USING BRT TO MAXIMIZE PERSON CAPACITY WITHIN LIMITED RIGHT-OF-WAY

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Bus Rapid Transit (BRT) is defined by the Federal Transit Administration as "a rapid mode of transportation that can provide the quality of rail transit and the flexibility of buses." The implementation of BRT can improve the speed, reliability, and identity of transit services, increasing the likelihood of transit system usage. In addition, some applications of BRT can maximize person capacity along corridors that are characterized by limited right-of-way.

This paper presents three approaches to using BRT to maximize person capacity. These approaches include:

(1) **Mixed Traffic** - Person capacity has been increased in many communities by implementing BRT in mixed traffic without exclusive lanes. Such an approach typically requires an investment in mainline transit signal priority, queue jumps, and bypass lanes along the corridor. Other BRT elements are also integrated into the system, including rail-like rubber-tired vehicles, level boarding, off-board fare collection, and unique branding. Los Angeles is a good example of widespread implementation of BRT in mixed traffic.

(2) **Bus Use of Shoulders** - Bus use of shoulders on interstates, arterials, and bridges has been implemented by many communities along selected corridors. Bus use of shoulders typically comes with restrictions and generally allows buses to bypass congestion when travel speeds are less than 35 miles per hour on the through lanes. This approach can essentially result in an additional lane of capacity in both directions.

(3) **Use of Existing Medians** - Divided roadways that have sufficient median space provide opportunities for integrating exclusive lanes within the existing right-of-way. The exclusive lanes may involve two-way traffic for transit vehicle flow or a single, reversible lane of traffic for transit vehicle flow.

These three approaches to using BRT are presented in this paper to emphasize techniques that can be used to maximize person capacity within limited right-of-way.

BUS RAPID TRANSIT

Overview

BRT has been defined by the Federal Transit Administration as "a rapid mode of transportation that can provide the quality of rail transit and the flexibility of buses." In many respects, BRT is rubber-tired light rail transit, but with greater operating flexibility and generally lower costs. BRT combines a variety of physical and operating elements into an integrated system that displays a distinct identity and high quality image. These elements include transit stations, vehicles, running ways, and advanced technologies. The implementation of BRT improves the speed, reliability, and identity of transit services, increasing the likelihood of transit system usage. BRT was developed as a transit mode that allows for flexibility in its application and can be tailored to fit a particular set of travel markets. The major components of BRT are listed below:

- Running ways
- Stations
- Vehicles
- Fare collection
- Intelligent transportation systems
- Bus operation and service
- Route structure
- Branding

Each of these system components provides insight into the physical and operational parallels between BRT and light rail and conventional bus transit systems.

Transit Investment Cost versus Performance

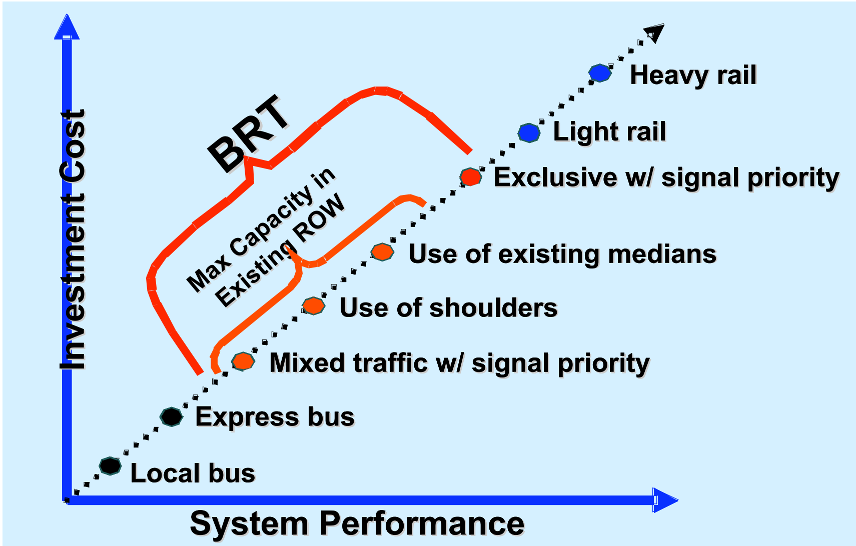
A conceptual illustration of the relationship between transit investment cost and transit system performance is provided in Figure 1. For the purpose of this paper, this relationship is intended to be conceptual and not based on empirical data. It should be noted, however, that it is intuitive that cost and performance are generally expected to have a positive correlation. While the exact slope of this positive relationship is left for future work, the conceptual relationship indicates that as transit system performance increases, so does transit investment cost. This positive relationship is referred to as the Transit Cost/Performance Line (TCP Line).

- At the low end of the TCP Line, traditional transit investments are observed, such as local and express bus service.

- At the high end of the TCP Line, rail investments are observed, such as light and heavy rail transit.

Figure 1

Conceptual Relationship of Transit Investment Cost and Transit System Performance



- Between traditional transit investments and rail transit investments, various types of BRT investments are observed. Figure 1 reflects four type of BRT investments, including:
    - Mixed traffic with signal priority
    - Use of shoulders on limited access and arterial roadways
    - Use of existing medians
    - Use of exclusive lanes adjacent to roadways or within an abandoned railway corridor

Since the focus of this effort is to evaluate methods for using BRT to maximize person capacity within limited right-of-way, the first three types of BRT investments are reviewed in the remainder of the paper since these investments can be implemented within the existing right-of-way along an existing roadway.

MIXED TRAFFIC

Person capacity has been increased in many communities by implementing BRT in mixed traffic without exclusive lanes. BRT can be operated in mixed traffic as long as the transit investment includes other mechanisms for reducing travel time and increasing reliability. This is generally accomplished through bus preferential treatments (BPT), which give buses traveling through busy intersections varying levels of priority over other vehicles.

Three basic types of BPT include transit signal priority (TSP), queue bypass lanes, and queue jump operations. TSP is a technology application that gives buses preference at signals when they arrive at an intersection. Given that bus delays at traffic signals account for 10 to 20 percent of overall bus travel times and 50 percent or more of delays, this technology has a significant effect on the level of service being provided to riders. TSP also can be conditional (e.g., applied only when the bus is late and/or full) such that not every bus gets priority at every signal. The adjustment of signal timing to expedite BRT can be implemented with minimal impacts to cross-street traffic. Queue bypass lanes allow buses to use bus-only lanes or right-turn-only lanes to "skip" queued traffic and travel through congested intersections quickly. Queue jump operations combine queue bypass lanes and TSP. Buses in the bypass lane are given a few seconds of early green on a separate bus-only signal head so the bus can progress through the intersection and merge back into the through lanes on the far side of the intersection ahead of other vehicles.

Other BRT elements are also integrated into the system, including rail-like rubber-tired vehicles, level boarding, off-board fare collection, and unique branding. The Metro Rapid system in Los Angeles is a prime example of widespread implementation of BRT in mixed traffic. The success that has been experienced to date with this system in Los Angeles is indicative of the benefits that can be achieved with even such a relatively base level of BRT implementation.

USE OF SHOULDERS

Bus use of shoulders on interstates, arterials, and bridges has been implemented by many communities along selected corridors. This approach can essentially result in an additional lane of capacity in both directions. Bus use of shoulders typically comes with restrictions and generally allows buses to bypass congestion when travel speeds are less than 35 miles per hour on the through lanes. Implementation is characterized by limited signage, little or no pavement markings, and low cost.

More than 10 applications exist in the U.S., including Minneapolis, Seattle, and Miami. By far, the Minneapolis-St. Paul area has the most significant program for bus use of shoulders. The Minnesota Department of Transportation has worked closely with Metro Transit, suburban transit providers, the Metropolitan Council, and other jurisdictions to establish Team Transit. Team Transit was formed to foster the development and implementation of transit enhancements throughout the Metro area.

One of the priority programs for Team Transit is bus-only shoulders, initiated in 1992. As of the end of calendar year 2006, approximately 400 buses operate on 14 routes and 260 lane-miles of shoulders. It is anticipated that another 12 lane-miles of shoulders will be operational by the end of 2007. Starting in 2008, the goal is to increase the number of lane-miles in the shoulder network by 8 lane miles annually. If these goals are achieved, the total lane-miles in the shoulder network will reach nearly 300 lane miles. Current restrictions include:

- Bus-only shoulders are operational at any time when the traffic in the adjacent through lanes is moving at a speed less than 35 miles per hour.
- Buses may not travel more than 15 miles per hour faster than the through lane traffic.
- The maximum speed allowed on the shoulder is 35 miles per hour.

For additional information on the bus-only shoulder network in Minneapolis-St. Paul, refer to the Twin Cities Metro Area Transit Tools web site (www.dot.state.mn.us/metro/teamtransit).

A smaller scale example of bus-only shoulders is observed near Fort Myers, Florida, where the shoulder of the Matanzas Pass Bridge is used by trolley buses to bypass significant traffic congestion that exists when traveling to Fort Myers Beach (see photo to the right). Bus-only use of the bridge shoulder is particularly effective during the peak tourist season (winter months) in Florida, when congestion reaches the highest levels of the year.

Trolley buses operated by LeeTran in Lee County, Florida, use shoulders to bypass congestion on the Matanzas Pass Bridge to Fort Myers Beach.

USE OF EXISTING MEDIANS

Divided roadways that have sufficient median space provide opportunities for integrating exclusive lanes within the existing right-of-way. The exclusive lanes may involve two-way traffic for transit vehicle flow or a reversible lane of traffic for transit vehicle flow. Recent applications in Cleveland and Eugene (Oregon) are demonstrating the effective use of existing medians to support the implementation of BRT. Safety concerns, such as left turns and passenger crossings, are being addressed as part of the system design.

Figure 2 illustrates an example mid-block cross section for a reversible, one-lane median busway. In this example, 20 feet are needed for the reversible, one-lane busway (12 feet for the bus lane and 4 feet on each side for separation from the through traffic.

SUMMARY AND CONCLUSION

In summary, this paper presents the cost/performance relationship for a range of possible transit investments, from traditional bus service to heavy rail technologies. The focus is then narrowed to consider the BRT investments that fall between the traditional bus and rail technologies. In particular, these three approaches to using BRT are presented to emphasize techniques that can maximize person capacity within limited right-of-way. These three approaches include:

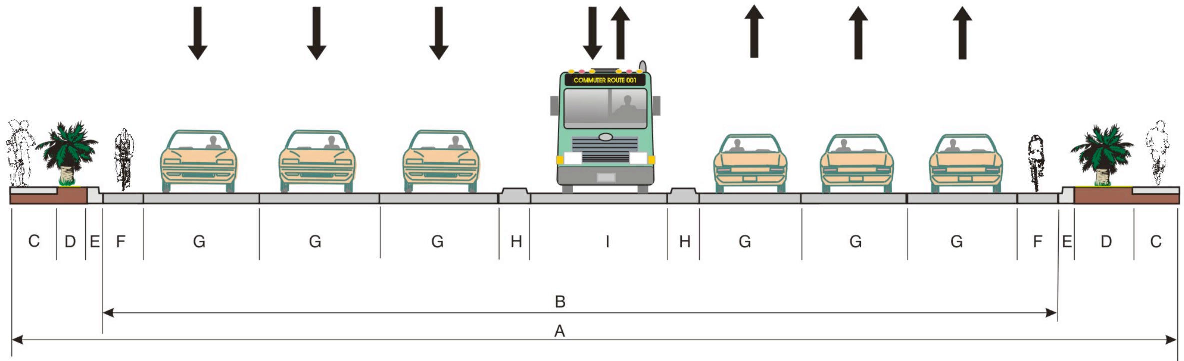
(1) **Mixed Traffic** - Through investments in bus preferential treatments and other technologies, person capacity can be increased by implementing BRT in mixed traffic without exclusive lanes.

(2) **Bus Use of Shoulders** - Bus use of shoulders on interstates, arterials, and bridges can essentially add a lane of capacity in each direction along selected corridors.

(3) **Use of Existing Medians** - Divided roadways that have sufficient median space provide opportunities for integrating exclusive lanes within the existing right-of-way, thereby increasing capacity without adding lanes adjacent to an existing roadway.

Due to right-of-way or financial limitations, many communities are struggling to increase capacity within congested and constrained corridors Opportunities can be identified to use the BRT investments discussed in this paper to maximize person capacity within limited right-of-way.

Figure 2
Reversible One-Lane Median Busway, Typical Mid-Block Section



DESIGNATION	DESCRIPTION	DIMENSION (FEET)								NOTES
		CBD/CBD FRINGE				EXISTING URBANIZED AREA				
		PREFERRED		CONSTRAINED		PREFERRED		CONSTRAINED		
		4L	6L	4L	6L	4L	6L	4L	6L	
A	RIGHT-OF-WAY WIDTH	106	130	88	110	106	130	88	110	12' border width preserved for preferred condition, constrained condition will require a design variance
B	CURB TO CURB PAVEMENT WIDTH	78	102	72	94	78	102	72	94	Curb to curb width will vary based on number of travel lanes and median width.
C	SIDEWALK	6		6		6		6		Sidewalk widths >6' may be used in heavy pedestrian environments.
D	PLANTING STRIP	4		0		6		0		Street trees are not allowed in planting strips < 6'.
E	CURB AND GUTTER	2		2		2		2		Type "F" curb and gutter
F	BIKE LANE	5		4		5		4		
G	TRAVEL LANE [2]	12		11		12		11		
H	SEPARATOR	4		4		4		4		4' Separator should be mountable to allow access and egress to the lane (pass and service disabled vehicles).
I	BRT/BUS LANE [1]	12		12		12		12		

REFERENCES

1 Page 8-20 in HOV Systems Manual, Page113 NCHRP 155 Report
2 FDOT District 4 Guideline
3 It was assumed that the location of the separator and the median/center station would alternate sides to conserve right-of-way.

REVERSIBLE ONE-LANE MEDIAN BUSWAY
TYPICAL MIDBLOCK SECTION, TWO-WAY STREET

REFERENCES

(1) Federal Transit Administration, Office of Research, Demonstration, and Innovation, *Characteristics of Bus Rapid Transit for Decision-Making* (August 2004).

(2) Transportation Research Board, Transit Cooperative Research Program Synthesis 64, *Bus Use of Shoulders: A Synthesis of Transit Practice* (2006).

(3) Twin Cities Metro Area Transit Tools web site (www.dot.state.mn.us/metro/teamtransit).

(4) Telephone discussion with Craig Lamothe, Manager of Facilities Planning for Metro Transit in Minneapolis, Minnesota.

(5) Lee County MPO, "2030 Transit Element," Chapter 6: Bus Rapid Transit Feasibility Assessment" (December 2005).

(6) Federal Transit Administration and National Bus Rapid Transit Institute, *Bus Rapid Transit: Elements, Performance, Benefits* (brochure).

(7) FDOT District IV, Office of Modal Development, "Bus Rapid Transit Functional Classification Study" (2003).