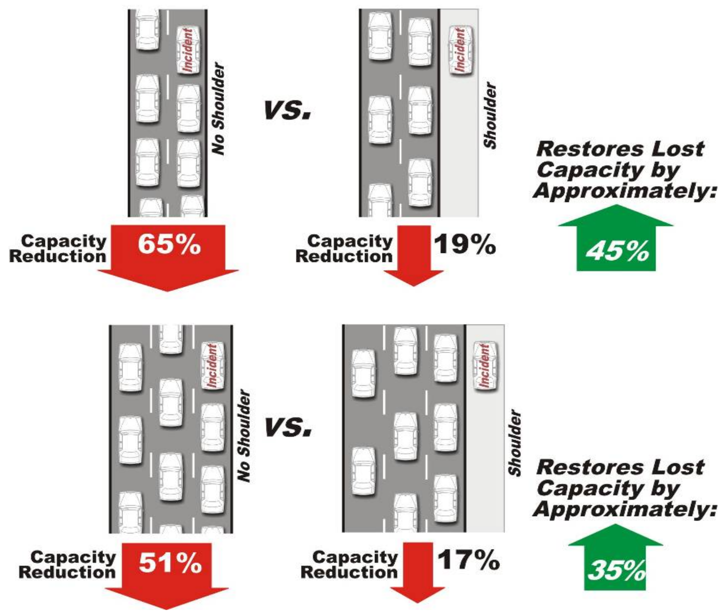

Figure 2: Illustration of lost capacity due to an incident

An innovative aspect of the targeted shoulder widening strategy proposed involves using a porous surface for the added shoulder area to avoid costly stormwater mitigation associated with this area. In Oregon, porous asphalt has been used for neighborhood streets and porous aggregate has been used on coastal highway shoulders. However, porous surfaces have not yet been applied to an urban freeway shoulder. While the shoulder would not be designed to operate as a regular travel lane, emergency vehicles and passenger vehicles could safely travel on it during incidents.

Financial benefits of targeted shoulder widening are expected because of costs savings associated with reduced vehicle delay and number of crashes. Six locations were proposed for targeted shoulder widening, focusing on locations with high crash rates, direct access for emergency vehicles, and the ability to avoid structural and wetland conflicts. Based on a conservative estimate of restoring 30% of lost capacity and reducing 5% of crashes in the targeted shoulder widening areas during an incident, each segment of shoulder widening (on average) could save motorists up to $1 million in reduced delay and accident damages over a five-year period. Providing shoulder widening at all six locations could achieve savings to the public of nearly $6 million over the course of five years.

Traveler Information

The traveler information strategy would provide travel time information for OR 217 at key decision points (on arterials and the freeway), allowing drivers make the choice to either use OR 217 or an alternate route. Informing drivers of congested conditions before they decide to enter the freeway can improve the reliability of travel on OR 217 and can decrease primary and secondary incidents by reducing congestion.[4]

The greatest benefits of traveler information signs would be accrued during peak congestion periods. Previous studies show freeway daily traffic can decrease by 20% and freeway delay time could improve by 50% during heavily congested periods.[5] Other studies show that up to 85% of travelers will change routes when en route delay information is available.[6] Benefits as sizeable as these are unlikely for OR 217 given the limitations of the surrounding network. However, even if delay is reduced by 20% during the p.m. peak period due to some drivers choosing alternate routes, modes, or trip times, five-year savings exceeding $8 million in cost of delay could be achieved.

Variable Speed System

A variable speed system proactively manages vehicle speeds based on real-time traffic information. The primary benefit of a variable speed system is to reduce rear-end collisions, which account for 70% of all collisions on OR 217. In regions where variable speed systems have been implemented, rear-end collisions have decreased by 30%, overall crash rates decreased by 20%, and secondary crashes went down by 40%.[7] For OR 217, that could mean two less crashes and associated travel delays per week.

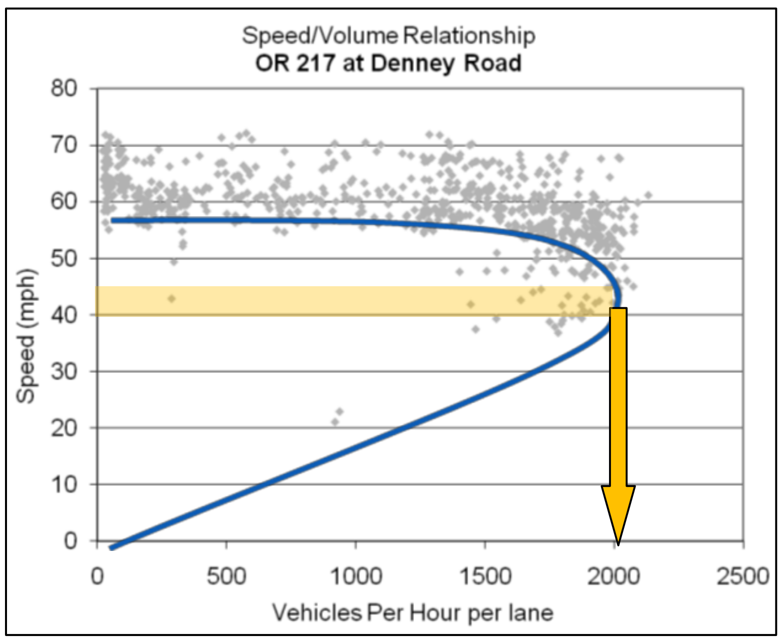

Figure 3: Flow rate on OR 217 at Denney Road

The use of variable speed control can also achieve improved throughput on a freeway during recurring congestion by lowering the speed limit. The optimal freeway capacity during congested operations is not achieved at 65, 60, or even 55 miles per hour. It is achieved at 40 to 45 miles per hour (as noted in Figure 3). The key to improving throughput is to avoid unstable conditions that can occur at higher speeds as flow rates approach 2,000 vehicles per hour per lane. Breakdown conditions can be reduced by slowing traffic prior to the point of congestion to harmonize speeds in the congested environment. Recent studies[8] on this topic have concluded that higher levels of throughput can be obtained using variable speed control.

Figure 4 shows the relationship between optimal flow rates (the "performance" curve) and safe flow rates (the "safety" curve). The performance curve assumes that vehicles are traveling at the given speed limit. However, the distance between vehicles necessary to maintain a given flow rate may be too short to stop in time if the vehicle in front suddenly stops, slows, or swerves. The safety curve shows that flow decreases with speed if vehicles maintain safe spacing (to avoid rear-end collisions). The crossing point of the two curves is around 40 mph, which maximizes flow rates without compromising safety. These speeds and flow rates can be obtained using variable speed limits.

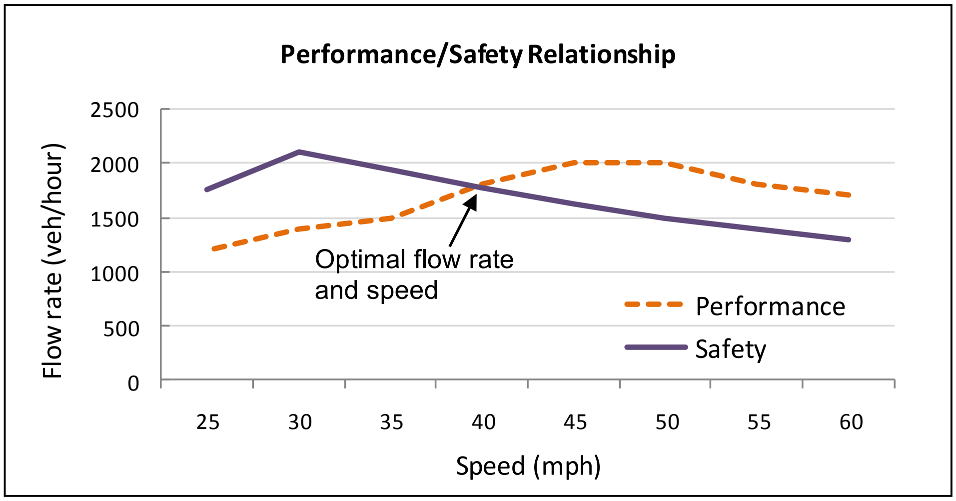

Figure 4: Balancing safety and optimal flow rates

Conservative estimates of a 20% reduction in rear-end crashes and a 5% reduction in delay on OR 217 were used to estimate benefits (about one less crash on OR 217 every two weeks). Over a five-year period, savings of crashes and delay to the public would be approximately $6.6 million.

Ramp Management Projects with Associated Street Improvements

These strategies offer significant potential to improve freeway operational performance in the near term. One of the main problems on OR 217 is the short spacing between interchanges (six-tenths of a mile apart on average), which creates even shorter weaving segments that range from about a tenth of a mile to one-half of a mile in length. This short spacing creates bottlenecks and high crash locations as drivers change lanes from entrance ramps to the mainline, weaving with drivers moving from the mainline to exit lanes. In these locations vehicles come virtually to a halt.

Each of the ramp management strategies considered eliminates at least one weaving location. Closing ramps offers both performance and safety benefits, which improve flow rates for the highway. Comparing OR 217 to the southern portion of I-205 (comparable length and geometry from I-5 to West Linn), which maintains approximately 2 miles between interchanges, I-205 is accommodating 10 to 15% more traffic than OR 217 during peak periods.

ODOT's number one concern for freeway traffic is safety, and adequate spacing between interchanges has proven to increase safety benefits. The Federal Highway

Administration (FHWA) conducted studies regarding the relationship between interchange spacing and safety.[9] FHWA investigated several locations where new interchanges were inserted between existing interchanges, thereby decreasing the spacing by about half the original distance. It was found that fatal and injury crashes increased by about 1.5 times the original amount. Working in reverse, this means that removing an interchange could decrease fatal and injury crashes by about 30%. This finding was further validated by comparing crash data from OR 217 and the comparable segment of I-205, which suggested that a crash rate reduction of 25% could be achieved on OR 217 by providing better interchange spacing (achieved by removing three interchanges).

To arrive at a reasonable set of alternatives, all interchanges were investigated on OR 217 in combinations of all-day closures for single ramps, multiple ramps, single interchanges, and multiple interchange closures. Four ramp management projects with associated street improvements appear to have an appropriate balance of improving OR 217, while not creating too much of an impact on the surface streets. In cases where one full interchange is closed, five-year benefits to the public measured by reduced delay and accident damages avoided range from $1.9 to $4.9 million. In cases where two or three interchanges are closed, five-year benefits range from $4.7 to $7.6 million.

CONCLUSIONS

Refinement of the Best in Class strategies yielded a menu of compatible projects that can advance the objective of enhancing safety and travel reliability at an affordable cost. These projects are not intended to replace the larger-scale interchange modifications and freeway widening projects identified through earlier plans, but to provide complimentary smaller steps toward achieving the ultimate goal. The relatively low design and construction costs allow these projects to be achievable even in this constrained fiscal environment. Furthermore, the diversity of project types offers flexibility when seeking funding opportunities (e.g., preservation, safety, operations, and modernization funding could all be applied).

Immediately following this planning effort, ODOT and Washington County began exploring funding opportunities and select projects from the menu were chosen for further refinement. This included developing a concept of operations for the traveler information and variable speed system solutions and applying some lessons learned from the ramp management strategies to two locations where collector-distributer roads between interchanges could be constructed at low cost. While one of the two ramp management solutions, the creation of a split-diamond interchange between the existing Allen Boulevard and Denney Road interchanges (southbound direction only), was found to have significant potential to improve travel safety and reliability at low cost, it was not chosen for implementation at this time. However, the traveler information and variable speed solutions, in addition to three of the shoulder widening projects, were funded and are currently being designed with construction to be complete in 2013. A summary of the refined Best in Class menu of projects for the OR 217 corridor is provided in Table 2.

Table 2: Refined Best in Class Menu of Projects for OR 217

Project	Estimated Cost
Targeted Shoulder Widening (in order of priority)	
Southbound from Scholls Ferry Rd. to Greenburg Rd.	$2.1 million
Northbound from Scholls Ferry Rd. to Denney Rd.	$5.0 million
Northbound from Greenburg Rd. to Scholls Ferry Rd.	$2.5 million
Southbound from Denney Rd. to Hall Blvd.	$2.4 million
Southbound from Allen Blvd. to Denney Rd.	$2.6 million
Southbound from Beaverton-Hillsdale Hwy to Allen Blvd.	$8.2 million
Traveler Information and Variable Speed System	
Large (5-foot) Half-Mile Markers to provide a better referencing system for motorists when reporting incidents.	$35,000
The original strategy included a set of 7 dynamic message signs on the freeway mainline and 10 dynamic message signs on arterial gateways to communicate travel times and incident warnings. Costs for signs ranged from $160,000 to $950,000 each depending on sign and mounting type. This strategy has since been further refined and bundled with other applications from a pilot project and a pavement preservation project. It is currently in design for construction in 2013 and includes: • New Street Name signs on overcrossings for improved referencing • 28 overhead dynamic message signs on gantries for posting variable advisory speeds (non-regulatory), incident warning, queue warning, and travel times • Pavement resurfacing including three of the targeted shoulder widening projects referenced above • Weather-based curve warning system (pilot project) • Ramp meter upgrades with new algorithms	$20 million (includes $9.5 million paving project)
Ramp Management and Associated Street Improvements*	
Southbound Allen Blvd./Denney Rd. Split-Diamond Interchange	$5.0 million
Close Wilshire St. Interchange	$400,000
Close Denney Rd. Interchange	$11.3 million
Close Wilshire St. and Walker Rd. Interchanges	$15.9 million
Close Wilshire St., Walker Rd., and Denney Rd. Interchanges	$30.9 million

* Ramp Management and Associated Street Improvement Projects would require further refinement and public involvement before implementation.

ODOT adopted policies favoring enhanced systems management over the construction of new capacity more than a decade ago. While many operational enhancements have been made over the years, when funding was thought to be available (or at least achievable), there has often been a continuing desire to opt for the construction of new or improved facilities. This may be due in part to a common opinion among the public that systems management solutions are only capable of providing minor benefits and that major construction is needed to make significant improvements.

The current transportation funding shortfall may have played a significant part in the public's acceptance of lower cost systems management solutions on OR 217. All stakeholders involved readily accepted the fact that there was a need to view project success differently - placing a stronger emphasis on improving safety and reliability of travel instead of how fast cars can drive or how many cars could be served during peak periods (i.e., level of service).

The project demonstrated the value of comprehensive system management strategies for developing practical, effective transportation solutions that are important to communities. As the severe funding shortfalls for ODOT and other DOT's around the nation continue, a focus on system management may gain new levels of public acceptance. This in turn will create a need for transportation professionals to document the benefits realized by these types of projects and share the lessons learned so that systems management solutions can be refined and continue to be competitive options even after transportation funding has returned.

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