Summary of Local and Other Experience with Bus On Shoulders (BOS)

Final Technical Memorandum 1

Prepared for the Bus On Shoulders Task Force of the National Capital Region Transportation Planning Board (TPB)

March 29, 2013

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Section A: Introduction and Background on the BOS Task Force

Bus On Shoulders Task Force - Background

At the July 18, 2012 meeting of the Transportation Planning Board (TPB), it was requested that a task force be established to identify promising locations in the region to operate buses on the shoulders of highways. As requested by the TPB, this task force will bring together the stakeholder agencies, including transit operators, departments of transportation, and local jurisdictions, to coordinate an assessment of the experience and potential for Bus On Shoulder (BOS) operations on the region's freeways and major arterials. The task force will oversee a scoping of potential locations for BOS, including a high-level benefit-cost analysis of implementing BOS along select corridors and bus routes. The proposed membership, work plan, and schedule for the Task Force were approved at the September 19, 2012 TPB meeting.

Task Force Membership

The task force co-Chairs are Ms. Carol Krimm, of the City of Frederick Board of Aldermen, and Mr. Chris Zimmerman, of the Arlington County Board. Other members were invited from the following:

Departments of Transportation	Transit Operators	Jurisdictions
• District of Columbia (DDOT) • Maryland (MDOT) • Virginia (VDOT)	• WMATA • PRTC • MTA Commuter Bus • Loudoun Transit	• Fairfax County • Frederick County • Montgomery County • Prince George's County • Others…

Work Plan and Schedule

The regional assessment of BOS feasibility is being coordinated through a series of meetings, with necessary work assigned through discussion.

Task 1 – Summary of Local and National Experience with Bus On Shoulders

The task force will develop a summary of critical experience with current and previous BOS operations, to include an overview of safety, roadway engineering, and bus service operations aspects. In addition, a summary of national experience and its applicability and use in this region will be prepared and reviewed, including federal regulations, requirements for

requesting design exceptions, and supporting state legislation. This information will be used as a resource for discussion and development of the assessment.

Task 2 – Assessment of the Feasibility of BOS at Specific Locations

Stakeholder agencies will identify potential corridors for BOS operation on the region's highway network, based on 1) existing highway congestion locations, 2) current bus service, and 3) highway shoulder conditions. This information will be used to screen out infeasible locations and to identify potential corridors and bus routes for further analysis.

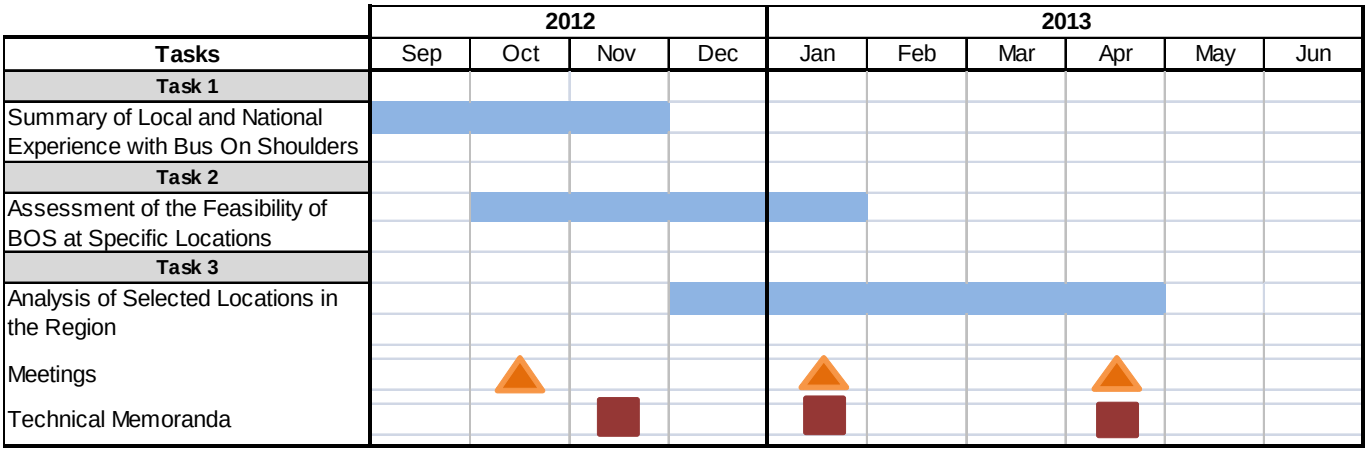
Task 3 – Analysis of Select Corridors/Routes in the Region

Using the results of Tasks 1 and 2, the TPB staff, with assistance from the respective highway and transit agencies, will conduct an analysis of the feasibility of BOS on the potential corridors/routes in the region. The analysis will:

1. Identify issues and challenges with safe operation,
2. Develop capital cost and operating cost inputs, as provided by the stakeholder agencies.
3. Determine potential travel time savings for bus routes based on highway congestion,
4. Present a benefit-cost analysis of the prospective benefits to riders and traffic relative to the projected costs of implementation of BOS service on the selected corridors/routes.

For each task, technical memoranda summarizing the results will be prepared, with supporting presentations for the task force. The work schedule and months for task force meetings and delivery of the technical memoranda are shown below in Figure 1.

Figure 1: TPB BOS Task Force Work Plan and Schedule



Section B: Local and National Experience with BOS

BOS is an arrangement by which buses providing public transportation service operate on designated highway shoulders, when safe and practical to do so, in order to circumvent peak traffic congestion. As described in the recently published *Transit Cooperative Research Program (TCRP) Report 151: A Guide for Implementing Bus On Shoulder (BOS) Systems*:

> *"Typically, the BOS projects limit buses using the shoulder to times when traffic on the highway is congested and moving very slowly, and they cap the speed buses are allowed to operate on the shoulder." (Page 1-1).*
> http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_151.pdf

Current local experience with BOS includes bus operation along a short section (1.3 mi) of the Dulles Airport Access Highway (VA 267[1]) for bus access to the West Falls Church Metrorail Station, and along the shoulders of US 29 near Burtonsville, MD. Previously, bus service operated along the Maryland portion of the Capital Beltway (I-495) in the vicinity of the American Legion Bridge; these buses were permitted to operate on the shoulders, however, this service was discontinued in 2003. Looking forward, VDOT is currently conducting an assessment of the potential of BOS along I-66 inside the Beltway.

In addition, as described in the TCRP report, several other cities across the United States and Canada also have BOS service; of these, Minneapolis / St. Paul has the most-developed network with over 280 miles of BOS corridors.

Local Experience

As introduced above, there are two current examples of BOS in the region, on VA 267 and on US 29 near Burtonsville. An addition, there was BOS operation along the Maryland portion of the Capital Beltway from 1999 to 2003, while BOS is being considered for I-66 inside the Beltway.

Virginia: VA-267 BOS

This corridor for BOS is limited in scope to 1.3 miles along the eastbound shoulder of VA-267 inside the Beltway. The corridor leads directly to a bus-only access ramp to the West Falls Church Metrorail Station, just before the intersection with I-66. The implementation of this BOS corridor is described in detail as the second case study in *TCRP Synthesis 64 Bus Use of Shoulders* (pp. 26-28).

[1] This is the Metropolitan Washington Airports Authority's designation of the untolled section of VA 267 inside the Capital Beltway (I-495). See http://www.metwashairports.com/tollroad/925.htm

Key findings from the TCRP case study include:

- Primary reason for implementation was to bypass congestion backing up on VA 267 from the merge with I-66 eastbound.
- Joint implementation by Fairfax County, Virginia State Police, the Metropolitan Washington Airports Authority, and VDOT.
- Use of BOS is restricted to the PM peak period (4:00 - 8:00 PM) and the maximum permitted bus speed is 25 MPH.
- Operators call in if any breakdowns or obstacles are encountered on the shoulder, at which point transit dispatchers instruct all bus drivers not to make use of the shoulder.

Maryland: US 29 (Columbia Pike) BOS

This corridor provides for BOS operation along approximately 4 miles, between MD 198 at the north and Randolph Road / Cherry Hill Road at the south (see Figure 2). However, BOS operation is now very infrequent due to significant reconstruction of this highway. Grade-separated interchanges were completed in recent years (MD 198 in 2004, Randolph Road/Cherry Hill Road in 2005, and Briggs Chaney Road in 2007) that have largely eliminated the congestion experienced previously at the then-signalized intersections. In addition, a new interchange with MD 200, the Inter-County Connector, has sizable entry and exit ramps that impact shoulder availability in the vicinity of the interchange.

Portions of the corridor remain posted for BOS, and buses will occasionally make use of the shoulders. However, the relative infrequency of BOS operation limits useful information from this corridor.

Maryland: Capital Beltway (I-495) BOS

In 1998, Metrobus Route 14 service between points along the I-270 corridor in Maryland and Tysons Corner in Virginia was introduced, operating along the Beltway and crossing the American Legion Bridge. Metrobus was given permission to operate along the shoulders on the Maryland portion of the Beltway to circumvent congestion, with appropriate signage installed. However, in practice the benefits were modest. VDOT did not allow shoulder operation on its portion of the Beltway for safety reasons. In addition, a major primary cause of congestion for traffic headed to Tysons Corner during this time frame was the poor I-495 (outer loop) access in Virginia to the Dulles Toll Road (VA-267), which the bus could not avoid. (This ramp was subsequently widened from one lane to two lanes in August 2005 and the bottleneck was eliminated). Ridership on the Metrobus Route 14 did not meet expectations, and by May 2002 was averaging only six persons per trip or approximately 400 persons per day. The service was discontinued on December 26, 2003.

The one key finding from this BOS implementation was that without end-to-end coverage of the corridor/route, and in particular not at the most congested location, BOS did not offer improved travel time or reliability. In addition, there were reports that "jealous motorists", whether in automobiles or trucks, occasionally attempted to block the buses.

Virginia: Study of I-66 inside the Beltway

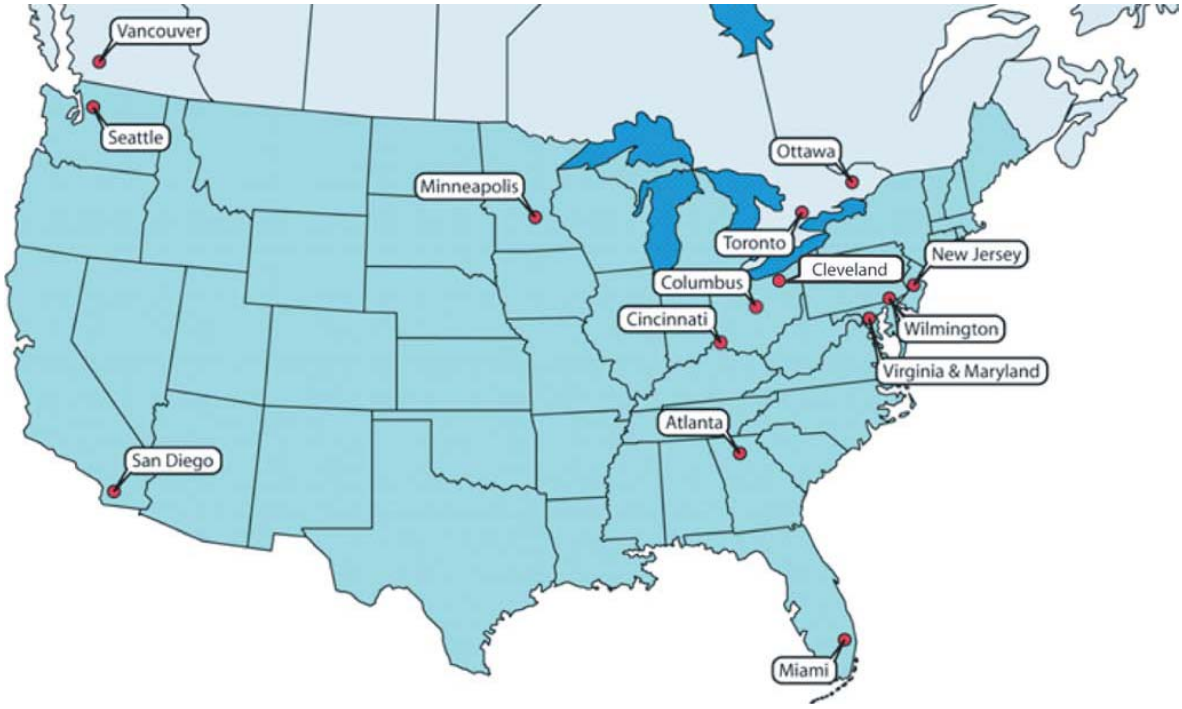
This is a VDOT study in progress on the feasibility of BOS for this corridor, with the goal of establishing a pilot project in 2013. The study will identify the best practices related to BOS systems, identify potential locations, and evaluate operational as well as design and safety issues related to a pilot BOS implementation on I-66 inside the Beltway.

As an operational study taking place contemporaneously with the TPB BOS Task Force work, information from the I-66 study will be used to better inform the task force's work.

National and Other Experience with BOS

There have been a number of studies of Bus On Shoulders by the Federal Highway Administration (FHWA) and by the TCRP. TCRP Report 151 provides considerable information on BOS operations in North America, including 11 in metropolitan regions in the United States and three in Canada, as shown in Figure 2.

Figure 2: North American Cities with BOS (TCRP Report 151)



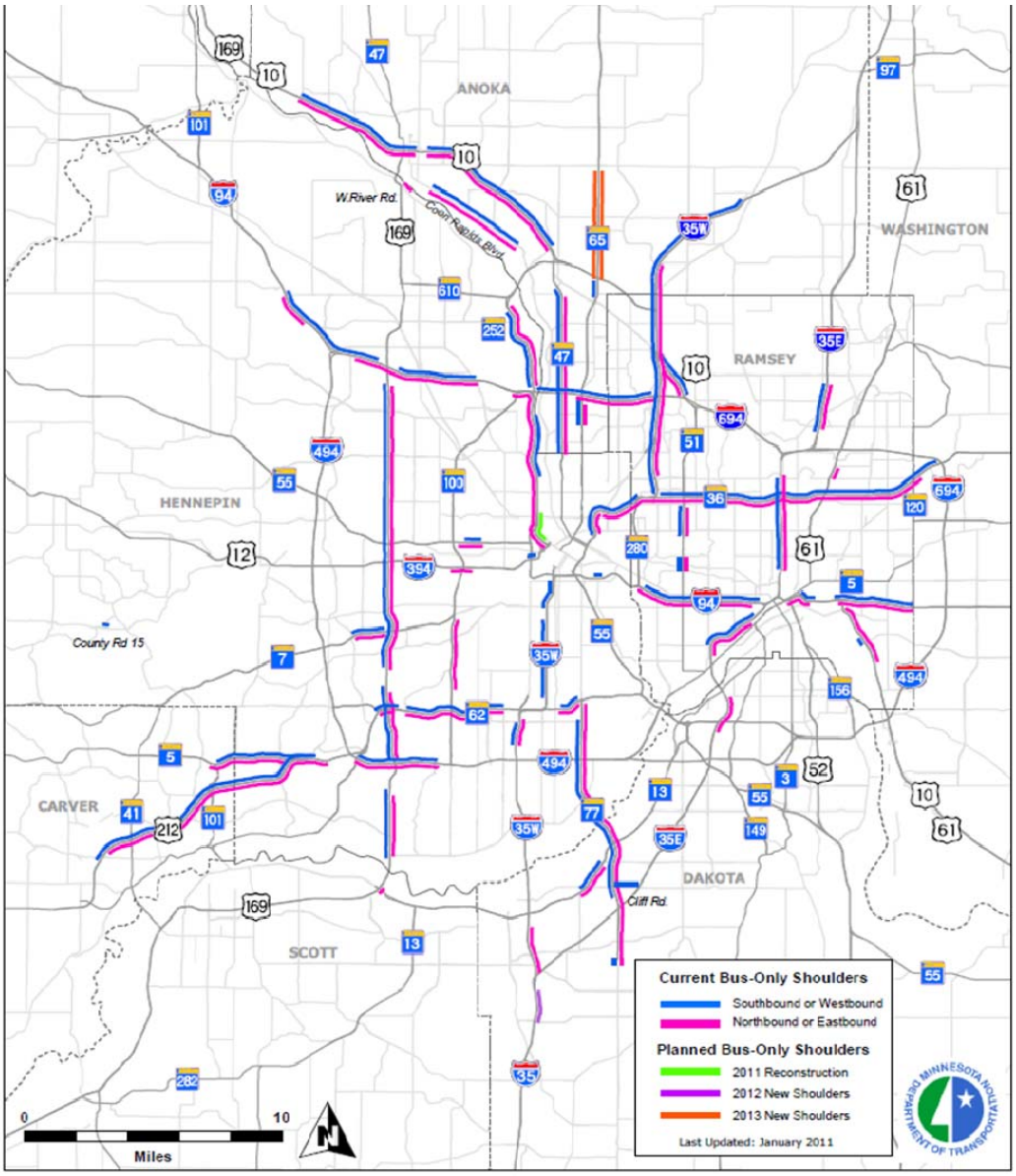
The dominant example of BOS is in the Twin Cities area of Minneapolis and St. Paul. Begun in 1991 in response to floods shutting down several key points on the road network, the quickly implemented measure proved successful, leading to further expansion. The Twin Cities now has a network of over 280 miles of highways with BOS, with four to eight miles added per year. Some 1,700 bus trips a day (400 buses) make use of at least part of the BOS network. Key characteristics of the Twin Cities' network include:

- Dedicated funding line item in the State DOT budget, which funds the road upgrades necessary for BOS at a cost of $150,000 to $250,000 per mile. Originally $2 million a year, funding approximately 20 miles of improvements. Now $1 million per year for improvements (funding 4 to 8 miles) and $1 million a year for maintenance of the shoulders.
- Rider perception of time savings is two times greater than actual time savings measured.
- Safety reviews have found no statistically significant differences between BOS and routine operations.

Policy for BOS implementation, operating requirements, and other elements of the Twin Cities' BOS program are described further in Section C.

As shown in Figure 3, the BOS Network in the Twin Cities is not a continuous network, but rather a series of distinct corridors or segments, focused on areas where there is recurring congestion that buses want to circumvent.

Figure 3: Map of Twin Cities BOS Network (Minnesota DOT)



Besides the Twin Cities, most BOS operations are newer and typically consist of just one or two corridors. One recently implemented BOS operation is along the I-55 corridor in the Chicagoland area. To date, the Chicago experience has proven very successful, with the operating agency Pace now having to add bus trips. From when the BOS pilot project began on November 14, 2011 to April 2012, travel times and on-time performance on the two routes using BOS improved from 68 percent of trips arriving on-time to 92 percent. Six months after implementation, the two routes carry a total of about 500 passengers per day, up almost 75% from before BOS was implemented.

Another recent BOS pilot implementation has taken place in the Triangle area (Raleigh / Durham / Chapel Hill) of North Carolina along I-40. This pilot project covers four Triangle Transit bus routes operating along on a little over 10 miles of roadway (most both directions, a small section one direction only) on the outside shoulder. Operation is 24/7 and cost is approximately $2,000 per mile for signage.

The most recent BOS implementation in North America (as of time of writing) is the Jo Xpress express buses operating on I-35 in Johnson County, KS, in the Kansas City Metropolitan Area. BOS operation began in January 2012. The project is a joint effort between Johnson County Transit and the Kansas Department of Transportation (KDOT), along with the Kansas Highway Patrol. BOS operation is permitted during peak periods and both signage and markings have been installed to allow buses to operate on the outside (right) shoulder. Buses are not permitted to use the shoulders at system to system interchanges with multiple ramps. Buses operating on the shoulders may not exceed the speed in the general traffic lanes by more than 10 mph and the maximum operating speed for BOS is 35 mph. The approximate cost of the shoulder improvements was $9,250 per mile.

Section C: Some Lessons and Challenges for BOS Implementation

There are numerous issues and topics that must be addressed in implementing a Bus On Shoulders project by highway, safety, and bus operating agencies. The TCRP reports and the reports, presentations, and other documentation prepared by federal and state agencies and within the transportation industry review the lessons learned and challenges of BOS implementation in considerable detail. As a supplement to these comprehensive studies, this section of the memorandum notes some of the highlights from these studies and provides some comparisons among BOS projects.

Implementation Considerations

Operational Speeds, Hours, Limits

Most BOS projects have specified speeds for traffic in the general purpose travel lanes that indicate when shoulders may be used and the operating speeds of buses using them. In addition, there may be restricted hours of operation and other limits set upon bus use of shoulders.

The operational speeds standard developed in the Twin Cities is: 1) must not use the shoulder when traffic is moving faster than 35 mph; 2) cannot exceed the speed of general traffic by more than 15 mph; and 3) maximum bus speed on the shoulders is 35 mph. Most other BOS projects in the United States have used these same rules, as shown in Table 1.

Table 1 – BOS Operational Speeds and Limits (TCRP Report 151)

	Twin Cities, Columbus, New Jersey, North Carolina	Atlanta, Miami	Cincinnati	San Diego	Ottawa
General Traffic Speeds	35 mph or less	25 mph or less	30 mph or less	35 mph or less	None
Maximum Bus on Shoulder speed	Up to 15 mph faster than general traffic, not to exceed 35 mph	Up to 15 mph faster than general traffic, not to exceed 35 mph	Up to 15 mph faster than general traffic. (i.e., up to 45 mph).	Up to 10 mph faster than general traffic, not to exceed 35 mph	Up to posted highway speed of 100 kph (62 mph)

In establishing protocols, operational speeds and permitted speed differentials should be matched with the corresponding shoulder width and the frequency of intersections or merge points.

Another limit occasionally discussed is the impact of foul weather and whether operational limits should be imposed on shoulder use. Due to increased congestion, shoulder use by buses during foul weather typically offers greater than usual travel time and reliability savings. However, the driving conditions are also more challenging in foul weather and bus drivers are therefore cautious in their use of shoulders, thus limiting the potential benefit in travel time and schedule adherence.

Bus Travel Time Savings / Reliability

The primary goal of implementing BOS is to reduce travel time and improve travel reliability for buses and their passengers. Accordingly, policy criteria for implementing BOS are typically established. In the Twin Cities, for BOS to be considered a corridor must be used by at least six buses a day, and use of the shoulders must save a bus eight or more minutes per mile per week in travel time. In Miami, congestion measured at level of service (LOS) E or F in the peak hour was identified as one threshold for screening corridors for BOS implementation.

Note that while criteria are typically established for recurring (i.e., regular) congestion, bus operating agencies also note the value of being able to use shoulders during non-recurring congestion, such as when lanes are by blocked by a breakdown or during congestion due to a special event. This is why bus agencies typically recommend allowing use of the shoulders unrestricted by time of day.

Regions in which BOS has been implemented have collected data on the travel time savings and increased schedule reliability of bus operations when using the shoulders. Some results are presented below in Table 2.

Table 2 – Observed Travel Time and Reliability Data (TCRP Report 151)

	Twin Cities	San Diego	New Jersey	Miami
Segment Length	(multiple corridors)	8 miles	4 miles	9 miles
Travel Time Savings	5-20 min. (10-60 min. worst case)	Up to 5 min.	3-4 minutes	n/a
Reliability Improvement	n/a	99% on time	n/a	50% reduction in late buses

Design Elements

Shoulder Width, Structural Strength, and Slope

The width of corridor shoulders is one of the primary factors affecting BOS, given that a public transit bus with mirrors typically requires at least ten feet of width. **Generally, shoulder widths range from a minimum of 10 feet to the standard lane width of 12 feet.** Some BOS is operated along lanes as narrow as 9.5 feet; however this narrow width appears to be feasible only for short segments and infrequent use. On the Twin Cities network, some 90% of the approximately 280 miles of designated shoulders are the minimum 10 feet wide, though the standard is 12 feet for all new construction. To provide sufficient shoulder width, Minnesota DOT has reduced some adjoining general lane widths by up to six inches.

Miami requires at least a twelve-foot shoulder when truck volumes exceeded 250 trucks per hour. In Cincinnati and Chicago where shoulders are in use along the median (i.e., left shoulder bus operation), a twelve foot minimum for these shoulders is required due to the restricted sight lines of the bus drivers towards the right, as well as to allow for the tendency of congested motorists to pull left towards the median in order to see further ahead.

An exception in shoulder width is Ottawa, which has widened shoulders beyond general lane width to allow BOS operation at full speed of 100 kph (62 mph). Shoulder width is 5 meters (16.4 ft) on one corridor, Regional Road 174, and 7 meters (23 ft) on Regional Road 417 (peak use of these corridors is 100 buses per hour and 60 buses per hour respectively). Seattle also has extra-wide shoulders for BOS operations.

After width, the second most important physical factor is the strength of the shoulder, largely determined by the pavement thickness. **Typical pavement thickness on general travel lanes is a minimum of is seven inches; however shoulders are typically thinner**, sometimes being only three inches thick. While thinner pavement can support infrequent use, this is not acceptable for frequent use, especially by heavier vehicles like buses. In the Twin Cities, they now build all shoulders to a seven inch thickness.

Shoulders typically have increased slope for drainage purposes. **Reconstruction to build up the shoulders to a flatter slope is recommended**; Minnesota DOT has moved to a two degree slope standard from the four percent slope of older shoulders. New Jersey required 2/5 degree slopes from the previous four degrees. The areas around drains should also be a focus for structural improvements; New Jersey added 78 new drain inlets for its four-mile long Old Bridge BOS project.

Roadway Geometry and Sight Distances

Roadway geometry affects both the operation of a vehicle itself and also the sight distances of the driver. Buses may off-track around curves (i.e., rear wheels swing wider) and require a larger shoulder width, while curves may also restrict sight lines to an obstacle in the shoulder and require the bus speed to be reduced. **Minnesota DOT requires that shoulders be upgraded to the same grades and slopes as the general purpose lanes**, along with a 250 foot minimum sight distance (see Table 4-1 in TCRP 151).

For arterial highways with unrestricted access (i.e., access roads or driveways along the road), wider shoulder widths are recommended due to motorists pulling forward into the shoulder to set up for merging.

Merging at Intersections and Ramps

Typically buses on shoulders must yield to any vehicle entering the shoulder, including at freeway ramps or intersections. **In complex or very busy intersections, shoulder use by buses is generally not permitted.** Generally, more than 1,000 vehicles per hour entering or exiting at an intersection indicate that buses should re-merge with general traffic beforehand, though another option is to implement ramp metering. For dual exit lanes, re-merging with the general lanes is standard practice; for dual entry lanes, bus drivers are usually permitted to weave through the traffic.

In Atlanta, a more restrictive protocol specifies that all buses must re-merge with general traffic before interchange off-ramps and not access the shoulder again until after the on-ramp merge.

It should be noted that motorists are more likely to illegally make use of shoulders at intersections, especially to exit during congestion, which can further impact safety at intersections.

To assist with merging, Minnesota DOT uses ramp metering, which is regarded as being effective in ensuring vehicle spacing for safer merging. In San Diego all intersections along the BOS corridor have auxiliary lanes between the off-ramps and on-ramps, enabling safer merges.

The above discussion applies to most BOS operation, which is along the right-hand shoulders of highways. However Cincinnati and Chicago are examples of median shoulder BOS operation for which intersections are typically less of a concern, unless there are left exits and merges are present along the roadway). However buses have to merge with general traffic and gradually cross to the other side of the highway when transitioning between median shoulders and right-hand entry and exit ramps. This can be challenging when crossing right due to restricted bus driver visibility towards the right rear of the bus.

Clearance at Barriers and Overpasses

In the Twin Cities and most other cities, a 10 foot shoulder width is the minimum acceptable for BOS operation, and is also acceptable for short distances on an overpass. For longer bridges, a minimum of 11.5 feet is required due to the challenge of driving a bus next to a bridge railing. **In general, there should be a 1.5 or 2 foot clearance beyond the shoulder width to any barrier or wall, as well as any drainage gratings or culverts.**

Vertical clearance is not typically an issue, unless a facility has bridges that predate modern design clearances, or if repeated resurfacing has raised the road height over time.

Posted Signage, Markings, and Warning Devices

In general, BOS implementation has used minimal signing and markings. In addition to relevant signage recommended in the Manual for Uniform Control Devices (MUTCD), regions implementing BOS projects have used a number of different signs as appropriate to their state codes, though there does appear to be a gradual convergence. Signs will indicate authorized bus use of shoulders, both along the shoulders and at intersections and merges. For roads within the National Highway System, the precise signage is subject to approval from the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA).

Figure 4: Samples of BOS Signage

In the Twin Cities, small yellow advisory "pinch-point" signs are posted when the shoulder narrows to less than 10 feet and the bus must re-merge into the general lanes.

While in Maryland and New Jersey the authorized time period for BOS operation has been included on signage, there is a growing opinion that this is unnecessary, as bus operations already take into account any time period limitations, while more flexibility might be needed in special circumstances. The exception would be if there are time period rules in effect for

general traffic as well (e.g., high occupancy vehicle operation in peak periods, or no turns on arterial highways in peak periods).

In addition to signage, pavement markings may be used, such as a double white line or a double-wide line, or a there may be a warning device such as rumble strips. Rumble strips between shoulders and the general travel lanes may not be possible if shoulder width is narrow, and existing strips may need to be removed if restricting the useable portion of the shoulder by buses.

Dynamic Signage and Lane Control

The use of Intelligent Transportation Systems (ITS) technology offers some potential applications for BOS. The Washington metropolitan region already employs ITS along I-66 outside the Beltway between the Beltway and US 50 to allow use of the shoulder lane by all traffic, when enabled by overhead signals.

Ottawa, which has bus stops along the highways, has customer actuated call buttons so that buses can exit the shoulders and access the stops to pick up waiting passengers.

BOS operations can benefit from variable message signs with specific information on shoulder use or conditions, or from coordinated traffic operations information on blocked shoulders being pushed to the drivers.

Looking to the future, the University of Minnesota has designed a lane guidance concept, which would use GPS location and other sensors to assist in steering and provide warnings, including a collision avoidance system, for implementation onboard buses. Further developments may lead to deployment of this technology in buses intended for BOS operation.

Operational Considerations

BOS Safety and Emergency Incidents & Responder Access

The reported safety record for all BOS systems evaluated in the TCRP reports has been exceptional. Periodic accident review has not produced any statistically significant findings concerning BOS operation. In general only minor property accidents have taken place, mostly involving mirrors. Proper education, enforcement, training, and signage have all been important in achieving this record in all the BOS projects evaluated.

Except in unusual circumstances, with completely blocked traffic, there have been few reported instances of buses not being able to re-merge into the general lanes to clear the way for emergency vehicles.

In Atlanta, additional bulb-outs outside the shoulders were added, for both enforcement use and for disabled vehicles.

Enforcement and Encroachment / "Jealous Motorist" Issues

Enforcement's primary role for BOS operation is to ensure only authorized buses make use the shoulders. In addition to motorists using the shoulders, motorists can also encroach upon the shoulders, blocking safe bus use. According to interviews and surveys, bus drivers using BOS often experience motorists blocking the shoulder so that the bus could not pass or pass only with difficulty; in Miami up to 44% of bus drivers reported experiencing this daily. This encroachment on the shoulder is particularly problematic when the other vehicle is a truck. Most of these incidents are ascribed to poor or inattentive driving, but there are also cases of other drivers deliberately blocking the bus: the "jealous motorist" issue. Education and enforcement are the common strategies to combat encroachment of any type.

In Miami, the fine for failure to yield to buses as they enter and exit shoulders, or for following a bus on the shoulders, is $133.50 plus license points.

Dedicated additional police enforcement is often provided during the early stages of BOS operation on a corridor; six to eight hours during the first couple of weeks and two hours per week for another four weeks. Some projects have also used escort vehicles the first day of operation, to accompany the buses.

Public Outreach and Education

In advance of the Miami BOS project on SR-874/878, a three-element outreach plan was conducted. First, a service campaign with details on the bus service to be provided: routes, travel time, fares, and park-and-ride lots. Second, a media and elected officials event, including a comparative trip by two buses, one using the shoulders and one not. Third, a public service announcement was made for the project, emphasizing enforcement.

For implementation in North Carolina, NCDOT drafted a one-page fact sheet and developed a list of Frequently Asked Questions (FAQs) and responses, for stakeholders to use in public outreach efforts.

Shoulder Cleaning / Snow Removal

Ensuring the shoulders are clear of debris or snow is essential for safe BOS operation. The Twin Cities includes shoulder clearance in their snow clearance plans. In Columbus, OH, the debris clearance periodicity for shoulders was increased from once every three weeks to once a week for the BOS segment.

Regulatory and Funding Considerations

Federal and State Exceptions to Design Code

FHWA must approve design code exceptions to allow BOS along the National Highway System. The Federal Transit Administration may also be involved if any FTA funds are used for implementation.

Most states also have vehicle codes that require amendment when first authorizing BOS; the amendments typically carefully define the shoulders as limited-access or special transit use lanes to get around general roadway standards. Exceptions are often used for pilot periods of two or three years, before legislation for permanent programs is required.

It is important to note for liability issues that any nonstandard exceptions to design code could be targeted in court in the event of a crash or accident. Several states, such as California, incorporate permission into code for transit-only use of shoulders provided comprehensive safety and engineering studies are completed and approved.

The exact designation of the BOS segments, whether as transit lanes or shoulder lanes, will in turn be reflected in the necessary traffic signage.

In regard to the Washington metropolitan region, it is recommended that signage in the region be either the same or as similar as possible across state lines. There do not appear to be any current BOS operations that continue across state lines, which would require coordination of regulatory and operational factors.

Eligible Vehicles

In most cases, BOS operation is typically limited to public transit buses. North Carolina further limits BOS operations to transit buses of standard size, though other projects offer wider latitude. Operationally, large transit buses can be seen by other motorists and the drivers sit high enough to see potential hazards. The drivers are also trained and supervised, as detailed below. Policy wise, this restriction limits shoulder use to a small number of vehicles and those vehicles are transit buses that directly help to reduce congestion. In addition, roughly half of BOS projects allow deadheading (i.e., empty) buses to make use of the shoulders; others only allow use when carrying passengers.

However, there are exceptions. Minnesota allows paratransit vehicles to use the shoulders. Private charter buses that have gained permits are also allowed to use the shoulders, though reports are that few private operators have invested in the necessary driving training in order to obtain permits. Minnesota also considered allowing vanpools to use shoulders, but this did not pass the state legislature.

An unusual exception to eligible vehicles occurred when Atlanta first implemented BOS; school buses also made use of the shoulders even though they were not permitted. However this violation was quickly corrected.

Bus Driver Training Requirements and Supervision

Public transit bus drivers are allowed to use the shoulders because they are professional drivers. They are accountable to operating rules and trained to handle complex driving decisions while driving on the shoulder.

Driver training typically includes lessons on the purpose and policy for BOS use, knowledge of signs and markings, operating speed limits for the bus and for general traffic, merging at intersections, accessing and exiting the shoulders, and procedures when the shoulders are blocked or need to be used by first responders. For instance, in the Twin Cities the BOS drivers are instructed to merge with the general lanes once within 1,000 feet of an obstruction.

In addition, to protocols, there may be special instructions when operating in the shoulder; for instance, in the Twin Cities, Miami, Columbus, and North Carolina, buses activate their four-way flashing lights. In San Diego buses don't use flashing lights but put on low-beam headlights.

Funding for Construction and Implementation

Costs range considerably for BOS implementation, depending upon the initial condition of the roadway and the desired conditions. The Twin Cities, with a specific fund of $1 million a year, is able to add four to eight miles of shoulder segments a year, at a cost of roughly $150,000 to $250,000 per mile. Other areas have had lesser costs per mile for less frequently used shoulders, typically only four to six buses per hour. At the higher end, the Old Bridge BOS project in New Jersey was $8.5 million for nine miles of arterial highway, but this involved substantial shoulder improvements, as well as bus shelters, sidewalks, and pedestrian islands.

Capital funding for BOS implementation typically comes from state and local sources. In the long run, fixed guideway miles become eligible for federal transportation funds, and shoulders may qualify under certain criteria. In the Twin Cities, with twenty years of operation, the transit agency collects FTA Section 5307 capital guideway funds of roughly $30,000 per shoulder lane mile.

Funding for Operations and Maintenance

Additional funding is needed for support of BOS operations. More frequent shoulder clearance of debris, or snowfall, adds to operating costs. Enforcement costs also increase to patrol the shoulders for traffic offenses and deal more quickly with any breakdowns or vehicle removal.

Bus operations for shoulder use will also require some additional funding, as new drivers require training on the protocol for bus operations and familiarization with the shoulders. Some additional supervision costs may also be incurred to ensure more frequent reporting on shoulder use. However, many of these are base costs already being incurred. The additional marginal cost of supporting BOS operations would be difficult to identify.

The net financial impact of BOS operations is likely to be indeterminate, or rely on variable traffic conditions. Much bus service using shoulders is implemented in conjunction with shoulder use, so tracking savings from improved travel speeds and schedule reliability is difficult. By and large, practitioners evaluate the bus operating savings as roughly offsetting the costs of driver training and supervision by the transit agencies as well as the enforcement costs for the police and increased road maintenance costs for the highway agencies.

Section D: References

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