Use of Freeway Shoulders for Travel — Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy

Appendix A. Case Studies of Successful Applications in the United States

A list of known part-time shoulder use applications can be found in Table 13. Though the application of part-time shoulder uses has been rather limited in some cases, it can be seen that this Active Traffic Management (ATM) strategy has been employed across most regions in the United States. The various examples highlighted in this section, which features corridors from all over the country and of vastly different implementation scales, evidence that under the appropriate conditions, part-time shoulder use is an effective strategy in reducing travel times and increasing overall network reliability and performance.

Though part-time shoulder use is more-widely implemented in Europe, it is difficult to establish comparisons between ATM strategies employed in Europe versus those employed in the United States due to differences in driver behavior, political support, and transportation networks as a whole. No effort was made to inventory European facilities with part-time shoulder use, but noteworthy practices from Europe were provided through this guidance document.

Table 13. Part-Time Shoulder Use Facilities in US.

Strategy	Location	Corridor	Length (miles)	Year Deployed	Vehicle Type	Usage Criteria	Maximum Allowed Speed	Lane Width (feet)	Note
Bus-on-shoulder	Minneapolis Metro Area	Multiple	290	1991	Buses only	24/7, when main line speed is under 35 mph	Maximum of 35 mph, and no more than 15 mph faster than mainline	10-12	Freeway application and a few arterials
	Wilmington, Delaware	US 202	0.3		Buses only	24/7			Arterial queue jump application
	Miami, Florida	SR 826	16	2005	Buses only		35 mph	10-12	Freeway application
	Miami, Florida	SR 836	18	2005	Buses only		35 mph	10-12	Freeway application
	Miami, Florida	Turnpike			Buses only	General purpose speeds drop below 25 mph	Maximum of 35 mph, and no more than 15 mph faster than mainline	10-12, depending upon truck volumes	Freeway application
	Miami, Florida	SR-874, SR-878	9	2007	Buses only	General purpose speeds drop below 25 mph	Maximum of 35 mph, and no more than 15 mph faster than mainline	10-12, depending upon truck volumes	Freeway application
	Montgomery County, Maryland	US 29	4		Buses only	M-F, 6-9am (SB), 3-8pm (NB)			Arterial queue jump application
	Mountainside, New Jersey	US 22 EB	1		Buses only				Arterial application
	Middlesex County, New	US 9	4	2006	Buses only	M-F, 5-9am	35 mph		Arterial application

	Jersey					(NB), SB pm peak period			
	Falls Church, Virginia	SR 267 EB	1.3		Buses only	M-F, 4-8pm	25 mph	12	Freeway queue jump
	Columbus, Ohio	I-70	10	2006	Buses only	General purpose lane speeds drop below 35 mph	35 mph		Minneapolis-St. Paul Twin Cities area model was followed
	Cleveland, Ohio	I-90/SR 2	10	2008	Buses only	General purpose lane speeds drop below 35 mph	45 mph		Freeway application
	Cincinnati, Ohio	I-71	10	2007	Buses only	General purpose lane speeds drop below 35 mph	45 mph	12	Freeway application, left shoulder
	Chicago, Illinois	I-55	14	2011	Buses only	General purpose lane speeds drop below 35 mph	45 mph		Freeway application,
	Raleigh, North Carolina	I-40	12	2012	Buses only	General purpose lane speeds drop below 35 mph	35 mph		Similar features as the Twin Cities network, freeway application
	Kansas City, Kansas	I-35	12	2012	Buses only	General purpose lane speeds drop below 35 mph	35 mph		Freeway application
	Seattle, Washington	SR 522	2.2	1970	Buses only	24/7	Buses allowed to operate at full posted speeds		Arterial application
	Seattle, Washington	SR 99							Arterial application
Static	Alpharetta, Georgia	GA 400	12	2005	All	General purpose lane speeds drop below 35 mph	35 mph max, speed differential with general purpose lanes below 15 mph		Previously buses use only, freeway application
	Boston, Massachusetts	I-93, I-95, SR 3	45	1985	Passenger vehicles only	M-F, 5-10am, 3-7pm	65 mph (60 mph on SR 3)	10-12	Freeway application, shoulder running has been eliminated on

									several miles of I-95 after road widening
		Fairfax County, Virginia	I-66	6.5	1992	All	M-F, 5:30-11am (EB), 2-8pm (WB)	55 mph	12	Freeway application
		Virginia Beach, VA	I-264	3.5	1992	All	M-F, 6-8am (EB), 4-6pm (WB)	55 mph	10	Freeway application
		McLean, Virginia	I-495	1.5	2015	All	7-11 am, 2-8pm	55 mph	11	Planned left-shoulder application
		Everett, Washington	US 2 EB	1.22	2009	All	M-F, 3-7pm	60 mph	14	Arterial application
		Honolulu, Hawaii	I-H1			All	Morning peak period			Temporary condition until high-cost capacity improvements are implemented, freeway application
		Seattle, Washington	US 2	1.55		All	Evening peak period	Same as general purpose lane		Permanent application, capable to accommodating growth
		Trenton, New Jersey	NJ 29	1		Cars only	M-F, 7-10am	Same as general purpose lane	13	Additional exit lane to NJ 129 (creating 2 lane exit)
		Newark, New Jersey	I-78 EB	7	2014	All	Peak periods	Variable, but same as general purpose lane	12	Temporary due to closure of adjacent freeway for reconstruction
		Minneapolis, Minnesota	I -35W	2.5	2009	Dynamic priced		Freeway free- flow speed	17-19	Freeway application
	Dynamic									
		Fairfax County, Virginia	I-66	6.5	2015	All		variable	12	Was static from 1992-2015

Minneapolis-St. Paul, Minnesota — Bus on Shoulder

Perhaps the foremost part-time shoulder use network in the country, the bus on shoulder (BOS) program in Minneapolis-St. Paul has allowed transit vehicles to travel on more than 290 miles of shoulder throughout the region since 1991. Though all 290 miles of shoulder have not been open since the program's inception, the extent to which the program has grown has made it—without a doubt—the most-extensive system in the United States. While many BOS systems arise out of the desire to increase transit reliability (and therefore its appeal to potential riders), the BOS system in Minnesota germinated out of a rather unique situation.

In May of 1991, major flooding forced officials to close one of the bridges on I-35W, a primary means of travel in and out of the Twin Cities. In a state of emergency, the governor called a summit to help develop strategies for increasing throughput on the adjacent bridges while repairs were made to the I-35W bridge. Ultimately, it was decided that buses would temporarily be allowed to travel on the shoulder to improve subsequent traffic congestion. The quick turnaround and immediate success of the strategy prompted officials to begin testing bus shoulder running on other congested roadways in the Twin Cities area. The result was the development of a designated task team consisting of key stakeholders, such as Metro Transit and suburban bus operators, MnDOT officials, state police officers, and the Metro Council of Governments. Several central staff members at the DOT were selected to act as advocates for the program.

Over the past decade, the task team has successfully advocated for the inclusion of BOS operations on hundreds of miles of freeways, primarily as part of larger construction or shoulder maintenance projects. MnDOT now has an overall program that

looks annually at where shoulder running can be added on freeways.(42). A 1998 survey of the program estimated that the BOS system resulted in a bus travel time savings of 5 to 15 minutes depending on levels of congestion and route length. Respondents also saw the shoulders as a way to minimize their stress sitting in congestion and increase individual trip reliability. While safety has been identified as a primary concern by program officials and other key stakeholders, the most- concerning safety issues for buses in the shoulders have been sideswipe crashes and mirror hits, which tend to be less severe crash types.(24)

In 2009, MnDOT converted the right shoulder (previously used for BOS) into a general purpose lane on a section I-35W to maintain lane continuity into downtown as other portions of I-35W were widened. The left shoulder was converted to a dynamic priced lane. Buses and high- occupancy vehicles can use the lane for free, and single-occupant vehicles pay a variable toll.(52)

Fairfax County, Virginia

At the same time that a BOS system was being developed in Minneapolis-St. Paul, VDOT was establishing an alternative part-time shoulder use strategy for one of its most-heavily congested roadways. I-66, which extends radially outward from the Capital Beltway (I-495) in Northern Virginia, suffers from recurring congestion both during and outside of peak hours. To help aid peak-direction travel, VDOT converted the leftmost general purpose lane to an high-occupancy vehicle (HOV) lane and allowed general purpose traffic to use the shoulder to offset the decrease in general purpose capacity. Static part-time shoulder use was opened in 1992 and was available for use by all traffic during specified peak periods on a 6.5-mile section of I-66 between I-495 and US 50. These periods have been revised over the years to respond to changes in traffic, and, in 2015, a more-advanced active traffic management system with dynamic part-time shoulder use was installed. The shoulder is now opened whenever warranted by traffic conditions. A 2007 investigation into system performance revealed that these shoulders operate at near capacity (V/C ratios: 0.90-1.0 eastbound, and 0.83-1.0 westbound), indicating the part-time shoulder use is able to help significantly augment throughput during the peak periods. A similar investigation was completed with regards to the safety effects of the part-time shoulder use; a negative binomial regression analysis using several years of crash data indicated the part-time shoulder use did not have any statistically significant effect on crash frequency.(24)

Alpharetta, Georgia

In the northern suburbs of Atlanta, nearly 12 miles of part-time shoulder use has been developed on GA 400. The project has incrementally grown from BOS in one direction to static part-time shoulder use in both directions. Part-time shoulder use was initially operated only in the southbound direction during the AM peak and was only open to buses. Opened on September 12, 2005, the project was championed by the GDOT and Georgia Regional Transportation Authority (GRTA), which operates express bus services in the area. The program was modeled after the successes of the Minneapolis-St. Paul BOS program but initially considered a temporary solution until the roadway could be permanently widened. The project development process included a bus ridership estimate using the regional travel demand model, benefit forecasts, and a field assessment of shoulder conditions. Both GRTA and Metropolitan Atlanta Rapid Transit Authority (MARTA), which operate four and eight buses per hour (respectively) on the BOS section of GA 400, report averages of five to seven minutes of travel time savings on their commuter bus routes. The routes end at a heavy rail station with direct access from GA 400. During peak congestion, up to 25 minutes were saved through the 12-mile corridor. The disparity of travel times between buses and general traffic later decreased due to the widening of GA 400. TCRP Report 151 states, as of 2012, no crashes related to BOS were reported in Georgia; no further safety information is provided in the report.(42) More recently, the southbound BOS was converted to general purpose part-time shoulder use, and northbound part-time shoulder use was opened. The part-time shoulder use only occurs on auxiliary lanes between interchanges and does not extent through interchanges.

San Diego, California

The San Diego Association of Governments (SANDAG) implemented BOS along five miles of I-805/SR 52, used by express bus route 960 in the mid-2000s. SANDAG agreed to a two-year pilot program with Caltrans to test BOS; it was initially envisioned as a temporary improvement until managed (i.e., HOV and HOT) lanes could be deployed or until the roadway was widened. In collaboration with SANDAG and local transit operators, BOS on I-805/SR-52 was opened in December 2005 by Caltrans. Several key findings were determined with a six-month assessment of the program: (42)

- Safety
  - No crashes [As stated in TCRP Report 151—presumably this refers to shoulder- running buses only, as crashes in general likely happen on a freeway in a six month period of time].
  - No issues related to enforcement or Caltrans maintenance.
- Bus Travel Time and Reliability
  - Route 960 buses have 99 percent on-time performance.
  - Up to 5 minutes travel-time savings for buses during heavy congestion.
- Freeway Level of Service and Maintenance
  - California Highway Patrol and Caltrans report no changes in freeway levels of service.
  - Transit operator indicates need for additional maintenance to remove debris on shoulders.
- Structural Changes

- 10-foot shoulder width is optimal.
- Buses can safely operate in narrower shoulders, but it does slow operations.

- Perceptions
  - 72 percent of bus drivers feel use of shoulders is safe.
  - 86 percent of bus drivers believe use of shoulders is a good idea.
  - 91 percent of passengers feel use of shoulders provides travel time savings.
  - 90 percent of passengers feel safe with buses on shoulders.

The pilot program has since ended. However, another demonstration project is currently planned in the San Diego area on I-805/SR 94 from SR 54 to downtown.(53)

Middlesex County, New Jersey

Due to the success of BOS along US 22 in Mountainside, New Jersey (which is limited in scale and has existed for decades), New Jersey DOT opened a second BOS corridor along four miles of US 9 in Middlesex County. Opened in November 2006, the BOS was designed to serve over 400 buses and 6,800 passengers during peak commute periods. The plan was a key element of the NJDOT's Enhanced Bus Improvement Program, which is tasked with reducing delays and increasing travel-time reliability of bus services. Feedback from the program has been overwhelmingly positive from both passengers and bus operators alike; the latter responded positively to the use of 12-foot shoulder priority treatments. As of 2012, no crashes have been reported [As stated in TCRP Report 151—presumably this refers to shoulder-running buses only, as crashes in general are likely to happen on an arterial in a six year period of time], and travel time savings on the order of three to four minutes have been seen during peak trips along the 4-mile corridor.(42)

Seattle, Washington

In order to help improve travel time, reduce the impacts of bottlenecks, and relieve congestion at a critical interchange, the Washington State DOT began opening the shoulder to all traffic along a 1.55-mile segment of US 2 near Seattle. WSDOT employed outreach efforts prior to implementation, which aided significantly in the development of the part-time shoulder use concept. It was determined the shoulder would only be open to traffic during the evening peak period, and restriping was undertaken to reduce weaving throughout the corridor. As a result of the additional throughput with part-time shoulder use, WSDOT considers it a permanent solution (at least for the near future) to solve the aforementioned issues along the corridor. Average delays for all vehicles have been reduced from 8-10 minutes to 1-2 minutes along the 1.55 mile stretch of US 2.(24)

Miami, Florida

In 2002, residents of Miami-Dade County (MDC) developed the People's Transportation Plan, which sought to improve mobility and reduce congestion throughout the county. Seventeen million dollars was committed under the plan to improve local bus services through the addition of routes, increased efficiency of service, and expansion of rapid transit services. Complementing this plan, the MDC MPO conducted an extensive, two-phased investigation into the feasibility of special-use lanes in the county. Phase I provided a high-level assessment of the applicability of various types of special-use lanes along several of MDC's most-congested corridors. The primary outcome of this phase was the identification of rapid transit corridors comprised of Expressway Core routes. In Phase II of the study, these Expressway Core routes were further vetted for potential use with shoulder running schemes by the Center for Urban Transportation Research at the University of South Florida. The study outlined key operational characteristics required for the successful implementation of shoulder running in MDC. Based on several factors, including roadway characteristics, programmed corridor improvements, and proposed express transit, five corridors were ultimately identified as holding the most potential for a pilot bus on shoulder program.

After further investigation by the MDC MPO, the SR 874 and SR 878 corridors were selected for the first BOS project. Consisting of approximately nine miles of freeway, buses were allowed to begin operating on the shoulders of these routes when the speed of general traffic fell below 25 miles per hour. Four years after their opening in 2007, a 50-percent reduction in the number of late buses running along the BOS corridor was found. Key stakeholders in the program included the MPO, Office of the County Manager, Miami-Dade Transit, Miami-Dade Expressway Authority, Florida DOT and Turnpike Enterprise. Key stakeholders noted bus shoulder running was not the ideal solution to congestion, but it served as an effective means to help improve mobility and transit reliability throughout Miami-Dade County.(40)

Minneapolis, Minnesota — Dynamic Shoulder Lane

Focused on reducing traffic congestion in the I-35W corridor and downtown Minneapolis, the Minnesota Urban Partnership Agreement (UPA) developed the first dynamic part-time shoulder use application in the United States on I-35W. Opened in 2009, the "priced dynamic shoulder lanes" (PDSL) allow buses, vanpools, carpoolers (2+), and MnPass users to utilize the 17-19 foot left-shoulder during congested periods; it previously operated as BOS. The 2.5-mile length of shoulder features both static and changeable message signs every 0.5 miles to inform drivers when the shoulders are open, as well as the price per segment to utilize the PDSL.

To implement this innovative system, the UPA relied on more than traditional technical analyses (e.g., operations, transit, and safety analyses); it also maximized the benefits of the institutional arrangements used to manage and guide the development of the initial proposal and implementation of the UPA projects, outreach activities, media coverage, and political and community support. The multi-agency organizational structure was essential for the initial implementation of this shoulder running application, and the subsequent processes, structures, media coverage, and staff competencies supported its development. Table 14 summarizes the non-technical success factors that were vital to the implementation of the PDSL, as well as other UPA projects on the I-35W corridor.

Table 14. Non-Technical Success Factors of the I-35W Priced Dynamic Shoulder Lane.

Questions	Results	Evidence
What role did the following areas play in the success of the Minnesota UPA project deployment?		
1. People	Effective	Key elements included the multi-agency organization structure, support throughout the agencies, and neutral conveners.
2. Processes	Effective	Forums, workshops, meetings, presentations, and newsletters were used to communicate with different groups.
3. Structures	Effective	The strong agency working relationships supported the implementation of the UPA projects.
3. Media	Effective	Media Effective Played role of informing the public, rather than attempting influencing public opinion.
3. Competencies	Effective	Agency personnel had the technical expertise and project management skills needed to successfully deploy the UPA projects.
Does the public support the UPA strategies as effective and appropriate ways to reduce congestion?		
	Supported	The reports from the various surveys of bus riders, commuters in the I-35W South corridor, and I-35W MnPASS customers indicate general support for the UPA strategies as effective and appropriate methods to reduce congestion.

Opened in both the northbound and southbound direction on I-35W, the PDSL have helped reduce congestion, improve travel-time reliability, and increased throughput along the corridor. A year after implementation, the PDSL (in conjunction with the I-35W HOT lanes) pulled an average of 50,000 to 60,000 month trips from the general purpose lanes and generated $74,000 to $102,000 in monthly revenue. Preliminary safety studies have shown that the addition of the PDSL do not appear to negatively affect safety.(54)

Idaho Springs, Colorado

Serving as the only east-west interstate in Colorado, the I-70 Mountain Corridor provides critical access for both localized and regional traffic from Denver to the mountains of West Colorado. As such, the corridor experiences heavy traffic demand, resulting in severe congestion and traffic delays in the eastbound direction. The 13-mile stretch of I-70 between Empire Junction and Idaho Springs, in particular, suffers from severe recurring congestion during peak periods. This four-lane section of highway would potentially benefit from traditional capacity improvements (e.g., road widening); however, strict physical constraints resulting from the surrounding mountainous terrain have forced the Colorado Department of Transportation (CDOT) to consider more context sensitive solutions.

As a part of the CDOT's comprehensive plan to improve travel along this corridor, a task force began investigating alternative solutions to help alleviate recurring congestion along I-70. Coordinating with representatives from the local community, including key community members, county and city officials, law enforcement, and historical and environmental protection advocates, CDOT formed Project Leadership and Technical Teams to gather valuable insights during the planning phase all the way through to final construction. These teams helped develop the guiding core principles for the alternatives analysis; this ultimately led to the development of a peak period shoulder running alterative in the eastbound direction.

After fully vetting the operational and environmental viability of shoulder running between Empire Junction and Idaho Springs, CDOT proceeded with a plan to develop an optional, dynamically-tolled third lane on I-70. This scheme not only aims to alleviate congestion, reduce travel times, and increase throughput of the critical corridor, but it does so without expanding the existing roadway. Slated for completion in the fall of 2015, CDOT will open the left-shoulder for use during the peak periods, promoting a more-reliable travel experience for drivers by actively displaying prices for the tolled-shoulder via variable message signs. Though a static operation, the dynamic pricing of the lane will help maintain the travel time savings expected under shoulder use.(55)

Boston, Massachusetts

One of the earliest part-time shoulder use operations in the country opened on several miles of I- 95 and SR-3 in 1985 outside of Boston. Prior to implementation, standstill traffic along these corridors prompted drivers to begin using the shoulder, despite a lack of permitted use. To help alleviate congestion along these corridors, the Massachusetts Department of Transportation (MassDOT) developed a static part-time shoulder use scheme on I-95 and SR-3 during the peak travel periods (5 a.m. to 10 a.m. and 3 p.m. to 7 p.m. on weekdays) for passenger cars and trucks. Before this could be introduced, however, these corridors required a few minor improvements to accommodate the safe and efficient flow of traffic on the existing shoulders.

Prior to implementation, MassDOT strengthened and relocated drainage structures on the shoulder, conducted minor repairs to pavement, widened shoulders to meet a 10-foot minimum (12-foot desired), and developed emergency breakdown turnouts at 0.5 mile intervals to facilitate incident management and emergency response. MassDOT also employed the assistance of the Massachusetts State Police, who travel the lanes each day prior to opening the shoulder for use to ensure motorists will be safe from debris. Though no specific performance measures are collected on the effect of the shoulder lanes, the early success of the shoulder lanes increased travel speeds along these corridors, prompting MassDOT to extend shoulder operations to additional sections of roadway.

Since opening in 1985, part-time shoulder use in the Boston area have expanded to over 45 miles of roadway, including sections of I-93 north of the city. The infrastructure of these operations have also expanded, as pavement markings have been updated to reflect lessons learned, and signing plans have evolved to include both static and changeable message signs at the beginning and end of operations, as well as at freeway entrance ramps. The implementation of part-time shoulder use on these corridors, however, is only temporary. Prior to 2009, MassDOT was required to reapply for approval from Federal Highway Administration (FHWA) to implement the strategy every five to seven years until funding for permanent road widening was obtained. Since then, MassDOT has eliminated part-time shoulder use on half of the I-95 corridor after recent widening; it has plans to eliminate part-time shoulder use on the other half of I-95 within the next few years.[24]