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Bus Riding on Shoulders

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16. Abstract

Bus on shoulder (BOS) operations have been ongoing in several locations across the United States and abroad. Public transit buses in the designated highway and arterial shoulders are generally allowed to travel up to 15 mph faster than traffic in the general lanes, but no more than 35 mph. These operations are typically undertaken to give public transit riders a faster and more reliable traveling experience when highway and arterial general traffic lanes are congested.

The research team reviewed the literature on safety and operational aspects of shoulder use and the ways in which shoulder use has been incorporated as a way to manage congestion in several regions. They also interviewed primary stakeholders, who might be involved in planning and operating a BOS system in Northeastern Illinois and analyzed their comments. They found that highway shoulders have been used for a variety of purposes in many regions over time with proper precautions and appropriate authorization, including operating buses on them to bypass congestion in the general traffic lanes. In this study, the investigators show that BOS operations have been undertaken as part of congestion management strategies in many regions.

Although Illinois stakeholders have raised many concerns, it appears that BOS operations are feasible for Northeastern Illinois, although much will depend on the selection of the right highway segments, bus driver education and training, awareness among motorists, and various other strategies that should be addressed. Cost and legal factors governing BOS operations should also be addressed.

BOS operations may effectively work in Northeastern Illinois, if implemented as part of an overall congestion management strategy and after being studied as a part of a year-long demonstration project to identify the best ways to operate.

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EXECUTIVE SUMMARY

Transit agencies have operated buses on highway and/or arterial shoulders across the United States and abroad to increase schedule reliability and decrease travel times. In bus on shoulders (BOS) operations, buses typically are allowed to run on sufficiently wide and durable shoulders when traffic in the general traffic lanes travel less than 35 mph. However, the buses must merge back into the general traffic lanes when traffic has exceeded 35 mph, when the shoulder segment is no longer sufficiently wide or durable, or when an obstruction is temporarily blocking the shoulder (debris, disabled car, etc.). When merging back into traffic, these buses must yield to vehicles entering, leaving, or crossing the shoulder to access or leave an interchange ramp or intersection.

Pace, the suburban bus division of the Regional Transportation Authority, initiated the idea of operating a BOS service in the region and approached the Illinois Department of Transportation (IDOT). Since stakeholders could not agree whether this idea was beneficial, IDOT and Pace initiated this study to systematically address stakeholder concerns over BOS service in this region, using lessons learned from the experiences of other BOS implementers.

To address these concerns, the research team worked with IDOT and Pace to identify relevant stakeholders from various backgrounds (e.g. highway and transit operations, highway safety, road maintenance, and law enforcement) who would likely affect BOS implementation. The research team reviewed the BOS literature, discussed this subject with experts in the field, visited several BOS operators, prepared a presentation, and structured interview questions for the aforementioned stakeholders. After interviewing the stakeholders, the research team identified major concerns that needed resolution and developed a planning process that has taken their primary concerns into account.

Since stakeholders most often cited safety as their primary concern, the research team delved into studies that dealt with traffic safety on highways and arterials, such as crash incidence, conflicts at on-off ramps, copycat cars using the shoulders, impacts on motorists in adjacent lanes, debris on the shoulders, speed differentials, potential need to narrow general traffic lanes, and buses needing to periodically merge into and out of the shoulder and general traffic lanes. Evidence to date shows that appropriate bus driver training; signage; motorist education; and consistent upkeep, maintenance, and removal of debris can promote safe BOS operations. The fact that BOS operations are becoming more widespread, particularly in communities that have established BOS operations, is further evidence that localities are comfortable with the safety performance of these operations.

Since better road design can promote safety, the research team also examined how road engineers can modify and/or build highway and arterial shoulders to support daily BOS operations. Their issues include minimal shoulder width and thickness, shoulder texture treatments, and pavement markings. These and other necessary design modifications can cost up to $250,000 per mile, depending on the amount of work required.

Stakeholders raised other specific concerns regarding BOS implementation, which the research team has addressed in the following tables and in the main body of this report.

Although stakeholders raised many concerns, the research team found that BOS operations are feasible and could effectively operate in Northeastern Illinois as part of an overall congestion mitigation strategy. This project's success will largely depend on such things as selection of appropriate highway segments, bus driver education and training, greater motorist awareness, and resolution of financial and legal factors surrounding BOS operations.

1. Traffic Safety Issues	
STAKEHOLDERS' CONCERNS	**POSSIBLE RESOLUTION/MITIGATION**
▪ *Conflicts at on- and off-ramps*	▪ Clarify whether buses would merge into traffic lanes before highway interchanges; ▪ Implement speed management for bus drivers and merging traffic (e.g., ramp metering); ▪ Select highway segments that do not have frequent entrances and exits; ▪ Select highway segments that do not involve major interchanges serving large numbers of unfamiliar drivers; and ▪ Provide proper signage for BOS operations.
▪ *Sight distance adequacy, particularly at on-ramps*	▪ Manage highway speeds better; ▪ Restrict operations that impair sight distances, particularly at on-ramps; ▪ Use left shoulders for BOS operations; ▪ Yield to oncoming traffic; and ▪ Integrate BOS operations with ramp metering.
▪ *Conflicts for motorists pulling onto the shoulder*	▪ Use enforcement and technology (e.g., video surveillance) to monitor operations; ▪ Train motorists better (e.g., to use turn signals when pulling onto the shoulder); and ▪ Select highway segments where BOS operations are frequent enough to familiarize motorists (e.g., a handful of buses each day will not be enough to change motorists behavior).
▪ *Losing the safe evasive movement shelter (shoulder) area*	▪ Provide proper signage for BOS operations; and ▪ Allow sufficient time to familiarize motorists with BOS operations.
▪ *Bus driver training*	▪ Substantially upgrade the training and recruiting standards for bus drivers.
▪ *Speed differential*	▪ Substantially educate drivers and motorists on BOS operations; ▪ Provide proper signage for BOS operations; and ▪ Allow sufficient time to familiarize motorists with BOS operations.
▪ *Impact of BOS operations on adjacent lane motorists*	▪ Provide proper signage for BOS operations; and ▪ Allow sufficient time to familiarize motorists with BOS operations.

▪ *Return merge distance adequacy*	▪ Coordinate with the Chicago area traffic operations center that monitors area-wide traffic speeds; ▪ Provide proper design and signage for BOS operations; and ▪ Allow sufficient time to become familiar with BOS strategies.
▪ *Shoulder area debris hazards*	▪ Clean as often as the general purpose lanes.
▪ *Reduced clearance for buses at bridge abutments*	▪ Prohibit bus use of shoulders at bridge abutments.
▪ *Assistance of a broken-down bus*	▪ Use incident management personnel; ▪ Park bus properly to protect passengers; ▪ Communicate protocol with transit dispatchers; and ▪ Deploy an integrated Incident Management Program.

2. Loss of Intended Shoulder Functions	
STAKEHOLDERS' CONCERNS	**POSSIBLE RESOLUTION/MITIGATION**
▪ *Removal and storage of disabled vehicles and accidents*	▪ Provide good communications with transit dispatcher; and ▪ Deploy Vehicle Infrastructure Integration (VII) technologies.
▪ *Emergency vehicle use*	▪ Provide quick emergency response through good communications with transit dispatchers.
▪ *Staging area for maintenance work*	▪ Provide good communications with transit dispatchers; ▪ Deploy a Maintenance Management Information System (MMIS); ▪ Provide motorist training that adheres to DMS; and ▪ Provide more stringent police enforcement.
▪ *Snow storage*	▪ Provide good communications with transit dispatchers; ▪ Use only right shoulders for BOS operations; and ▪ Prohibit BOS operations during snow removal.

3. Physical Design Issues	
STAKEHOLDERS' CONCERNS	**POSSIBLE RESOLUTION/MITIGATION**
▪ *Shoulder width adequacy*	▪ Only run BOS operations on standard width segments (10 feet or more).
▪ *Shoulder pavement strength*	▪ Require engineering review.

▪ *Signage*	▪ Benefit from experiences with signage from other cities with long traditions of BOS operations; ▪ Decide on the merits of passive or active signage; ▪ Deploy DMS integrated with the Chicago area traffic operations center that has access to network traffic times; ▪ Educate motorists; and ▪ Provide enforcement.
▪ *Lateral obstruction adjacent to shoulder*	▪ Have buses merge back into the general traffic lanes.
▪ *Narrowing general traffic lanes*	▪ Avoid by all means.
▪ *Conflicts of BOS operations with pavement edge rumble strips*	▪ Construct noise barriers that don't interfere with BOS operations; and ▪ Limit BOS operations when traffic in the general traffic lanes is light.
▪ *Drainage cross slopes*	▪ Maintain low bus speeds to eliminate any problems with drainage cross slopes.

4. Legal/Institutional Issues	
STAKEHOLDERS' CONCERNS	**POSSIBLE RESOLUTION/MITIGATION**
▪ *Regulations*	▪ Provide tort immunity from transit operators; ▪ Prohibit interference between BOS operations and emergency response vehicles; ▪ Allow minutemen to operate in a similar manner with police and firefighters (e.g., siren use); ▪ Obtain permits from FHWA on all interstate segments selected for BOS operations; and ▪ Incorporate relevant new regulations into the "Rules of the Road."
▪ *Enforcement*	▪ Expand the current use of cameras in BOS operations; and ▪ Use ISTHA's existing monitoring system on tollways.
▪ *Liability*	▪ Indemnify highway operators; ▪ Address the vacuum in the liability framework that exists since most highway shoulder designs do not conform to the standards manual of IDOT's Bureau of Design and Environment (BDE); ▪ Address Chicago standards vis-à-vis national standards; and ▪ Address any legal vacuum that exists during the BOS pilot demonstration.
▪ *Insurance coverage*	▪ Discuss between transit and highway operators.
▪ *Union involvement*	▪ Bring bus driver unions to the table as soon as possible.

▪ *Who should be involved during planning and implementation of BOS operations*	▪ Include IDOT, CDOT, the Cook County DOT's Legal Office, the Secretary of State's Office, councils of mayors, counties, individual municipalities, tow truck operators, fire departments, other interested officials, and the public at large.
▪ *Private buses*	▪ Give public buses priority over private buses; and ▪ Clarify which types of bus services would be called "private," based on the type of services they provide and then assign priorities for designated shoulders.

5. Cost Issues	
STAKEHOLDERS' CONCERNS	**POSSIBLE RESOLUTION/MITIGATION**
▪ *Cost to upgrade shoulders for bus use*	▪ Estimate the cost to upgrade shoulders for bus use based on an engineering study.
▪ *Cost to keep shoulders free from debris*	▪ Consider potentially additional costs due to rescheduling.
▪ *Cost to maintain the shoulder pavement*	▪ Develop a database to track costs and level of effort.
▪ *Cost sharing*	▪ Negotiate between the parties involved and allocate cost sharing based on the level of benefits each party realizes; and ▪ Identify a committed funding source.

6. Special Issues	
STAKEHOLDERS' CONCERNS	**POSSIBLE RESOLUTION/MITIGATION**
▪ *Acceptance of toll paying motorists for BOS use*	▪ Engage in extensive public outreach.
▪ *BOS at toll plazas*	▪ Provide extensive motorist training; and ▪ Involve Pace, ISTHA, and the Illinois State Police.
▪ *Trial period for a BOS demonstration*	▪ Avoid ISTHA segments during the trial period; ▪ Make the trial period long enough to evaluate the effectiveness of the concept, and agree beforehand when to terminate the trial period; and ▪ Design and fund experiments well.

▪ *Highway segment selection*	▪ Prioritize highway segments for BOS operations based on their level of service; ▪ Select segments with a large portion of local traffic; ▪ Select segments that are lengthy and wide enough for BOS operations to break even in effectiveness; ▪ Select segments away from the Chicago Loop where there are many exits together; ▪ Select segments to attain the highest ridership; ▪ Select segments so that BOS operations would focus on suburban areas; ▪ Select segments so that BOS would serve areas where rail service is limited, constrained, or non-existent; ▪ Select segments with the proper shoulder width and structural strength of the shoulder pavement; ▪ Select only right shoulders on tollway facilities for BOS operations; and ▪ Stay away from tollway segments.

7. Operational Issues	
STAKEHOLDERS' CONCERNS	**POSSIBLE RESOLUTION/MITIGATION**
▪ *Adverse weather conditions*	▪ Obtain more information from other cities that experience the harsh realities of Chicago-like winters.
▪ *Snow and debris removal*	▪ Implement a new operational procedure for snow and debris removal (at great cost).
▪ *Right or left shoulder*	▪ Avoid left shoulders since they are insufficiently wide for safely operating BOS operations; ▪ Evaluate the right shoulder for areas with high truck volumes; and ▪ Acknowledge that right shoulders are easier on bus drivers.
▪ *Operating speed*	▪ Establish a safe speed to safely merge with general traffic; ▪ Propose low speeds; and ▪ Apply effective enforcement.
▪ *Public acceptance*	▪ Undertake a substantial public outreach effort to educate motorists; and ▪ Implement a successful demonstration project.
▪ *Impact on agency operations*	▪ Coordinate with other agencies to minimize impacts on agency operations.

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CHAPTER 1 INTRODUCTION

Several American and international cities and regions let their public transit agencies operate buses on highway shoulder segments under certain conditions to help them avoid congestion and adhere to their schedules at little cost to transit operators. This practice is generally referred to as Bus-on-Shoulder (BOS) riding. Based on existing studies, BOS services have attracted riders to these routes over time and have helped mitigate highway congestion, without significantly disrupting automobile drivers or contributing to traffic accidents.

Given BOS' record of efficiency and safety, cities and regions have tried to implement BOS systems with mixed results. Successful cities and regions have had their government agencies and affiliated organizations consistently and methodically work together early in the planning process and continue through the demonstration testing, engineering, implementing, and operating phases. However, little documented information exists about how previous BOS implementers have dealt with the administrative, financial, institutional, legal, and operational issues that had accompanied the development of their BOS systems. This lack of information may be one of the primary reasons why many communities have not yet adopted BOS strategies. This report, therefore, will look at the experiences of previous BOS implementers and use it to address some of the issues and concerns that potential BOS stakeholders have had in Northeastern Illinois.

CHAPTER 2 LITERATURE REVIEW

2.1 PLANNING FOR BOS IMPLEMENTATION

Many government agencies and affiliated organizations are needed to effectively plan and implement a BOS network, including transit service providers; federal, state, county, and/or local departments of transportation (DOT); state police; metropolitan planning organizations; and federal, state, county, and/or local officials. Universities may also serve as advisors.

However, local transit providers and state departments of transportation usually play the primary roles in BOS implementation and are often responsible for financing its planning, public involvement, infrastructure, training, operations, and maintenance costs. They usually start BOS operations as demonstration projects within a fixed time period to determine whether they can achieve their stated goals. To limit the potential for conflicts, some of these agencies have entered into binding agreements beforehand, which specify each party's responsibilities and indemnification issues as well as the BOS operation's goals, operating rules, location or locations, and time period.

The local transit providers and state departments of transportation evaluate their demonstration projects during and after the trial period; modify them, if desired; and determine whether these projects have met their stated goals and should be continued. Throughout this process, the larger group of aforementioned agencies and organizations need opportunities to provide their input. If these agencies and organizations collectively deem a pilot project successful, they should seek legislation that formally recognizes the BOS service or services in their region and/or state.

One of the most challenging aspects of establishing a BOS system is determining where to initiate a demonstration project or projects. Government agencies and affiliated organizations from many of the cities and regions with BOS services have typically selected highway shoulder segments that only needed minor modifications with no ongoing or planned construction in their near future as sites for their initial demonstration projects. These shoulder segments had significant amounts of bus service and sufficient congestion to warrant BOS operations.

2.2 THE FUNDAMENTALS OF A BOS NETWORK

In a BOS network, state departments of transportation and local transit service providers allow public (and sometimes, private) transit buses onto designated highway and/or arterial shoulders to avoid congestion in the general traffic lanes. Since standard size buses are generally nine feet wide and have projecting mirrors on each side, highway and arterial shoulders must be at least ten feet wide to provide sufficient clearance from traffic in adjacent lanes. Wider shoulders may also be necessary on bridges or viaducts due to lower visibility. Given the benefits of BOS networks, some departments of transportation have included shoulder widening in their construction and reconstruction plans.

Typically, transit operators run their buses on the right shoulders of designated highways or arterials in a BOS system. These shoulders are generally wider than left shoulders, provide easier access to highway entrance and exit ramps, and are adjacent to the passenger side of vehicles traveling in the general traffic lanes. This lessens the chances that bus drivers might startle drivers who are unaware of the BOS lanes. The Southwest Ohio Regional Transportation Authority's Route 171 from Kenwood to Kings Island in the Cincinnati region is a notable exception. Here, buses travel on the left shoulders since the long distances between highway exits makes these shoulders faster and safer for them. Their perfect safety record appears to back up this theory.

All transit agencies require drivers who operate vehicles along highway shoulders to undergo training. In many cities, bus drivers use their discretion if they want to operate along a shoulder. There have been instances in Minneapolis when bus drivers have not used the highway shoulders, even though their riders have asked them to.

Transit agencies' operating rules for buses travelling on highway shoulders are fairly similar. First, all transit agencies train their drivers on the proper use of BOS lanes before they use them. Second, all of these agencies require their drivers to yield to traffic entering or exiting the highway. Third, all of these agencies require their drivers to reenter the general traffic lanes if an obstruction, such as a disabled vehicle, is temporarily in the shoulder. Fourth, most of these transit agencies prohibit their drivers from going 10-15 mph faster than traffic on the general traffic lanes or from exceeding 35 mph on the highway arterial shoulders. Fifth, many of these agencies prohibit their drivers from using the highway shoulders during inclement weather. Sixth, many of these agencies require their drivers to keep their hazard lights on when traveling on the shoulders. And finally, each of these agencies has signage that tell drivers in the general traffic lanes that buses may be operating on the shoulders.

2.3 CHALLENGES ASSOCIATED WITH IMPLEMENTING A BOS NETWORK

Implementing a BOS network involves operational, traffic safety, and structural issues. Although BOS operations allow buses to move their customers faster and more reliably, operational highway shoulders provide space for emergency and disabled vehicles, for drivers receiving tickets, and for snow that has been removed from the general traffic lanes. Since these roles remain unchanged for cities that allow buses to operate on their highway shoulders, it is crucial that proper training is provided to transit operators and that regular communication occurs between bus drivers and their main transit operations center.

Traffic safety issues also need to be identified, including how to handle the following: potential conflicts at on-off ramps, copycat cars wanting to use highway shoulders, impacts on motorists in adjacent lanes, debris on highway shoulders, speed differentials, and buses needing to periodically merge in and out of the highway shoulders and general traffic lanes. These issues can be largely overcome via bus driver training, proper highway signage, motorist education, and/or consistent maintenance upkeep by highway staff.

Other challenges pertain to the physical adequacy of highway shoulders, such as highway shoulders' width and durability, and the presence of rumble strips. The costs associated with these issues vary depending on the amount of work required. The State of Minnesota, for example, has estimated its cost to upgrade shoulder lanes at $250,000 per mile, including costs for rebuilding drainage grates and paving additional asphalt. (Martin, page 2-3, A Guide for Implementing a Bus-on-Shoulders System, Draft TCRP Report). Other sources have estimated less than half of this cost.

All of the parties involved in implementing a BOS operation must give adequate attention to these and other challenges and details, so that a BOS network will be safe and successful.

2.4 THE EARLIEST AMERICAN BOS OPERATIONS

BOS operations likely began in Seattle in 1970 when the Washington State Department of Transportation allowed buses and other select high occupancy vehicles to ride on the shoulder of a 2.7-mile segment of westbound SR-520 and a 2.2-mile westbound segment of SR-522. The Washington State Department of Transportation allowed these vehicles to travel at the posted speed limit on the SR-520 shoulder segment because it originally was a toll booth bypass lane. In 1986, the Washington State Department of Transportation began allowing bus access on the eastbound segment of SR-520.

The 2.2-mile westbound segment of SR-522, on the other hand, was originally built wider and stronger than a normal highway shoulder to accommodate buses. The Washington State Department of Transportation wanted to give motorists on this highly congested road to and from Seattle a more reliable commute using buses (from a private conversation with Chris Picard, Manager of Urban Planning at the Washington Department of Transportation).

Although the number of collisions that could be attributed to these lanes is not currently known, anecdotal evidence from the Washington State Department of Transportation's traffic engineers and communities along SR522 have not indicated a higher accident rate due to the operation of these lanes.

Twenty-two years later, Minneapolis-St. Paul implemented its own BOS network, which has become the largest BOS system with more than 250 miles of BOS-accessible highway and arterial segments. The other American BOS networks combined are only a fraction of that in Minneapolis-St. Paul.

Like many parts of the country, Minneapolis-St. Paul faced growing congestion that adversely impacted its local transit providers' ability to meet their route schedules. The Minnesota Department of Transportation, the Metropolitan Council (regional planning organization), the Metropolitan Transit Commission (now referred to as Metro Transit), the University of Minnesota's Center for Transportation Studies, and transit advocacy groups, therefore, met to develop solutions to this problem. These meetings led to the formation of Team Transit in 1991 (Hubert H. Humphrey Institute of Public Affairs, University of Minnesota, *Bus-Only Shoulders in the Twin Cities Final Report*, June 2007). Its core partners have been Metro Transit and the Minnesota Department of Transportation, with the other partners serving advisory roles. One of Team Transit's first ideas was BOS, which was initially launched in 1992 on a few arterial roads with stoplights, which enabled buses to more easily merge into the general traffic. At the beginning of this implementation process, Metro Transit assigned one of its employees to work on BOS issues with the Minnesota Department of Transportation. Without this cooperation, the BOS project would have not likely been implemented.

In the spring of 1993, this process got a jump start when a flood caused the closure of several bridges over the Minneapolis River, severely curtailing access to Bloomington, Minnesota. The State of Minnesota, therefore, permitted buses to ride on the shoulder of one highway segment (MN 77) to reduce congestion. Previously, the Minnesota Department of Transportation and the Federal Highway Administration refused to let Metro Transit operate buses on highway shoulders because of safety concerns. Since these buses were able to transport passengers more effectively, BOS became a permanent feature in the area. BOS service had become so popular that the Minnesota Department of Transportation hired a full-time employee to handle BOS issues in 1997.

Between 1994 and 2007, Minneapolis-St. Paul has annually expanded its BOS network 10-41 miles each year. At the beginning of 2007, Minneapolis-St. Paul had 262 miles of BOS highway and arterial segments. Each of these shoulder segments has met the Minnesota Department of Transportation's BOS design criteria.

The Minnesota Department of Transportation relies on input from bus drivers and related agencies' staff to identify shoulders they believe are appropriate so that its traffic, design, and materials offices can examine their feasibility. These shoulders should be at least ten feet wide and adjacent to general traffic lanes with regular congestion delays and buses travelling at least six times an average weekday on them. Use of these shoulders must also save buses eight or more minutes per mile per week. It has balanced these criteria against the costs involved to convert these shoulders and against whether it can coordinate these conversions with ongoing or planned maintenance projects.

The Minnesota Department of Transportation has also been looking at ways to enhance BOS services, including 12-foot wide shoulders and shoulder pavement depth of at least seven inches on all new highways and catch basins that support shoulder transit use (MnDOT 2007). This innovative process has been going on since the inception of BOS operations in Minneapolis-St. Paul. Since 2004, for example, its plow drivers have routinely removed snow from highway and arterial shoulders for BOS operations. These shoulders were previously closed during some winter storms because highway maintenance workers were not clearing snow on the shoulders or were using them for snow storage.

Under TEA-21's guidelines, the Federal Transit Administration has given approximately $20 million annually to the Metropolitan Council for its transit providers' BOS capital and operating expenses. The Metropolitan Council has also funneled federal Congestion Mitigation and Air Quality (CMAQ) funds to them.

Besides federal funds, the Minnesota Department of Transportation has provided funding for BOS capital costs related to road and safety improvements and the counties have paid some of the capital costs associated with upgrading designated shoulders on their county roads. Metro Transit and other transit agencies have also contributed to their own park-and-ride facilities and other transit amenities.

Metro Transit supervisors train their bus drivers who drive on the designated highway and arterial shoulders. Between 1991 and 2001, only 20 accidents involving buses occurred on highway and arterial shoulders, which caused only minor damage (Douma 2007). Since 2001, there was only one injury – which led to a fatality – but the bus driver was found not at fault. The accident rate has been so low that Metro Transit reserves only $7,000 per year for damages resulting from BOS-related accidents.

Seeing a need to create uniform operating rules for all BOS services, the Minnesota legislature codified existing operating rules for BOS services in 2001 and amended these statutes four years later to include paratransit buses and buses with over 40 seats engaged in interstate commerce. However, all transit companies are required to register with Team Transit prior to using these shoulders.

The Intelligent Transportation Systems Institute within the University of Minnesota's Center for Transportation Studies and the Minnesota Department of Transportation have been developing intelligent transportation systems technology, that could ultimately help bus drivers operate on highway and arterial shoulders. This is especially important since drivers are operating 9 to 9 ½ foot wide buses in lanes that are usually 10 feet wide.

In the late 1990s, several studies calculated the effectiveness of Minneapolis-St. Paul's BOS services. These studies collectively showed that BOS services decreased operational costs because drivers accumulated less overtime and/or increased transit ridership. A two-year study completed in 1997 showed that ridership increased more than 9% on nine routes that operated on the shoulders, while non-BOS routes lost 6.5% of riders overall during the same time period (Douma 2007). In one survey, Metro Transit determined that 95% of riders indicated that they were saving time, and 65% of riders recommended the service to others (Martin 2006). A 1998 survey, moreover, found that riders overestimated twice to three times the actual time saved on their bus trips.

With shorter and more reliable travel times, Metro Transit could eliminate one bus and driver from its BOS routes and complete the same number of trips or provide new services to a larger area using the same number of buses and drivers. Given the aforementioned benefits, Minneapolis/St. Paul's BOS network serves as a great example for the rest of the country's public transit operators who are seeking to implement BOS services.

2.5 NEWER AMERICAN BOS OPERATIONS

Unlike Minneapolis-St. Paul, BOS operations in the Miami-Dade metropolitan area evolved from an exhaustive two-phase study to investigate ways to reduce congestion and commuter time on this region's highways. The first and second phases of this study were released in 2004 and 2005, respectively. The second phase of this study recommended BOS services for the Don Shula and Snapper Creek Expressways, with additional highway segments, if successful.

In March 2007, Miami-Dade County Transit entered into intergovernmental agreements with the Florida Department of Transportation and the Miami Dade Expressway Authority to implement a three-year BOS demonstration project for approximately nine miles of the Don Shula and Snapper Creek Expressways. Miami-Dade County Transit also consulted with the Florida Turnpike Enterprise, the Florida Highway Patrol, and the Miami-Dade Metropolitan Planning Organization beginning with this project's preliminary planning, even though it did not have any contractual ties with these groups.

On these highways, buses have been able to travel up to 35 mph on 11 foot wide designated shoulders, if traffic in the general lanes flows less than 25 mph. However, they cannot exceed 15 mph more than the average speed of traffic in the general lanes.

In Florida, cars must also yield to buses when entering and exiting the shoulders. In April 2007 - just a month after BOS service began – these buses beat their agencies' systemwide average on-time performance. Currently, Miami-Dade Transit is looking to add park-and-ride lots to its existing BOS network and provide this service on other expressways. This network has grown to nine miles.

In July 2007, the Southwest Ohio Regional Transit Authority (Metro) began operating its Route 71X and Route 72 buses on 11.7 miles of I-71's northbound and southbound left shoulders. This service initially began as a 12-month demonstration project in cooperation with the Ohio Department of Transportation, the Federal Highway Administration, the state highway patrol, and several local sheriffs' offices and police departments.

Metro operates on the left shoulder because of its excellent pavement condition, 12 foot width, and distance suitable enough to give BOS drivers time to reach the right hand exit lanes. Most of the other rules applying in the Cincinnati region are similar to BOS networks in Minneapolis and other cities (e.g. buses cannot exceed 35 mph on the shoulder or go more than 15 mph than traffic in the general traffic lanes and must have their hazard lights on when driving). While buses are permitted to travel on the shoulders during inclement weather, Metro has advised its BOS drivers to be extra cautious when choosing this option.

On October 6 and 11, 2007, Metro distributed an eight-question survey to all passengers on Routes 71X and 72. Almost 95% of these respondents experienced portions of their trips riding on the shoulder. Ninety-nine percent of them stated that they felt safe when their bus driver used the shoulder lane and arrived at their destination faster. Over 96% of these people would recommend the bus route to other commuters because of BOS service (Southwest Ohio Regional Transit Authority/Metro, I-71 Bus on Shoulder Project Passenger Survey Results, 2007).

In August 2009, Metro announced that it would make its BOS routes permanent. These services have enjoyed increased ridership and a zero accident safety record.

2.6 POSSIBLE SCENARIOS FOR BUS ON SHOULDER PRACTICE

Several proposals to the U.S. Department of Transportation's Urban Partnership Initiative have identified the role that highway and arterial shoulders can effectively play in congestion management. The Minnesota Department of Transportation, for example, will replace shoulders that buses currently use from 46th Street to Downtown Minneapolis with dynamically priced shoulder lanes that all vehicles may use during peak periods. This will allow buses to travel at free-flow highway speeds, instead of the current 35 mph limit on bus-only shoulders.

In the Miami Urban Partnership Plan, the Florida Department of Transportation will convert a 21-mile, single HOV lane in each direction on I-95 into two high-occupancy toll (HOT) lanes by narrowing the travel lanes from 12 feet to 11 feet and narrowing the shoulders. These express lanes will be an important part of a Bus Rapid Transit (BRT) network.

In Chicago, Pace submitted a proposal to the Urban Partnership Initiative to study the feasibility of BRT operations on I-55's shoulder lanes. This proposal seeks to investigate Pace's use of inside shoulders on I-55 between Illinois 53 and Damen Avenue to significantly decrease travel times and avoid this highway's typically severe congestion. This proposal also seeks to study the feasibility of new transit services with lane-keeping technology for these shoulders.

Transportation agencies in Denmark, England, Germany, and the Netherlands have also used strategies such as speed harmonization, temporary shoulder use, dynamic signing, and rerouting for several years (U.S. DOT, FHWA International Technology Scanning Program, 2007). Many of these countries have typically used speed harmonization and temporary use of highway and arterial shoulders to provide additional capacity during peak periods.

2.7 RELEVANT INTELLIGENT TRANSPORTATION SYSTEMS TECHNOLOGY

The University of Minnesota's Center for Transportation Studies has been developing a Heads Up Display and virtual mirrors to help BOS drivers (Center for Transportation Studies at the University of Minnesota 2003). In interviews and focus groups with BOS drivers, they found that manually keeping 9.5 foot wide buses in 10 foot wide lanes was difficult as well as stressful. Its heads up display and virtual mirror technologies would alleviate some of this stress.

With a heads up display, BOS drivers could look straight ahead into transparent displays to view essential information while they are driving. This would give them a clearer vision of the road since they would no longer have to look downward at their instrument panels. This application is currently available on snow plow trucks, which often operate in low visibility.

Virtual mirror technology would build upon the heads up display. Virtual mirrors simulate a real mirror by projecting the viewer's image and his or her immediate surroundings. These two images are then displayed and synthesized consistent with the viewer's position of these surroundings. The resulting images would give the viewer a clearer idea of how close his or her bus is to surrounding objects, such as vehicles and walls.

Both of these applications require Differential Global Positioning Systems (DGPS), which continuously monitor bus trajectories on the shoulders at highway speeds. The degree of accuracy required for the corresponding GPS database allows for very small margins of error. The Center for Transportation Studies is currently developing a sufficiently accurate GPS database and a feasible way to incorporate these technologies into buses.

CHAPTER 3 IDENTIFICATION OF STAKEHOLDERS AND THE DATA COLLECTION PROCESS

With the Technical Review Panel's help, the research team identified a core group of stakeholders who would likely be involved in implementing a BOS system in Northeastern Illinois. This core group came from the Federal Highway Administration (FHWA), the Illinois Department of Transportation (IDOT), the Illinois State Police (ISP), the Illinois State Toll Highway Authority (ISTHA), and the Regional Transportation Authority (RTA).

The research team had conducted face-to-face, structured interviews with this core group of stakeholders after giving them a questionnaire that identified issues and concerns found in the BOS literature, mentioned in discussions with previous BOS implementers, or based upon the research team's experience. The research team's questionnaire is shown in Appendix 1 of this report.

This questionnaire was structured into the following seven sections:

- Traffic Safety Issues,
- Loss of Intended Shoulder Function Issues,
- Physical Design Issues,
- Legal and Institutional Issues,
- Financial Issues,
- Special Issues, and
- Operational Issues.

This study's Technical Review Panel and the University of Illinois at Chicago's Institutional Review Board approved this questionnaire's format and content. Because universities that receive federal funding are required to institute human subject research protections that comply with federal regulations, this latter approval was necessary.

After receiving this approval, the research team scheduled interviews with core stakeholders in Northeastern Illinois and Springfield. To familiarize interviewees with this study, the research team provided background information on BOS operations, including video clips from Atlanta and Minneapolis, this study's scope of work, and the survey questionnaire. This gave stakeholders time to collect their thoughts on BOS issues.

CHAPTER 4 FINDINGS FROM STAKEHOLDER INTERVIEWS

4.1 TRAFFIC SAFETY ISSUES

Survey respondents among the core group of stakeholders emphatically stated that safety in general is their primary concern. Not surprisingly, respondents emphasized different traffic safety aspects that reflected their own expertise, experience, and areas of responsibility. These traffic safety aspects are discussed below.

4.1.1 Traffic Conflicts Along the Shoulder Lane

Survey respondents were concerned that unexpected movements on the shoulder lanes could potentially conflict with traffic from the general lanes. These incidents could occur when motorists are entering or exiting the highway or are entering the shoulder lanes. To mitigate this potential problem, stakeholders may (a) clarify whether buses could merge from the shoulders into the general traffic lanes near highway interchanges; (b) implement speed management (e.g. ramp metering) for bus drivers and merging traffic; (c) avoid highway segments with frequent entrances and exits; (d) avoid highway segments with major interchanges serving large numbers of unfamiliar drivers; and (e) provide proper signage for motorists travelling in the general lanes.

Motorists entering the highway may also unexpectedly encounter buses traveling on the shoulder that can momentarily block or restrict sight distances of traffic in the general lanes (Martin 2006). This is particularly acute in areas with horizontal curves where the turning radii results in a restrictive view; where noise retaining walls exist; or where some additional interference may exist, such as illumination posts on shoulders and shoulder super-elevations. Stakeholders may mitigate these issues using (a) speed management, (b) operating restrictions in these areas, (c) use of the left shoulders; (d) rules having buses yield to oncoming traffic; and (e) integration with ramp metering.

Since highway shoulders have historically functioned as safe refuges, motorists have used the shoulders for such diverse activities as talking on the phone, finding directions, or even taking a quick nap during a long drive. Stakeholders can (a) use enforcement and technology (e.g., video surveillance) to monitor operations (with an impact on cost); (b) provide motorist training (e.g., use of turn signals when pulling onto the shoulder); and (c) selecting highway segments where BOS operations would be frequent enough to teach motorists not to use the shoulders for unnecessary activities. (A handful of buses each day will not be enough to change motorists' behavior.)

The Illinois State Police, however, are highly skeptical of the BOS concept in general and this issue in particular. They had noted that "…(BOS operations are) not safe at any speed because (the shoulders are) where the Illinois State Police…conduct sobriety tests, and other field work…(BOS) just adds another volume of traffic. … The Illinois State Police make 80,000 stops a year on the Tollway system and offer 30,000 motorist assists in 10,000 crashes (all of these on the shoulders)."

Most of the other respondents have believed that proper signage, rigorous bus driver training, higher recruiting standards for bus drivers, and sufficient enough time to familiarize motorists with bus on shoulder riding can mitigate any of the aforementioned potential problems.

4.1.2 Impacts on Traffic Using General Traffic Lanes

The second group of traffic safety issues relates to potential impacts on traffic in the general traffic lanes. Unexpected traffic traveling at high speeds in the shoulder lanes could surprise some motorists and lead to unexpected traffic slowdowns and/or accidents. This could make BOS implementation on the left shoulder more difficult to accept.

The issue of return merge distance adequacy is also somewhat thorny, especially when traffic is moving over 35 mph and buses must merge back into the general traffic lanes to avoid potential conflicts with motorists or with police on the shoulders. Since buses must have adequate time to merge back into the general traffic lanes, BOS operations planners should work with the Chicago area traffic operations center to provide enough merge time for buses using the highway shoulders.

Proper design and signage of BOS operations, speed restrictions, driver education, and time sufficient enough to allow motorists to familiarize themselves with BOS operations could mitigate these issues.

4.1.3 Obstructions and Physical Features

The final group of traffic safety issues relates to shoulder debris, bus breakdowns, potential hydroplaning, and reduced clearances. Respondents reacted somewhat strongly to shoulder area debris hazards since highway shoulders would have to be cleaned as often as the general traffic lanes. Failure to adequately clean these shoulders would force buses around the obstructions or result in bus mechanical problems and/or breakdowns.

If buses broke down in the shoulders, their drivers and passengers would need to wait inside the buses, while they were being repaired or substituted with replacement buses. To prevent needless accidents, BOS drivers would need to park their buses on oblique angles to traffic in the general traffic lanes to protect passengers that would try getting off. It would also require good communications protocols with transit dispatchers to quickly get help. Deployment of an integrated Incident Management Program could also eventually address this concern.

Although shoulder pavement material does not follow the same specifications as the general traffic lanes, drainage and hydroplaning are not major issues because buses on the shoulders would be going too slow (35 mph or less) to hydroplane. This issue is even less important on Illinois' tollways since the Illinois State Toll Highway Authority allows for excess drainage on its left and right shoulders.

Reduced clearances for buses at bridge abutments is an issue because there are many locations under bridges with deficient shoulder widths. Prohibiting buses from using shoulders at bridge abutments is the easiest way to resolve this issue.

4.2 LOSS OF INTENDED SHOULDER FUNCTIONS

Highway shoulders allow space for removal of disabled vehicles, quick access or safe havens for emergency vehicles, staging areas for maintenance work, and snow storage. The research team, therefore, asked respondents how BOS operations may potentially impact each of these functions in their questionnaire.

The research team learned that BOS operations on highway shoulders will require BOS drivers to maintain good and open communications with their transit dispatchers to avoid running into maintenance work staging areas or colliding with disabled or damaged vehicles in the shoulders. Other smarter technologies could eventually replace or complement this practice. To reduce bus collisions with impediments in the shoulders, the research team has recommended use of vehicle infrastructure integration (VII) technologies that can detect disabled or damaged vehicles or other impediments and relay this information to bus drivers in a timely manner to permit a safe return to the general lanes. To reduce the chances of buses running into work staging areas, the research team recommends use of maintenance management information systems (MMIS) that could provide alternate directions to BOS drivers and other motorists via dynamic message signs.

Obviously, this would require motorist training to adhere to the dynamic message signs and not use the shoulders during an incident response. Police enforcement would probably be needed at an additional cost.

Keeping the shoulders well-managed and clear as much as possible is important since stalled or abandoned vehicles on the shoulder cause considerable gawker congestion, especially during rush hours. The Federal Highway Administration supported and expanded upon this idea in its Traffic Incident Management Handbook, which stated that a stalled vehicle or crash blocking one lane on a three-lane highway can reduce capacity by 50%. A crash on a highway shoulder can reduce capacity by 19% and a stalled vehicle on that shoulder can reduce capacity by 9% (FHWA 2000). Emergency vehicles will thus need to respond to these incidents as quickly as possible. (It is worth noting that ISTHA does not own any response trucks; ISTHA has an agreement with local fire departments to use its shoulders to respond to incidents that occur on its roads.)

Snow storage can also pose potential problems for BOS operations since it would likely require changing the way that snow removal/plowing is done. IDOT and ISTHA do not normally de-ice or plow the shoulders until the storms end. ISTHA, for example, plows the left lane left towards the wall in urban and suburban areas and keeps re-plowing it so that snow doesn't consolidate with the wall. Plowing the right lane is less problematic as long as there is an adjacent right shoulder for snow storage. This excludes areas with noise walls that are within three feet of a shoulder. Adding more snow trucks and crews to plow the shoulders during storms would be very expensive.

Possible resolution of these issues include: (a) having good communications with transit dispatchers; (b) using only the right shoulder for BOS operations; and (c) prohibiting BOS operations during snow removal.

4.3 PHYSICAL DESIGN ISSUES

The research team also asked respondents about BOS' potential impacts on highway shoulders' physical design. Most modern highway shoulders are 10 to 12 feet wide, including the Tollway's 11 foot wide shoulders. (IDOT has recommended 12 foot wide, paved shoulders for all new right shoulders, for new left shoulders on roads with three or more lanes in one direction, and for new left and right shoulders on bridges. From the IDOT Bureau of Design and Engineering Manual (2002), Chapter on Rural and Urban Freeways, Section 44-5—Geometric Design Criteria for Existing Cross Section Elements to Remain-in-Place on Urban Freeways.) Shoulders on each of these newer roads can accommodate buses that are approximately 10 feet wide with mirrors.

Many shoulders on older highways are narrower and have less clearance for lateral obstructions. (On existing four lane freeways, median (or left) shoulders are normally four to eight feet wide. Right shoulders on existing freeways vary in length.) These lateral obstructions can reduce minimum sight lines for drivers in the BOS and general traffic lanes. BOS drivers will therefore have to merge back into the general traffic lanes. Agencies with prior BOS experience agreed that new BOS implementers should not allow BOS operations on segments of sub-standard widths. AASHTO's <u>A Policy on Geometric Designs of Highways and Streets</u> (2004) also suggested minimum 10 foot wide right shoulders for highways with modest truck volumes (fewer than 250 trucks per hour) and 12 foot wide shoulders for highways with high truck volumes. When the research team alternatively suggested narrowing existing general traffic lanes to widen narrow shoulders, respondents quickly dismissed this idea because it could reduce the general traffic lanes' uncongested capacity and safety.

Rumble strips on existing highway shoulders can effectively alert motorists who are driving into the shoulders and possibly off of the road. Thus, they serve an important safety role and cannot be removed, although they can potentially provide an uncomfortable and unsafe surface for BOS operations. To balance these concerns, the highway engineers at District 1 mentioned that these rumble strips might be moved slightly to fit between the buses' wheels to allow a safer, more comfortable ride.

Like rumble strips, drainage inlets along highway shoulders are not designed for vehicles to comfortably ride on them. Yet, reconstruction of drainage inlets can compromise their ability to effectively remove water from the roadway. This seems to be more of a problem for concrete supports, rather than steel grated sewers. Respondents for the most part did not think this is a big issue because "…steel inlets can take a lot of pounding" and because the buses would not be traveling at a high rate of speed.

An issue identified from the literature concerns drainage cross slopes. Shoulders typically have cross slopes (½ inch per foot on average) greater than general traffic lanes (3/16 inch per foot on average) and the higher cross slopes increase the level of discomfort for bus passengers. Respondents felt that this issue would not be a problem for buses on shoulders at low speeds. Others felt that BOS operations might affect the initial shoulder design and cause problems on the general traffic lanes. The shoulder pavement has not typically been as thick or as strong as the general traffic lane pavement because shoulders are not designed for regular use by large vehicles. Yet, these shoulders may still be able to handle BOS operations.

District 1's road engineers will need to examine the integrity of specific shoulder segments from various roadway plans since no relevant database is available. These engineers will need to conduct reflectometer tests for each shoulder segment's structural integrity, strength, and remaining life to determine the properties of the shoulder's different layers all the way to the ground. Based on the expected number of buses operating on the shoulder and the shoulder material, these engineers could determine whether the designated shoulders are suitable for BOS operations. In metropolitan Chicago, IDOT has stated that rehabilitated shoulders should be 12 inches or more thick to ensure adequate load capacity.

Signage is also important because BOS implementers have to decide whether to use passive or active signs and strike the right balance between conveying the message and creating 'sign pollution. Learning from other cities' experiences with signage can greatly help strike this balance. Ideally, BOS drivers and other motorists should receive advance notice about congestion downstream, but this would probably require deployment of digital message signs integrated with the Chicago area traffic operations center, which has access to network traffic times.

Motorists will also need to be educated about BOS operations, the need to obey the signs, and police enforcement. Some respondents expressed some skepticism about how to make people obey signage; their "…first instinct is to obey lanes; (however) people follow whatever moves in complicated and stressful situations, even through a work zone.…"

4.4 LEGAL/INSTITUTIONAL ISSUES

Since Illinois law does not currently allow vehicles to use shoulder lanes to bypass congestion, the research team asked respondents what kind of laws, regulations, or policies should be enacted to successfully implement BOS operations. These respondents suggested tort immunity from transit operators; new regulations regarding interference between BOS operations and emergency response vehicles; changes in current regulations to allow the

Minutemen to operate in a similar manner as police and firefighters (e.g., siren use), if they provide emergency services to buses using the shoulders; and incorporation of these new regulations into the "Rules of the Road." Overall, a standard or systemwide policy about BOS operations is needed. The Federal Highway Administration would also need to issue permits for interstate segments selected for BOS operations.

Respondents were clear about the need to indemnify highway operators, but were uncertain about how to do this because most highway shoulder designs do not conform to the AASHTO Build Design Environment (BDE) manual's standards. Other respondents were unsure if BOS operations have been nationally accepted, and if not, what future types of problems would result by addressing liability issues only in Northeastern Illinois.

Respondents asked that transit and highway operators need to further study insurance coverage for BOS operations. Discussions on this topic will clarify existing practices and remaining issues for all stakeholders.

Enactment of new rules and regulations would not serve their purpose without enforcement. Some respondents acknowledged that it would be somewhat difficult to conduct enforcement on shoulders without video equipment, but current state statutes allow the use of cameras only at highway-rail grade crossings and for red light infractions. ISTHA's existing monitoring system would likely help on the tollways, but IDOT does not have a similar capability. Yet, other respondents expressed doubts whether sufficient resources can provide additional enforcement for BOS operations.

The research team also asked respondents about who should help plan and implement BOS operations in Northeastern Illinois. They replied that this group should include members of the Federal Highway and Transit Administrations, the State of Illinois (including IDOT and the State Police), the affected counties, relevant municipalities (including their police and fire departments), public transit agencies, and the general public.

The respondents were not sure about including private bus operators to these discussions because they wanted to give priority to public transit buses without making the shoulder appear as another traffic lane. However, they were willing to revisit this issue in the future since a large number of private buses operate in the Chicago metropolitan area. Pagano (1993) had estimated that 14,715 private buses provided 1.8 million rides per weekday.[3]

4.5 COST ISSUES

The research team asked respondents about their concerns regarding the costs needed to upgrade the shoulders for bus use, maintain the shoulder pavement, and keep the shoulders free from debris. Respondents agreed that cost considerations are especially critical in this time of financial crisis in Illinois. They suggested estimating the costs of upgrading the shoulders based upon an engineering study of the type of work required and annually budgeting funds for cleaning and maintaining the shoulder pavement. Various cost and cost-sharing considerations, therefore, need to be addressed before implementing BOS operations.

The BOS implementers would need to negotiate cost sharing, most likely based upon each party's level of benefits. Finding a committed funding source would likely make these decisions easier to make.

4.6 SPECIALIZED ISSUES

The research team also asked about respondents' concerns on implementation issues and on specialized issues that are relevant to specific areas of BOS operations. The respondents agreed that a future BOS implementation study be well-designed and well-funded so that a subsequent BOS demonstration project can be fully and fairly evaluated on its merits. Some of the respondents believed that a demonstration project should last only 12 months, while others wanted a longer trial period. All agreed, however, that the trial period should be long enough to evaluate the concept's effectiveness and that a deadline should be agreed to beforehand in a formal, written agreement.

Although highway segment selection would be extensively addressed during Phase II of this study, the research team had asked respondents what criteria they would use to select shoulder segments for BOS use. They recommended the following criteria:

- Prioritize highway segments according to their level of service, so that the regularity of BOS operations will allow the driving public to become familiar with them.
- Select segments with large portions of local traffic since out-of-town drivers could be confused with BOS operations.
- Select segments to attain the highest ridership. Reverse commuting from the city to the suburbs, for example, should be better served by transit and could have the greatest ridership gain potential.
- Select segments so that BOS operations would focus on suburban areas, and not on radial service, like Minneapolis. Metra trains already do that here.
- Select segments so that BOS operations would serve areas where rail service is limited, constrained, or non-existent.
- Select segments lengthy and wide enough for BOS operations to be effective.
- Select segments not too close to the Chicago Loop where exits are close together; these exits should be a mile or two apart.
- Select segments with the proper shoulder width and material strength.
- Do not select left shoulders on Tollway facilities because ISTHA will eventually convert these shoulders into general travel lanes when demand warrants.
- Do not select segments on the Tollways because ISTHA anticipates that BOS operations would not be needed once capacity improvement programs are completed.

4.7 OPERATIONAL ISSUES

During their interviews, several respondents discussed their concerns over use of the left or right shoulder, the rate of speed that buses should travel on the shoulders, bus use of the shoulders in bad weather, and public outreach. Their concerns are summarized below.

Respondents who spoke about left and right shoulders could not agree on which one was better-suited for BOS operations. Either shoulder would present its own set of issues, and some respondents felt that it would be dangerous to operate BOS service on either side. The left shoulder has the least amount of exit and entrance ramps, but requires an adequate amount of time for BOS drivers to enter and cross each of the general traffic lanes before exiting the highway. This maneuver can be done with enough time and would likely require coordination with systemwide monitors of traffic conditions. Use of the left shoulder would also require new procedures for snow and debris removal since these shoulders are generally used for snow removal and temporary storage of debris. On the other hand, use of the right shoulder involves buses merging in and out of the general traffic lanes to avoid traffic exiting and entering the highway.

Respondents who discussed the rate of speed for buses on the shoulders thought that BOS drivers should not drive significantly faster than traffic in the general traffic lanes because this speed differential may pose a safety hazard and startle unsuspecting drivers. Many of the respondents were comfortable with the generally accepted norm of no more than 15 mph faster than the existing speed of motorists in the general traffic lanes and no more than 35 mph overall.

Respondents who discussed whether buses should run in the shoulders during bad weather thought that this issue should remain up to the transit operators. However, they wanted to know how previous BOS implementers dealt with this issue.

For a successful BOS demonstration project, respondents universally believed that BOS implementers will need to undertake a substantial public outreach effort to educate motorists. Particular attention should be given to educate drivers unfamiliar with the Chicago area. A successful demonstration project that impresses the general public would go a long way to persuading motorists about the BOS strategy. Nevertheless, respondents did not hide their concern that this would be an uphill battle with growing pains.

4.8 GENERAL OBSERVATIONS

The respondents also offered additional general observations that focus on different aspects of BOS operations and reflected their professional expertise. These observations are as follows:

- Agencies could achieve higher occupancy of highway shoulders by implementing a transit strategy such as HOV or HOT lanes rather than BOS service. This responds to Illinois Public Act 95-0708, which amended the following language to 70 ILCS 3615/2.09:

"(b) … The [Regional Transportation] Authority and the Suburban Bus Division, in cooperation with the Illinois Department of Transportation, shall develop a bus rapid transit demonstration project on Interstate 55 located in Will, DuPage, and Cook Counties. This demonstration project shall test and refine approaches to bus rapid transit operations in the expressway or tollway shoulder or regular travel lanes and shall investigate technology options that facilitate the shared use of the transit lane and provide revenue for financing construction and operation of public transportation facilities."[4]

[4]http://www.ilga.gov/legislation/publicacts/95/PDF/095-0708.pdf

- BOS service should be implemented on an experimental basis, but after a BRT demonstration project.
- A careful assessment of the return on investment using a microsimulator such as VISSIM or AIMSUN should be made prior to general BOS deployment.
- An understanding about how BOS operations can affect general vehicular congestion is needed, not just transit ridership and on-time performance.
- Allowing the use of highway shoulders for bus operations will introduce exceptions into the traditional use of shoulders and therefore may require changes in the way federal, state, and local highway agencies plan for operations.
- Minimizing weaving, conflicts, and unintended snowballing consequences during BOS operations is important (e.g. What would happen when traffic picks up and the bus is still on the shoulder? Can the bus then safely accelerate and return to the general traffic lanes?)
- District 1 should conduct an engineering study to determine the integrity and costs of upgrading the affected shoulders when assigning BOS segments.

CHAPTER 5 ADDRESSING STAKEHOLDERS' CONCERNS

This section summarizes the concerns that core stakeholders raised during their face-to-face interviews. Success indicators to address these concerns are also discussed, based on stakeholders' expertise and experience, literature review findings, and discussions with professionals in areas outside of Illinois that have planned or implemented BOS operations.

STAKEHOLDERS' CONCERNS	POSSIBLE RESOLUTION/MITIGATION
1. Traffic Safety Issues	
• *Conflicts at On-and-Off Ramps*	• Clarify whether buses would merge into traffic lanes before highway interchanges, • Implement speed management for bus drivers and merging traffic (e.g. ramp metering), • Select highway segments that do not have frequent entrances and exits, • Select highway segments that do not involve major interchanges serving large numbers of unfamiliar drivers, and • Provide proper signage for BOS operations.
• *Sight Distance Adequacy, Particularly at On-ramps*	• Manage Speeds, • Restrict operations where sight distance is inadequate, • Use the left shoulder, • Have buses yield to oncoming traffic, and • Integrate with ramp metering.
• *Conflicts for Motorists Pulling onto the Shoulder*	• Use enforcement and technology (e.g., video surveillance) to monitor operations, • Provide motorist training (e.g., use of turn signals when pulling onto the shoulder), and • Select highway segments where BOS operations are frequent enough to familiarize motorists (e.g., a handful of buses each day will not be enough to change motorists' behavior).
• *Losing the Safe, Evasive Movement Shelter (Shoulder) Area*	• Provide proper signage for BOS operations, and • Allow sufficient time to familiarize motorists with BOS operations.
• *Bus Driver Training*	• Substantially upgrade the training and recruiting standards for bus drivers.
• *Speed Differential*	• Provide a substantial educational effort for bus drivers and other motorists, • Provide proper signage for BOS operations, and • Allow sufficient time to familiarize motorists with BOS operations.
• *Impact of BOS Operations on Drivers in the Adjacent General Traffic Lane*	• Provide proper signage for BOS operations, and • Allow sufficient time to familiarize motorists with BOS operations.

• *Return Merge Distance Adequacy*	• Coordinate with the Chicago area traffic operations center that monitors area-wide traffic speeds, • Provide proper shoulder design and signs for BOS operations, and • Allow sufficient time for bus drivers to become familiar with BOS strategies.
• *Shoulder Area Debris Hazards*	• Clean shoulders as often as the general traffic lanes.
• *Reduced Clearance for Buses at Bridge Abutments*	• Prohibit bus use of shoulders in those locations.
• *Assistance of a Broken-Down Bus*	• Use incident management personnel, • Properly place broken-down buses to protect passengers, • Have a good communications protocol with transit dispatchers, and • Deploy an integrated Incident Management Program.
2. Loss of Intended Shoulder Functions	
• *Removal and Storage of Disabled Vehicles and Accidents*	• Have good communications with transit dispatchers, and • Deploy Vehicle Infrastructure Integration (VII) technologies.
• *Emergency Vehicle Use*	• Have quick emergency response through good communications with transit dispatchers.
• *Staging Area for Maintenance Work*	• Have good communications with transit dispatchers, • Deploy a Maintenance Management Information System (MMIS), • Have motorist training adhere to DMS, and • Have police enforcement.
• *Snow Storage*	• Have good communications with transit dispatchers, • Use only the right shoulder for BOS operations, and • Prohibit BOS operations during snow removal.
3. Physical Design Issues	
• *Shoulder Width Adequacy*	• Do not allow BOS operations on segments that are less than 10 feet wide.
• *Shoulder Pavement Strength*	• Require engineering review.

• *Signage*	• Learn from the experiences of other cities with a long tradition of BOS operations with signage, • Decide on the merits of passive or active signage, • Deploy DMS integrated with the Chicago Area Traffic Operations Center that has access to network traffic times, • Educate motorists, and • Provide police enforcement.
• *Lateral Obstruction Adjacent to Shoulder*	• Have the bus merge back into the general traffic lanes.
• *Narrowing General Traffic Lanes*	• Avoid by all means.
• *Conflicts of BOS Operations with Pavement Edge Rumble Strips*	• Construct noise barriers that don't interfere with BOS operations, and • Limit BOS operations in times of little traffic to the general traffic lanes.
• *Drainage Cross Slopes*	• Not a problem at low bus speeds.
4. Legal/Institutional Issues	
• *Regulations*	• Provide tort immunity from transit operators, • Devise a way to prevent interference between BOS operations and emergency response vehicles, • Allow Minutemen to operate in a similar manner with police and firefighters (e.g., siren use), • Obtain permits from FHWA on all interstate segments selected for BOS operations, and • Incorporate relevant new regulations into the "Rules of the Road."
• *Enforcement*	• Expand the current use of cameras to BOS operations, and • Use ISTHA's existing monitoring system on tollways.
• *Liability*	• Indemnify highway operators, • Address vacuum in liability framework because most highway shoulder designs do not conform to the standard AASHTO <u>Build Design Environment</u> (BDE) Manual, • Address Chicago standards vis-à-vis national standards, and • Address the legal vacuum during pilot demonstration.
• *Insurance Coverage*	• Have discussions between transit and highway operators.
• *Union Involvement*	• Bring bus drivers unions to the table as soon as possible.
• *Who Should be Involved During Planning and Implementation of BOS Operations?*	• Councils of Mayors, individual municipalities, counties, private parties, CDOT, Cook County, IDOT, DOT, the Secretary of State's Office, fire departments, tow truck operators, and the public at large.

• *Private Buses*	• Give public buses priority over private buses, and • Clarify the types of buses that would be called private, based on the type of services they provide, and then assign shoulder priorities.
5. Cost Issues	
• *Cost to Upgrade Shoulders for Bus Use*	• Estimate based on an engineering study.
• *Cost to Keep Shoulders Free from Debris*	• Consider the potential costs of rescheduling.
• *Cost to Maintain the Shoulder Pavement*	• Develop a database to track costs and level of effort.
• *Cost Sharing*	• Have the implementing agencies negotiate how much of the costs they are willing to pay. Costs may be allocated based on the level of benefits each agency will realize, and • Identify a committed funding source.
6. Special Issues	
• *Acceptance of Toll Paying Motorists for BOS Use*	• Provide extensive public outreach.
• *BOS at Toll Plazas*	• Provide extensive motorists training, and • Involve Pace, ISTHA, and Illinois State Police.
• *Trial Period for a BOS Demonstration*	• If possible, do not use ISTHA segments during the trial period, • Make the trial period long enough to evaluate the effectiveness of the concept, • Draft an agreement that would set a deadline for the demonstration project before beginning it, and • Thoughtfully plan and well-fund the demonstration.
• *Highway Segment Selection*	• Prioritize highway segments for BOS operations, based on the highway's level of service; • Select highway segments with a large portion of local traffic; • Select highway segments that are lengthy and wide enough for BOS operations to be effective; • Select highway segments that are not too close to the Chicago Loop, where many exits are close together; • Select segments to attain the highest potential ridership; • Select segments so that BOS operations would focus on suburban areas; • Select segments so that BOS would serve areas where rail service is limited, constrained, or non-existent; • Select segments with the proper shoulder width and pavement strength; and • Do not select segments on the tollways for BOS operations.
7. Operational Issues	

• *Adverse Weather Conditions*	• Learn from other cities' experiences with BOS, especially from cities with harsh winters.
• *Snow and Debris Removal*	• Implement a new operational procedure for removing snow and debris.
• *Use of Right or Left Shoulder*	• Some respondents have believed that most of the left shoulders are not wide enough to safely operate BOS, • Evaluate use of the right shoulders for areas with high truck volumes, and • Right shoulders are easier on bus drivers.
• *Operating Speed*	• Establish a safe speed to safely merge with general traffic, • Propose low speeds, and • Apply effective enforcement.
• *Public Acceptance*	• Undertake a substantial public outreach effort to educate motorists, and • Implement a successful demonstration project.
• *Impact on Agency Operations*	• Minimize any negative impacts on agency operations through interagency coordination.

CHAPTER 6 CONCLUSIONS

BOS operations have been a fact of life in many urban areas for more than a decade. Yet, little information exists on BOS' costs and benefits; none of the cities running BOS operations have experienced Northeastern Illinois' traffic environment, seasonally amplified by the harshness of Chicago winters. This region's transit and highway officials and planners have therefore decided to move cautiously before they commit resources to testing and eventually implementing BOS services. This study has thus helped to identify stakeholders' issues and concerns before proceeding to the next planning phase.

The concerns aired during the structured interviews with core stakeholders are similar to those reported in previous BOS studies. Traffic safety, loss of intended shoulder functions, physical design, legal and institutional issues, costs, and operational issues were exhaustively discussed during the interview process and later documented.

Each of the stakeholders was primarily concerned with BOS' impacts on traffic safety. The perception that BOS operations was unsafe at any speed came out strongly during the interviews. However, these perceptions were unfounded. The traffic safety issues that were raised could be wisely managed.

Some of the stakeholders were also concerned about the loss of intended shoulder functions. Highway shoulders provide important functions such as removal and storage of disabled or damaged vehicles, safe havens for emergency vehicles, staging areas for maintenance work, and snow storage. These stakeholders thought that the impacts of BOS operations on these functions can be moderated, with widely different costs for different mitigation strategies.

Stakeholders also acknowledged the impacts that highway shoulders' physical design limitations had on BOS operations. These stakeholders had agreed to prohibit BOS operations on narrow shoulder segments when they dismissed narrowing general traffic lanes to widen narrow shoulder segments. Finally, these stakeholders agreed that pavement edge rumble strips could be moved to fit under the wheels of buses travelling on shoulders, although it would be costly.

Several regulatory reforms would need to be enacted so that BOS operations are not in a legal vacuum. These reforms would cover insurance and tort immunity issues within a proper liability framework, resolving any interference between BOS operations and emergency response vehicles, and enforcement.

Various cost and cost-sharing considerations would need to be critically examined before implementing BOS operations, especially in this time of budget crises. Cost sharing is a huge issue that would need to be negotiated between the parties involved.

Stakeholders reached a consensus for a well-designed and well-funded pilot demonstration to fully evaluate a BOS strategy in Northeastern Illinois. Public acceptance of BOS operations is critical to establishing permanent BOS operations in this region and would entail an extensive outreach effort.

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APPENDIX 1 – BOS SURVEY INSTRUMENT

BUS ON SHOULDERS: ANALYSIS OF PRELIMINARY CONCEPT

A Study Conducted by the
Urban Transportation Center
University of Illinois at Chicago
Email: vonu-pt@uic.edu

for the Illinois Center for Transportation and
IDOT's Division of Public and Intermodal Transportation

CORE STAKEHOLDERS SURVEY QUESTIONNAIRE

Background: Several transit agencies around the country have implemented bus use of highway or arterial shoulders (or Bus on Shoulders, BOS) to effectively improve bus operations and schedule reliability. To evaluate institutional issues related to BOS design and operations in Northeastern Illinois, this survey seeks to identify issues and concerns that are anticipated to be major obstacles to implementing BOS operations here. Your help and input is critical and greatly appreciated.

General Information

Agency Name:
Address:
Contact Name/Title:
Experience/Expertise:
Responsibilities:
Telephone/Email:
Familiarity with BOS Concept: Very Good / Good / Average / Below Average / Poor
Date of Interview:
Interviewer:

Traffic Safety Issues for BOS Operations

Issue	Agency Concern (Y/N)	Why?	How Critical for Implementing BOS Operations?	Possible Resolution
Conflicts at on- and off-ramps				
Sight distance adequacy, particularly at on-ramps				
Conflicts for motorists pulling onto the shoulder				
Loss of safe evasive movement shelter area				
Need for bus driver training				
Speed differential				
Impact on adjacent lane motorists				
Return merge distance adequacy				
Shoulder area debris hazards				
Reduced clearance for buses at bridge abutments				
Drainage and hydroplaning				
Assistance of a broken-down bus				
Other				

Loss of Intended Shoulder Functions from BOS Operations

Issue	Agency Concern (Y/N)	Why?	How Critical for Implementing BOS Operations?	Possible Resolution
Removal and storage of disabled vehicles and accidents				
Emergency vehicle use				
Staging area for maintenance use				
Snow storage				
Other				

Physical Design Issues for BOS Operations

Issue	Agency Concern (Y/N)	Why?	How Critical for Implementing BOS Operations?	Possible Resolution
Shoulder width adequacy				
Shoulder pavement strength				
Signage needs				
Lateral obstruction adjacent to shoulder				
Need to narrow general traffic lanes				
Modifications to drainage inlets compromise function				
Conflicts with pavement edge rumble strips				
Drainage cross slopes				
Other				

Legal/Institutional Issues for BOS Operations

Issue	Agency Concern (Y/N)	Why?	How Critical for Implementing BOS Operations?	Possible Resolution
Regulations				
Enforcement				
Liability				
Insurance Coverage				
Union Involvement				
Who should be involved during planning of BOS operations?				
Who should be involved at the implementation stage of BOS operations?				
Private buses				
Other				

Cost Issues of Concern for BOS Operations

Issue	Agency Concern (Y/N)	Why?	How Critical for Implementing BOS Operations?	Possible Resolution
Cost to upgrade shoulders for bus use				
Cost to keep shoulders free from debris				
Cost to maintain the shoulder pavement				
Who should pay the costs?				
Other				

Special Issues for BOS Operations

Issue	Agency Concern (Y/N)	Why?	How Critical for Implementing BOS Operations?	Possible Resolution
Acceptance of toll paying motorists for BOS use				
Shoulder at toll plazas				
Length of trial period				
Highway segment selection				
Other				

Operational Issues for BOS Operations

Issue	Agency Concern (Y/N)	Why?	How Critical for Implementing BOS Operations?	Possible Resolution
Shoulder width				
Weather conditions				
Snow and debris				
Right or left shoulder? Using right shoulder for segments with high truck				
Volumes				
Operating speed				
Public acceptance				
Impacts on agency operations				
Other				

APPENDIX 2 – LIST OF CORE STAKEHOLDERS RECOMMENDED BY THIS STUDY'S TECHNICAL REVIEW PANEL

Chicago Interviews

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*Designates a face-to-face interview.

APPENDIX 3 – INFORMATIONAL MATERIAL FOR INTERVIEWEES

The following material was prepared and sent to participants in advance of the face-to-face interviews:

- Bus on Shoulders Study (scope of work.doc) – is a summary of the scope of work. (Please see below.)
- Information for stakeholders.ppt – is a brief presentation about the Bus on Shoulders Study. (Please see, Appendix 4.)
- UIC_BOS_Questionnaire_DRAFT.doc – is the questionnaire instrument that the research team used during the interview. (Please see, Appendix 1.)
- MARTA shoulder.wmv – is a video clip about BOS operations in Georgia.
- Training For Bus Drivers (MNDOT).wmv – is a video clip about BOS driver training in Minnesota.

Bus on Shoulders Study: Scope of Work

The Illinois Center for Transportation has commissioned this study. This study's co-principal investigators are Dr. Vonu Thakuriah and Dr. Paul Metaxatos and the senior researcher is Dr. Kouros Mohammadian.

This study's Technical Review Panel has the following members:

- Chuck Abraham – IDOT-Public and Intermodal Transportation;
- John Baczek –IDOT-District 1;
- Mike Bolton – Pace;
- Patty Broers – IDOT-Materials and Physical Research;
- Lil Budzinski – IDOT-Public and Intermodal Transportation;
- Adam Litner – ISTHA; • Taqhi Mohammed – Pace;
- Jim Schoenherr – IDOT-Central Operations;
- Dave Tomzik – Pace;
- Mary Wells – ISTHA; and
- Rocco Zucchero – ISTHA.

The study will be conducted in two phases:

Phase I: Identify and address issues and concerns regarding BOS operations, and
Phase II: Prioritize highway segments for BOS operations.

At this stage we are conducting activities in Phase I as follows:

Task 1: Identify Major Stakeholders

With the help of the Technical Review Panel, the research team will identify core stakeholders.

Task 2: Conduct Structured Interviews

The Research Team will conduct face-to-face interviews of the stakeholders identified in Task 1 using a structured interview approach. This structured interview process will require development of a survey instrument to conduct the interviews. These interviews will identify issues and concerns anticipated to be major obstacles to implementing BOS operations in Northeastern Illinois.

Task 3: Address Stakeholder Concerns

The research team will address the issues, concerns, and barriers for BOS implementation in Northeastern Illinois, as documented in Task 2. Task 3's primary objective will be to develop success indicators to educate and address the concerns of the stakeholder "core" group who could face similar concerns from other community organizations at a later stage.

APPENDIX 4 – INFORMATION FOR STAKEHOLDERS

Bus on Shoulders
Analysis of Preliminary Concept

A Study Conducted by

Drs. Vonu Thakuriah, Kouros Mohammadian and Paul Metaxatos
Urban Transportation Center
University of Illinois at Chicago

for the
Illinois Center for Transportation

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Purpose of Bus on Shoulders Study

This phase of the study will evaluate institutional issues related to BOS operations and design in the Chicago area

Methodology

- Identify Major Stakeholders
- Conduct Structured Interviews
- Address Stakeholder Concerns

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Technical Review Panel

IDOT	ISTHA	Pace
Chuck Abraham	Adam Litner	Mike Bolton
John Baczek	Mary Wells	Taqhi Mohammed
Patty Broers	Rocco Zucchero	Dave Tomzik
Jim Schoenherr		
Lil Budzinski		

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Current BOS Operations

Comprehensive Networks
- Minneapolis-St. Paul (271 miles)
- Dublin, Ireland (70 miles)
- Ottawa, Ontario (14 miles)

Congestion Bypass Lanes
- Atlanta, GA
- Falls Church, VA
- Miami, FL
- San Diego, CA
- Seattle, WA
- Toronto, Ontario
- Vancouver, B.C.
- Washington, D.C.

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Atlanta BOS Sample Video

Please visit
http://pigpen.utc.uic.edu/BOS

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Minnesota Training for BOS Bus Drivers Video

Please visit
[illegible]

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BOS Costs

- Capital improvements to shoulder infrastructure
- Loss of intended shoulder use (disabled vehicles, emergency vehicles, maintenance work, snow storage)
- Maintenance costs of keeping shoulders clear of debris.

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BOS Benefits

- Improved bus reliability
- Increased bus ridership
- Decreased travel times
- Decreased congestion

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Safety Issues

- Proper safety protocol and driver training has prevented an increase in crash frequency
- "Driver Assistive Technology" exists to help drivers stay within the shoulder lane in low-visibility weather

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Purpose of Upcoming Interview

To address your agency's concerns with BOS operations in Northeastern Illinois

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APPENDIX 5 – OTHER BOS PROFESSIONALS CONTACTED

• Jennifer Conover
Team Transit, The Minnesota Department of Transportation Metro District
651/234-7711
Jennifer.Conover@dot.state.mn.us

Ms. Conover is the project manager for Team Transit, which coordinates the BOS network in the Minneapolis-St. Paul area. Team Transit works in conjunction with the Minnesota Department of Transportation and Metro Transit. Its website, http://www.dot.state.mn.us/metro/teamtransit, is an excellent source of information free to download, including the driver training video clip.

• Frank Douma
Assistant Program Director
State and Local Policy Program
Hubert H. Humphrey Institute of Public Affairs - University of Minnesota
612/626-9946
douma002@umn.edu

Mr. Douma prepared an FTA report entitled, Bus-Only Shoulders in the Twin Cities – June 2007, which provided an extensive overview of Minneapolis-St. Paul's BOS network.

• Stephan Parker
Senior Program Officer
Transportation Research Board
202/334-2554
SAParker@nas.edu

Mr. Parker provided the research team with a copy of the draft interim report entitled, A Guide for Implementing Bus-On-Shoulder (BOS) Systems. Peter Martin of Wilbur Smith Associates has been preparing this report.

• Jesus Guerra
MPO Manager
Miami-Dade MPO
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GUERRAJ@miamidade.gov

Mr. Guerra had provided comprehensive reports that determined whether BOS operations could be feasibly implemented in the Miami-Dade region. He also notified the research team that The Corradino Group was preparing an evaluation of Miami-Dade's BOS system.

• Wanda Van Zandt
Georgia Regional Transportation Authority (GRTA)
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404/463-2436

Ms. Van Zandt works with Xpress GA, the Georgia Regional Transit Authority's regional commuter bus service. She provided the research team with a DVD that shows how BOS operations work in the Atlanta metropolitan area.

• Tim Reynolds
Director, Transit Development - Metro
Southwest Ohio Regional Transit Authority
treynolds@go-metro.com
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Mr. Reynolds shared Metro's BOS pilot project proposal and a passenger survey that documented customer satisfaction with Metro's BOS service.

• Jennifer Williamson
Senior Transportation Planner
San Diego Association of Governments
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The San Diego Association of Governments issued a report in October 2006, which showed that San Diego's BOS demonstration projects were successful.

• Peter Martin
Wilbur Smith Associates
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Lead author on main TCRP BOS reports, including TCRP Synthesis 64 and TCRP D-13 Draft Report.

APPENDIX 6 – MINNESOTA'S BOS STATUTE

http://www.reviser.leg.state.mn.us/st2005/169/306.html
Minnesota Statutes 2005, Chapter 169

169.306 Use of shoulders by buses.

(a) The commissioner of transportation may permit the use by transit buses and metro mobility buses of a shoulder of a freeway or expressway, as defined in section 160.02, in the seven-county metropolitan area.

(b) If the commissioner permits the use of a freeway or expressway shoulder by transit buses, the commissioner shall also permit the use on that shoulder of a bus with a seating capacity of 40 passengers or more operated by a motor carrier of passengers, as defined in section 221.011, subdivision 48, while operating in intrastate commerce.

(c) Buses authorized to use the shoulder under this section may be operated on the shoulder only when main line traffic speeds are less than 35 miles per hour. Drivers of buses being operated on the shoulder may not exceed the speed of main line traffic by more than 15 miles per hour and may never exceed 35 miles per hour. Drivers of buses being operated on the shoulder must yield to merging, entering, and exiting traffic and must yield to other vehicles on the shoulder. Buses operated on the shoulder must be registered with the Department of Transportation.

(d) For the purposes of this section, the term "metro mobility bus" means a motor vehicle of not less than 20 feet in length engaged in providing special transportation services under section 473.386 that is:

> (1) operated by the Metropolitan Council, or operated by a public or private entity receiving financial assistance from the Metropolitan Council; and
>
> (2) authorized by the council to use freeway or expressway shoulders.

HIST: 2002 c 364 s 10; 2005 c 51 s 1

APPENDIX 7 – HIGHWAY AND ARTERIAL SHOULDER FUNCTIONS

The role of highway and arterial shoulders has dramatically grown over time. Highway and arterial shoulders originally provided lateral support to the travel lane pavement structure, offered a refuge for emergency and stranded vehicles, and temporarily housed debris that once was in the general traffic lanes. Now, these shoulders also perform many new functions, such as accommodating increases in traffic, expediting water runoff from general traffic lane pavement, providing more space for construction and maintenance activities, accommodating bicycle paths or slow-moving vehicle and equipment lanes, reducing edge stresses, preventing or minimizing edge and corner deflections, reducing development of pavement edge drop-offs, providing maneuvering areas, and increasing sight distances on horizontal curves. These and other shoulder functions are summarized in Table 2.1 below.

Table 2.1 Highway Shoulder Functions
(Source: IDOT BD&E Manual, 2002)

Important Functions that Highway Shoulders Serve

- Provides structural support for the general traffic lanes;
- Provides support for the guardrail and prevents erosion around guardrail posts;
- Prevents or minimizes pavement edge drop-offs;
- Increases highway capacity;
- Encourages uniform travel speeds;
- Provides space for emergency and discretionary stops;
- Provides more recovery area for disabled vehicles;
- Provides lateral clearance for encroaching vehicles (e.g. during construction or maintenance operations);
- Improves sight distance around horizontal curves;
- Enhances highway aesthetics;
- Facilitates maintenance operations (e.g. snow removal and storage);
- Provides additional lateral clearance to roadside appurtenances (e.g. guardrails and parapets);
- Provides space for walls, traffic signals, and highway signs;
- Facilitates pavement drainage (water is discharged farther from the general traffic lanes);
- Provides space for pedestrian and bicycle use; and
- Provides space for bus stops and mailbox turnouts.

Shoulder Use

Shoulder use for vehicle movement is not new. According to a 1977 survey, five states permitted regular use of shoulders for slow-moving vehicles and ten states allowed shoulder use under limited conditions, such as temporary use of shoulders during construction and maintenance (NCHRP, 1979). In limited cases over time, states have allowed highway shoulder use during peak periods and have temporarily placed interim high occupancy vehicle (HOV) lanes within highway shoulders.

Other demands for alternative uses of highway and arterial shoulders have also increased over time. In 1999, the Federal Highway Administration (FHWA) developed a policy to integrate bicycling and walking into transportation infrastructure that requires bicycle and pedestrian ways in all new urban construction and reconstruction projects (including highway and arterial shoulders). However, this policy does not apply if 1) the law prohibits bicyclists and pedestrians from using the roadway, 2) the cost of establishing bikeways or walkways is excessively disproportionate to the need or probable use, and/or 3) a sparse population or other factors indicate no need for bicycle or pedestrian ways. The FHWA defines an excessively disproportionate cost as more than twenty percent of the larger transportation project's overall cost.

In rural areas, the FHWA requires paved shoulders for all new construction and reconstruction projects on roadways used by more than 1,000 vehicles per day. Paved shoulders provide safety and operational advantages for all road users and offer a place for bicyclists and pedestrians. Under the transportation enhancement (TE) provisions of the Intermodal Surface Transportation Efficiency Act (ISTEA, 1991), states could use TE funds to build or pave highway shoulders for bicycle and buggy lanes, if the shoulders primarily accommodate non-motorized transportation modes, such as bicycles, buggies, and pedestrians (FHWA, 2008).

APPENDIX 8 – NON-BOS SAFETY BENEFITS OF HIGHWAY AND ARTERIAL SHOULDERS

A stream of literature exists on highway and arterial shoulders' general (non-BOS related) safety benefits. Studies included in the Transportation Research Board (TRB)'s Special Report No. 214, Designing Safer Roads – Practices for Resurfacing, Restoration, and Rehabilitation (TRB, 1987) and Publication No. FHWA/RD 87/094, Safety Cost-Effectiveness of Incremental Changes in Cross Section Design – Informational Guide (Zeeger, et. al., 1987) have cited reduced accident rates with the use of paved shoulders. By providing room to remove potential conflicts from the traffic stream, shoulders generally provide an important safety function, including serving: as an area for disabled vehicles, as a site that police issue violations for motorists, as a lane for emergency vehicles to travel, and as a place to stow snow that has been removed from the main highway lanes. Hauer (2000) noted that several factors unfortunately make it difficult to extract the safety effect of shoulder width and shoulder paving from empirical evidence for crash rates or frequencies because they often go hand-in-hand and are therefore jointly determined (e.g. narrow lanes, narrow shoulders, unpaved and unforgiving roadsides) for crash rates and frequencies.

Shoulders are most closely associated with Run-Off-Road (ROR) crashes. ROR crashes involve vehicles that leave the travel lane and encroach onto the shoulder and beyond and hit one or more of any number of natural or artificial objects, such as bridge walls, poles, embankments, guardrails, parked vehicles, and trees (Neuman, et. al., 2003). However, these crashes are highly concentrated on rural roadways. Fitzpartrick, et. al. (2000) noted that the following accident types can be affected directly by lane and shoulder width improvements: head-on, ROR/fixed object, ROR/rollover, same direction sideswipes, and opposite direction sideswipes.

Because safety is cited to be the most frequent concern for BOS operations, the research team reviewed studies that identify the most important safety-related aspects of shoulders. However, most of these studies related shoulder safety aspects to specific characteristics, such as shoulder width or shoulder lanes converted to general use travel lanes.

Studies relating crashes to shoulder width show that the relationship is far from simple. Hauer (2000) noted that the mechanism by which shoulder width may impact safety is fourfold. First, the shoulder is an even and obstacle free surface where drivers of stray vehicles can regain control, recover from error, and resume normal travel. Second, wide shoulders induce some voluntary stopping. Vehicles stopping, vehicles stopped on the shoulders, and vehicles returning to the traffic stream pose a substantial hazard. Hauer and Lovell (1984), for example, estimated that more than 10% of all fatal freeway accidents are associated with stopped-on-shoulder vehicles or with the maneuvers associated with leaving and returning to the outer lane. Third, wide shoulders may induce the use of shoulders for travel or passing other vehicles. Fourth, wider shoulders may lead to higher travel speeds. Even small increments in the mean speed have noticeable impact on accident severity. It follows that the shoulders' net safety effect is a sum of opposite tendencies. Whether the sum of these conflicting tendencies benefits safety or is detrimental to it, the actual nature of the relationship between shoulder width and crashes can be ascertained only by examining factual evidence.

Blensley and Head (1960) found a direct correlation between shoulder width and accident rate for ADT rates between 1,000 and 2,999. The opposite is true for segments with ADTs in the range between 3,000 and 5,600, which is consistent with what Head and Kaestner (1956) and Shoppert (1957) found earlier for gravel shoulders. Turner, et. al. (1981) found that two-lane roads without paved shoulders have much higher accident rates than roads with paved shoulders in all ADT ranges that were studied. A review of more recent studies relating crashes to shoulder width indicated that all studies found reductions in crashes with increases in shoulder width (Zeeger, et. al., 1987; Hadi, et. al. 1995; Miaou, 1996; Wang, et al, 1997).

Converting shoulder lanes to general purpose travel lanes have also been found to have mixed effects on crashes. For example, McCasland (1978), examined two freeway segments in Houston and Urbanik and Bonilla (1987) examined 10 freeway segments in California, where shoulder lanes were converted to general purpose travel lanes. Four out of the 12 projects examined showed a statistically significant reduction in accident rate per million vehicle-kilometers (veh-kil), whereas one project showed a statistically significant increase.

Bauer, et. al. (2004), in their assessment of the above mentioned research, expressed concern that accident rate rather than accident frequency was the index of investigation. In their own study, Bauer, et. al. (2004) examined several projects, which had undergone conversion from either four lanes in one direction to five lanes, or five lanes in one direction to six lanes. New travel lanes were developed from existing pavement width by converting paved shoulders to travel-lane width, narrowing existing lanes by restriping, or a combination of the two. Their results were mixed; narrow-lane or shoulder use lane projects on urban freeways increased accident frequencies for four to five lane conversion projects. Such conversions may increase accident frequencies for four to five lane conversion projects. Such conversions may increase accident frequencies for five to six lane conversion projects as well, but the results for those projects were not statistically significant. Because of the different findings for these two types of conversions, the results obtained are difficult to generalize to urban freeways as a whole. The authors noted that one possible explanation for the increase in accident frequency on conversion projects is that the added lanes in most of the projects were HOV lanes. Speed differentials between the main lanes and the HOV lanes on freeways have the potential to increase sideswipe and lane changing accidents, although this effect has not been satisfactorily quantified in the literature.

APPENDIX 9 – SUMMARY OF EXISTING BOS OPERATIONS

Transit agencies operate BOS networks in most regions in the United States that have moderate to heavy congestion and population centers over two million. These regions include the Great Lakes (Cincinnati, Cleveland, and Minneapolis-St. Paul); Northeast (Union County, Mountainside Borough, and the Town of Westfield in New Jersey; Southeast (Alpharetta, Georgia; Falls Church, Virginia, and the Miami-Dade metropolitan area); and West (San Diego and Seattle). These regions have climates ranging from little precipitation (12 inches in San Diego) to a lot of precipitation (51.8 inches in Alpharetta, Georgia) and from no snow (Miami-Dade metropolitan area and San Diego) to lots of snow (49.9 inches in Minneapolis-St. Paul).

These BOS operations range from a 1.3 mile highway shoulder (Falls Church, Virginia) to a 271 mile network that spans across a metropolitan area (Minneapolis-St. Paul). Many of these BOS operations occur on the right shoulder, while some occur on the left shoulder (Cincinnati).

The table shown below identifies and describes each of these existing BOS operations and its operating environment. The first three columns identify and describe the metropolitan region and service area for each BOS operation and the next two columns show the congestion level for each of these regions. The first of these columns on congestion shows how the metropolitan areas are ranked against each other for the number of delays per peak traveler in 2005. Falls Church, VA and Alpharetta, GA (a far suburb of the Atlanta metropolitan area), for example, rank second nationally in delays per traveler (in person hours), while the Chicago metropolitan area ranks sixteenth, and the Greater Cleveland area ranks seventy-fifth. The second of these columns on congestion shows the percent of congested travel during peak periods for 2007. This indicates the percent of peak period travel that occurs under congestion. Over 80% of travel is congested during the peak period in the Chicago, Miami-Dade, San Diego, and Washington, DC metropolitan areas, for example. The final two columns in this table show the precipitation and snowfall that may complicate BOS operations for each of these metropolitan areas. They can also prevent pavement distress if the shoulders are not adequately cleared or drained. Inadequate drainage is one of the principal causes of pavement distress (Christopher, et. al. 2000). Adequate drainage, however, can extend the life of pavement up to two or three times (Cedergren, 1987; Forsyth, 1987) more than undrained or inadequately drained pavement.

Implemented BOS Operations and Their Characteristics

Location	Description and Type of Operations	Estimated 2005 MSA Population	2005 Delay Per Peak Traveler (in Person Hours); National Rank	2007 Percent of Congested Travel During Peak Period	Weather Factor Affecting Operations (Annual in Inches)	
					Precipitation[3]	Snowfall[4]
Cleveland Metropolitan Area, OH	Shoulder along the I-90 Corridor in Eastern Cuyahoga and portions of Lake County	2,126,318	75	29	36.6	56.9
Cincinnati, OH	I-71 left shoulder between Kenwood and King's Island for 11.7 miles	2,070,441	45	51	41.6	23.4
San Diego Metropolitan Area, CA	SR-52 and I-805	2,933,462	6	85	12	0
Miami-Dade Metropolitan Area	SR-821/SR-836 Corridor, I-75/SR-826 Corridor, SR-826 Corridor, I-95 Corridor, and SR-874 Corridor	5,422,200	11	85	59	0
Alpharetta, GA	Express buses on the GA 400 shoulders from the North Springs MARTA Station to Windward Parkway	4,917,717	2[5]	76	51.8	2.1
Westfield, Mountainside Borough, Union County, NJ	Eastbound shoulder (right hand lane or curb lane) of U.S. 22 in Westfield and Mountainside Borough; Route 9 northbound	18,747,320	16[6]	68	50.9	28.4

	and southbound arterial bus bypass shoulder					
Seattle Metropolitan Area, WA	2.7-mile segment of westbound SR-520 and the shoulder of a 2.2 mile west bound and eastbound SR-522 (a 5-lane arterial highway north of Seattle.)	3,554,760	19	70	37.1	7.3
Falls Church, VA	1.3-mile segment of the shoulder on the inbound direction of the Dulles Access Highway (Route 267) to facilitate bus access to the West Falls Church Metrorail Station	5,214,666	2[7]	81	45.1	22.3
Minneapolis-St. Paul, MN	271 shoulder miles network-wide	3,142,779	23	61	29.4	49.9
Chicago Metropolitan Area		9,443,356	16	82	35.83	38.5

[1] Data for Delay per Peak Traveler taken from the Texas Transportation Institute's (TTI's), "Congestion Data for Your City," which is available at http://mobility.tamu.edu/ums/congestion_data/. This index gives extra time spent traveling at congested speeds rather than free-flow speeds divided by the number of people making a trip during the peak period.
[2]Data on Percent of congested Travel during Peak Period taken from the TTI's 2007 "Urban Mobility Report," in http:/tti/tanu.edu/documents/mobility_report_2007_wappx.pdf.
[3]Data for annual precipitation, based on a standard 30-year period from 1961 through 1990, taken from http://www.allcountries.org/uscensus/411_normal_monthly_and_annual_precipitation_selected.html
[4]Data for annual snowfall taken from the National Oceanic and Atmospheric Administration's National Climatic Data Center. http://lwf.ncdc.noaa.gov/oaclimate/online/ccd/snowfall.html.
[5] Data for the Atlanta, GA metropolitan area.
[6] Data for New York-Newark; NY-NJ-CT metropolitan area.
[7] Data for Washington, DC-VA-MD metropolitan area.

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