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Exclusivity and Shared Use: Examining the State of the Practice in US High Intensity Bus Service

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ABSTRACT

As a response to increasing congestion and in order to reduce travel time, transit agencies across the nation are introducing varying configurations of high intensity (express) bus service ranging from mixed with other traffic or wholly exclusive. Some of these configurations had been deemed bus rapid transit, but our review of the literature shows that express bus transit service has emerged as a self-identified service separate from bus rapid transit termed High Intensity Bus (HIB) in Moving Ahead for Progress in the 21st Century (MAP 21). The paper documents the extent of HIB systems in the US and differentiates those with mostly exclusive routes and those that are mostly in managed lanes with other vehicles. Performance thresholds are identified based on lane miles, revenue miles and passenger miles/urbanized areas population. We also examine different HIB scenarios for 4 case studies cities. The work presents a state of the practice review through which communities can consider new or expanded application of existing HIB bus service.

Keywords. High Intensity Bus, Express Bus Transit, Bus Rapid Transit, Buses in Managed Lanes

INTRODUCTION

Communities throughout the US are seeking methods to cope with congestion and attract more users to public transit. Financial constraints cause communities to consider optimizing the quality of their bus service as the most feasible solution for reducing traffic congestion. Goals such as improved bus speed and reliability increase the attractiveness to potential patrons. Goals such as faster bus speeds and improved reliability increase the attractiveness of bus service to potential patrons. Transit agencies strive to meet these goals through premium bus services operating in either mixed traffic flow, partially exclusive lanes, or fully exclusive configurations; buses could be on an arterial street, a traditional freeway, high occupancy vehicle (HOV) lane, high occupancy toll (HOT) lane, or in its own right of way. In some cities, buses may operate in a variation of HOV or HOT, labeled as managed lanes. Terminology and nomenclature vary, with some configurations referred to as *Express Bus*, or—the pinnacle in this service mode—*Bus Rapid Transit (BRT)*. In its ultimate configuration, BRT includes advanced technologies, infrastructure, and operational elements, such as traffic signal priority. Moving Ahead for Progress in the 21st Century (MAP 21) collapses the myriad of descriptions into the single category High Intensity Bus HIB).

This paper addresses the extent of HIB use in the US. The evaluation is based on specific performance characteristics developed from the literature. Initial performance variables were gathered from a previous set of case study by Levinson et al (2003), and current performance data were obtained through interviews with transit officials and published reports. The paper's purpose is to provide insight into the practices and experiences of those operating HIB services and serve as guidance for communities evaluating new or expanded express bus operation.

THREE OVERLAPPING CONCEPTS: BUS RAPID TRANSIT, EXPRESS BUS, AND HIGH INTENSITY BUS

Because of their related and sometimes overlapping objectives, it is important to differentiate the services denoted by bus rapid transit, express bus, and high intensity bus up front. All three modes are situated in between metro rail (heavy or light) and transit bus (on city streets) and are intended to increase travel speed for patrons. There are no standard definitions and each mode is flexible in practice.

Bus Rapid Transit (BRT)

In general, bus rapid transit (BRT) is a specialized bus service on dedicated lanes that is intended to emulate the speed of light metro rail systems at lower cost. Some BRT may operate short segments in mixed flow, while others may operate totally in exclusive right of way. Buses stop at stations that are often at-grade and simply designed. , Complex fare equipment is not used and therefore costs are lower than for rail.

Express Bus

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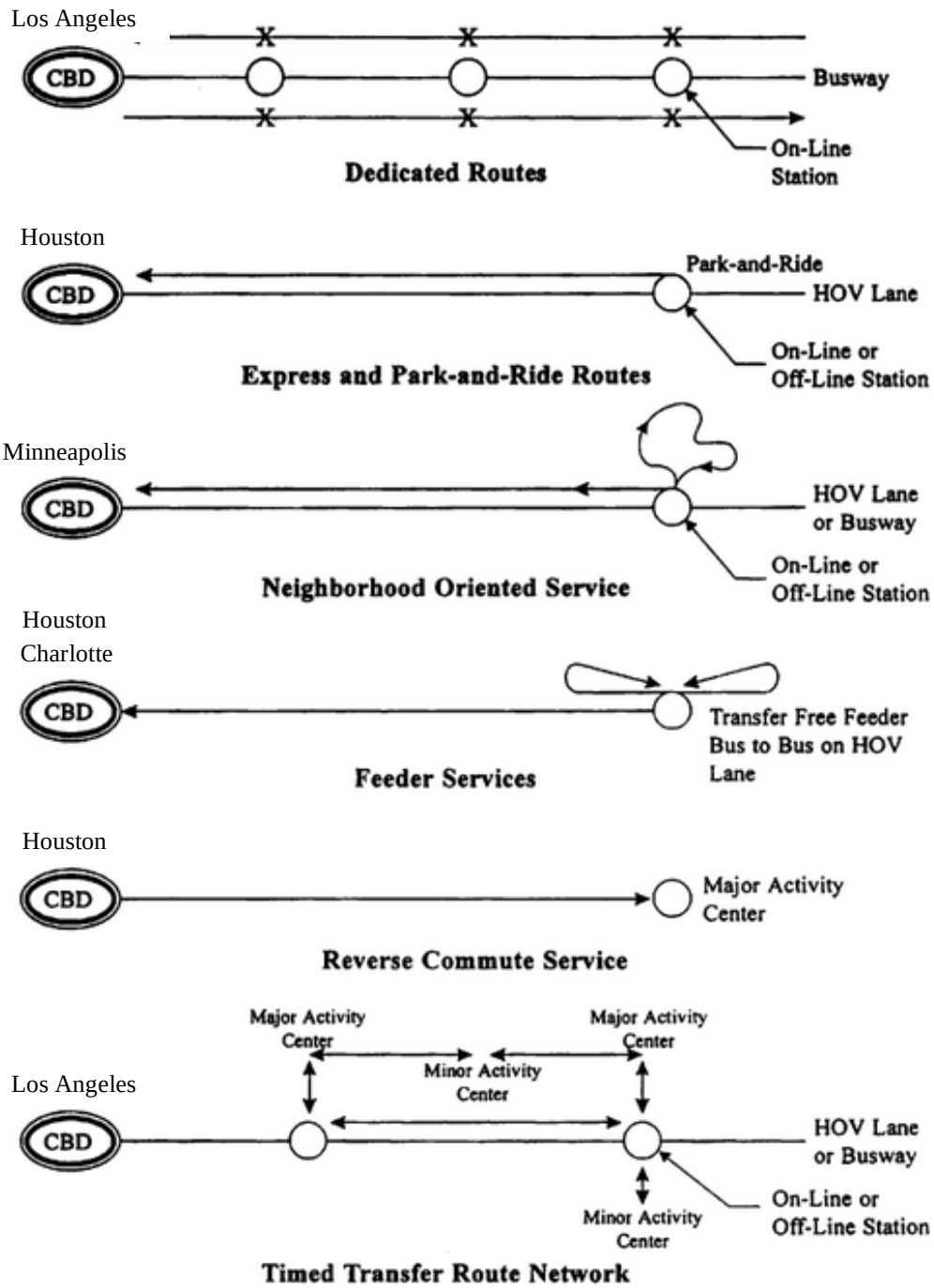
- Express bus services were generally developed to reduce the number of interim stops compared to traditional local bus, thus improving bus speeds. Express buses operate on either dedicated, managed, or shared lanes at lower cost than light rail service. Access is usually not via on-line stations, but through feeder/circulator bus or park and ride. Over the past twenty years express bus has emerged as a modal transit service in its own right. Numerous cities in the United States are providing or planning for express bus service as of 2015. Many transit agencies choose to operate bus service in mixed flow conditions because higher average speeds can be attained than operating mixed flow on local or arterial streets. Moreover, the higher speed is achieved without capital expense for the transit agency as the freeway would have been funded and maintained by county or state officials.
- Express bus systems in managed lanes are typically arranged in one of three service strategies: 1) from suburbs to central business district (CBD) focus; 2) hybrid service to both the CBD and intermediate destinations between suburbs and the CBD; and 3) multi-destination service to major points throughout the metropolitan area, including reverse commutes (1). Figure 1 expands the options available by showing exclusivity and feeder services.


Los Angeles
CBD
Busway
On-Line Station
Dedicated Routes
Houston
CBD
Park-and-Ride
HOV Lane
On-Line or Off-Line Station
Express and Park-and-Ride Routes
Minneapolis
CBD
HOV Lane or Busway
On-Line or Off-Line Station
Neighborhood Oriented Service
Houston
Charlotte
CBD
Transfer Free Feeder Bus to Bus on HOV Lane
Feeder Services
Houston
CBD
Major Activity Center
Reverse Commute Service
Major Activity Center
Major Activity Center
Minor Activity Center
Los Angeles
CBD
HOV Lane or Busway
Minor Activity Center
On-Line or Off-Line Station
Timed Transfer Route Network

These different service types result in express bus service operated as non-stop or selected periodic stop. As transit agencies design express bus systems with more attractive features in order to lure potential riders, these systems may begin to approach designs akin to BRT and have on-line stations. In general, the term "express bus" is being used to reflect a route that has at least a portion of service non-stop for several miles. Services called express may be considered "high intensity motorbus" if operating on a freeway or exclusive row.

High Intensity Motorbus

Because of the expansion of express bus in practice, the concept was formally defined in the Moving Ahead for Progress in the 21st Century Act (MAP-21) of 2012. MAP 21 created a new modal category called high intensity motorbus (HIB) which the law defined as "public transportation that is provided on a facility with access for other high-occupancy vehicles." (49 USC § 5337, page 126 STAT. 726(d)(1)). By this definition, the distinguishing characteristic of HIB is operation in a shared lane, such as a high-occupancy vehicle lane, a high-occupancy toll lane, and/or a managed lane. MAP 21 also defines fixed guideway systems as "public transportation facility using and occupying a separate right-of-way for the exclusive use of public transportation; using rail; using a fixed catenary system; for a passenger ferry system; or for a bus rapid transit system." (49 USC § 5302, page 126 STAT. 626(7)(A-E)). The important point here is that fixed guideway systems represent transit modes on exclusive lanes, such as BRT.

BUSES OPERATING IN HOV, HOT, OR MANAGED LANES

The high intensity bus services examined for this research are in a variety of roadway configurations. Those not in their own right-of-way are in HOV, HOT or Managed Lanes. A High Occupancy Vehicle (HOV) lane is any preferential lane designated for exclusive use by vehicles with two or more occupants for all or part of a day, including a designated lane on a freeway, other highway or street, or independent roadway on a separate right-of-way. A High Occupancy Vehicle facility is one that gives priority treatment to buses, vanpools, carpools and high-occupancy vehicles; including the HOV lanes, the park-and-ride lots, and other support facilities or elements. High Occupancy/Toll (HOT) lane means any HOV lane that allows vehicles not meeting minimum occupancy requirement to use the lane by paying a toll. The Federal Highway Administration defines managed lanes as "highway facilities or a set of lanes where operational strategies are proactively implemented and managed in response to changing conditions" (2). Managed lanes are distinguished by an active management perspective, whereby transportation officials apply strategies to meet performance goals for speed, congestion and density. Figure 1 presents a typical one lane reversible managed lane. The middle lane has managed lane features that is designed to flow inbound during peak commuting hours and outbound during suburban commuting hours as illustrated in Figure 1 below.

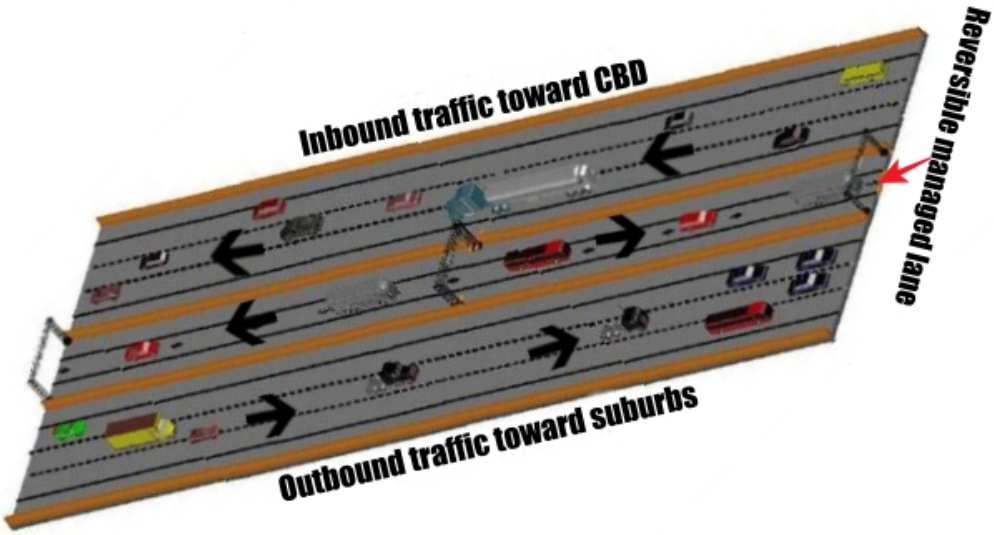


Figure 1: Typical One Lane Reversible Managed Lane

The average speed of traffic flow on freeway HOV/HOT managed lanes as a function of vehicle density (i.e., demand) is best estimated using the conventional Drake equation (3).

$$u = 58.2e^{(-k^2/5000)}$$

where: k = density
u = speed

Ardekani et al (3) used field data from a freeway site in Dallas, TX to calibrate this equation to an R^2 of 0.96. Traffic flow models like this are important for actively managing and predicting traffic density on shared and managed lanes to ensure that express bus service is able to maintain a minimum speed. Armed with this knowledge, transit operators can change toll amounts (i.e., congestion pricing) or otherwise reduce managed lane demand in order to maintain a minimum average speed.

The experiences of US transit agencies operating express buses in the HOV/ HOT or managed lane configuration cover a number of years, scenarios and operating characteristics. A summary of the literature provides a foundation to describe the services, review their operating parameters and compare outcomes.

LITERATURE REVIEW

In 2003 a major research project was published on bus rapid transit (4). The authors analyzed 27 BRT case studies from around the world: 14 from the US, Canada, and Europe and 13 from industrializing and developing countries. The Federal Transit Administration's (FTA) defines BRT as a "rapid mode of transportation that can combine the quality of rail transit and the flexibility of buses." Levinson, et al (5, 4) developed a more detailed definition of BRT as a "flexible, rubber tired rapid transit mode that combined stations, vehicles, services, running ways, and intelligent transportation system (ITS) elements into an integrated system with a strong positive image and identity." Levinson, et al further elaborated that BRT systems have a more positive image than regular buses, can be constructed incrementally as resources allow, and can be designed to fit appropriately in different environments and different markets.

Such a broad conceptualization allows a number of different service arrangements to be included under the BRT umbrella. Buses operating on exclusive or protected rights-of-way with premium quality vehicles, stations, and other amenities can be considered BRT (6). Buses operating on a mix of exclusive rights-of-way, reserved medians, bus-only lanes, and streets can be considered BRT. And buses operating mainly on city streets in mixed traffic may also be considered BRT (4). A great deal of practical and conceptual overlap exists between BRT, light rail, and express bus; with some viewing each as a distinct transit mode (7) and others viewing either BRT as a subset of express bus (8) or express bus as a subset of BRT (1; 9, 4). According to Hess et al (7), "BRT has quickly come to mean many things to many people" and is "an increasingly slippery concept."

One indication of this conceptual overlap is the recent bifurcation of BRT into two different service tiers based on the type of runningway. Wong and Fisher (10) defined BRT type 1 as operating on mixed flow and peak period lanes, and BRT type 2 as operating on dedicated

bus lanes and transitways. The Santa Clara Valley Transit Authority (VTA) found it useful to divide BRT this way in developing its Service Design Guidelines (without calling it express bus). In this case, express bus is viewed as a type of BRT (the BRT type 1 system)—also known as modified BRT— rather than a stand alone service mode. VTA categorized BRT into two service tiers on the basis of meaningful differences in capital cost and infrastructure investment.

According to Wong and Fisher both express bus and BRT require all-day frequent service, limited stops, signal priority, simplified routing, specialized vehicles, and branding Express bus is comparatively less expensive to build and operate than BRT, can be more flexible to install, and theoretically can fit a broader range of service models such as the hybrid and multi-destination strategies. Express bus systems typically operate in mixed flow lanes and peak period lanes while conventional BRT systems operate in dedicated lanes and transitways. Compared to express bus systems, BRT systems tend to be higher quality and higher speed, with rail-like stations instead of stops, and off vehicle fare payment. BRT also carries a higher volume of passengers than express bus (per hour, per station, and per mile). When express bus is viewed as a subset or type of BRT, certain features differentiate it from a conventional BRT system. These features are summarized in Table 1 and provide an example of features that are often tied to the express bus concept. However, it should be noted that these features and this framework are not consistent across the literature.

Table 1. Example of Express Bus Features Compared to Conventional BRT Features

Features	Express Bus Service, Narrowly Defined
Types of Stops/Stations	More robust than local bus, but not as elaborate as BRT.
Types of Payment	On-vehicle fare payment only.
Types of Lanes	Mixed flow, peak period, HOV, HOT, and dedicated lanes.
Average Trip Speed	Slower than BRT by all measures.
Average No. of Passengers	Fewer passengers than BRT by all measures.
Overall Investment/Cost	Less expensive than BRT by all measures.

Sources: Wong and Fisher (10); Levinson et al (4); Deakin et al (8).

Some metropolitan transit agencies have adopted a broader definition that places BRT under an express bus umbrella. Transit agencies in the San Francisco Bay Area, for example, define express bus as “any limited-stop bus service that moves people quickly between Bay Area cities and communities” (8). In this context the definition of express bus includes buses on freeways, conventional BRT service, limited-stop buses on arterials, and cross-town limited-stop buses on local streets. The remainder of this paper will describe the use of express buses in managed lanes, now termed HIB, and will evaluate the performance of these systems in selected case study cities.

DATA AND METHODOLOGY

Several sources of data were used in this study. Early data on the express bus systems in eight cities was pulled from the Levinson, et al (4) report. Additional data on the selected systems was acquired from the Federal Transit Administration, the Bureau of Transportation Statistics, National Transit Database, and the individual transit agencies of the selected cities. NTD records enabled a compilation of the miles of managed and exclusive lanes of express (high intensity) bus use for more than 15 years.

Updated information on express bus systems in select case study cities was obtained through phone interviews with transit officials from each city. First we identified eight cities representing each of the managed lane transit options presented in Figure 1. We reached out to these cities and achieved a 50 percent response rate. Our case study cities are Los Angeles, Houston, Minneapolis, and Charlotte. Los Angeles has express bus service with sections of on-line access. Their buses operate on-exclusive sections and some mixed with other traffic. Also, their express buses reflect the reverse commute service scenario in the figure, as the system is two-way (*dedicated routes and reverse commute scenarios* in Figure XX). Houston buses operate most like the *express buses via the park and ride routes* scenario in Figure 1. There is also an option to transfer to Uptown Galleria buses offered on some trips per the *timed transfer route network*. Minneapolis and Charlotte both operate neighborhood feeder services that directly access the peak direction to the CBD (*neighborhood oriented service* per Figure 1).

Our data analysis proceeded in two steps: descriptive analysis and performance analysis. First, each express bus system was described and the parameters of each system were determined by visually inspecting transit maps and by reviewing the interviews and databases for each city. Next, the parameters of interest included passenger miles, vehicle miles, operating expenses, and other performance metrics were displayed and analyzed.

GROWTH OF EXCLUSIVE AND MANAGED LANES

Review of historical records from the NTD yielded 16 years of data on exclusive and controlled transit lane miles for use by motorbus (MB) and commuter bus (CB) transit modes (11). Exclusive transit lanes (or rights-of-way) are not open to general traffic at any time. The tables referred to transit lanes (or rights-of-way) that are sometimes restricted and sometimes open to general traffic as *Controlled*. This definition matches the term *Managed Lanes* for this paper. Trends in total lane miles for each lane type are displayed graphically in Figure 2. The trends are based on national totals as well as totals for the top six high intensity bus systems, measured as the highest number of HIB vehicle revenue miles as a percentage of each system's total vehicle revenue miles for buses (MB, CB), as reported by the agency. It must be noted that some HIB systems are using exclusive lanes as well as controlled, or managed, lanes.

The national trend lines show sharp increases in both exclusive and managed lanes over the past 16 years. Lane miles were approximately equivalent for the two in the first year that records were available (1997), and have approximately quadrupled in that time period. In 2012, national exclusive and national managed lane miles converged at just over 2,000 miles each. These trends reveal continuously increasing use of both lane types. Trends for the six selected HIB systems reveal that in 1997 exclusive lanes in these six systems accounted for nearly half of the nation's exclusive lane miles. These systems also started out with relatively few managed lane miles. Managed lane miles grew faster than exclusive lane miles in the six selected

systems; however, the two lane types converged in 2008 at about 500 miles each. Unlike national trends, managed lane miles have not at any time surpassed exclusive lane miles for the top six systems. Trends overall, as of 2012, show continued increases in exclusive lane miles for both national and top six systems, and downward trends for managed lanes.

Note: Years 1997 to 2001 are in direction route miles; years 2002-2012 are in lane miles.

Figure 2. Growth of Exclusive and Managed Lanes in the US.

ANALYSIS AND RESULTS

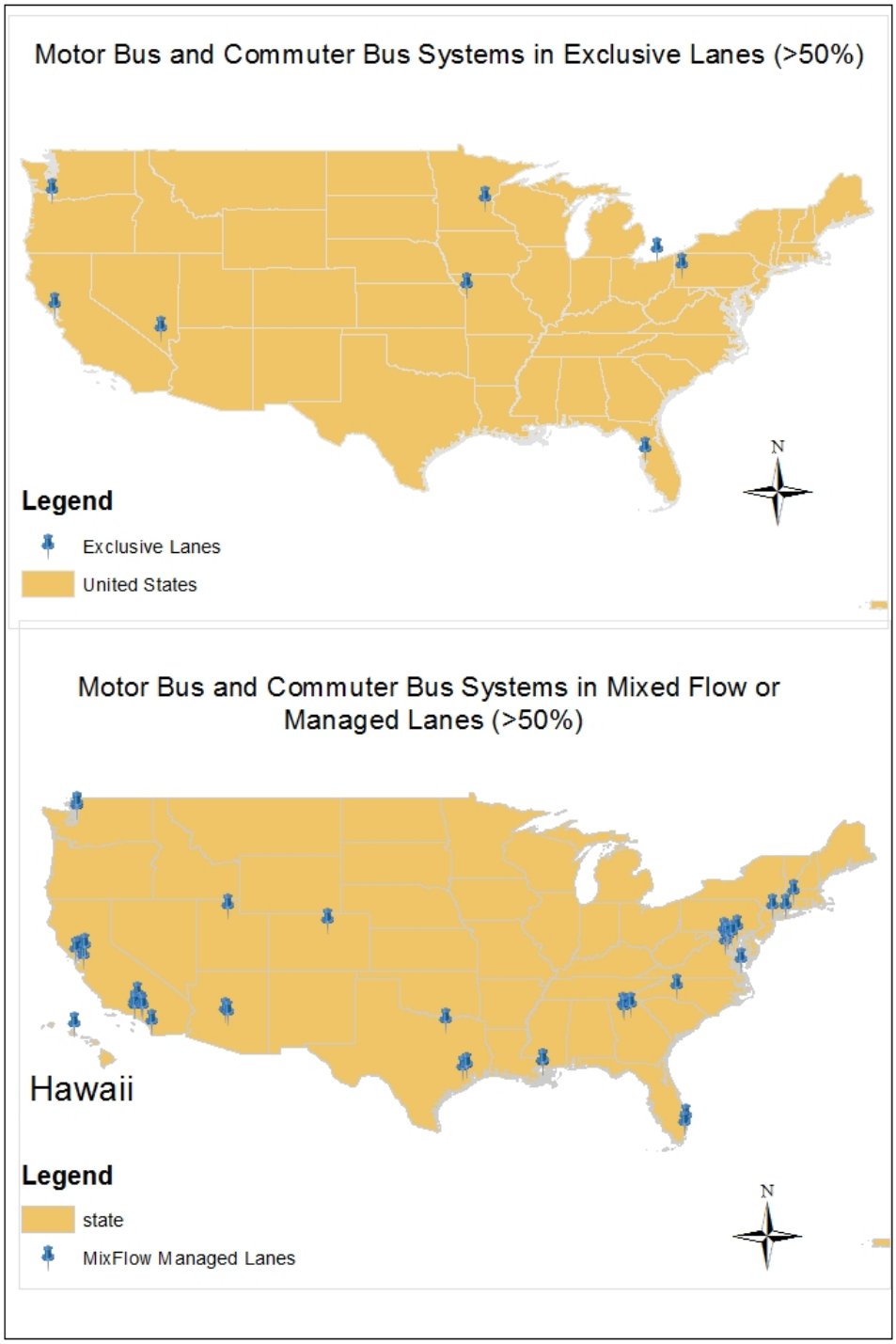
As local and state transportation departments construct more managed and toll facilities, these facilities provide an opportunity to operate bus service at higher speeds, avoid congestion and increase reliability. For the past several decades the manner in which buses operated with mixed flow varied across agencies with inconsistencies in service characteristics and terminology. Express bus, high intensity bus, bus rapid transit, busway, transitway – all could refer to buses operating exclusively or in mixed traffic; operations could have elements of non-stop or periodic infrequent stops. The physical facility might be an arterial, a freeway or other fixed guideway. Despite the varied descriptions, operating characteristics and scenarios, application of this category of service increased substantially as shown in Figure 2. As previously noted, MAP 21 established the reporting category *High Intensity Motor Bus (HIB)* for public transportation operating on managed lanes with personal passenger vehicles either high occupancy or tolled. To deal with the wide array of variance, this paper assembles existing data and forms a foundation against which growth and performance can be assessed.

As of 2013, the most recent year for which data were available, 21 U.S. cities exhibited above average performance in their high intensity bus systems while also achieving above average performance in their transit systems overall. System data were obtained from the National Transit Database (11). High intensity bus performance was measured as the combination of coverage (i.e., directional route miles) and service (i.e., unadjusted vehicle revenue miles). Citywide transit performance was measured as the combination of transit

ridership (i.e., passenger miles divided by service population) and service productivity (i.e., passenger miles divided by vehicle revenue miles). Performance measures were obtained from the Department of Transportation and the Federal Highway Administration (12).

A review of systems reported in NTD Table 24, 2013 shows many transit agencies with route miles consistent with the HIB definition. There are 55 systems geographically dispersed across the US indicating broad use of this strategy. They range from the shortest in Tampa, FL at 1.1 miles to the most extensive in Seattle, WA at nearly 214 miles in managed lanes. For this research, interest centered on the systems where greater than 50% of the lane miles are operated with buses in mixed traffic flow. Of the indicated systems, 46 operate more than 50% of their lane miles in mixed flow conditions (bottom of Figure 3). Some communities operate more than one system, so individual push pins may be difficult to see. The top of Figure 3 shows systems with greater than 50% of the lane miles exclusive. To assess performance of these systems, a mean value was calculated for route miles, revenue miles, citywide ridership/urbanized area population; 21 of the systems have above average HIB route miles, revenue miles and ridership/urbanized area. Data from the cities show them as above average on all measures. These top performing express bus cities are as follows: New York, Los Angeles, Miami, Dallas, Houston, Washington DC, Atlanta, Phoenix, San Francisco, Seattle, San Diego, Minneapolis, Denver, Pittsburgh, San Jose, Virginia Beach, Charlotte, Harford, Urban Honolulu, Lancaster-Palmdale (northern California) and Antioch (Bay Area, California).

Given the findings above and the limited data that are available, one can identify a handful of cases in which high performing HIB systems are currently in high performing cities. The following systems are identified for a more in-depth assessment: Houston/Harris County, Minneapolis, Los Angeles, and Charlotte. These cities represent a span of operational experience and system type and provide a solid spectrum to consider state of the practice. For the case study cities, the study team interviewed transit officials about how they defined high intensity bus, what performance measures they used, and the benefits of the service. Note that transit officials in two of the cities used the term “express bus” instead of “high intensity bus,” which has not yet become commonly used in the industry. Transit officials provided summary metrics of their high intensity bus systems.



*NOTE: Multiple transit systems operate in some cities. In these instances, one symbol may represent more than one system.

Figure 3: Systems Fitting HIB Definition with more than 50% of the Lane Miles Exclusively for Bus (top) Systems Fitting HIB Definition with more than 50% of the Lane Miles Managed (bottom)

CASE STUDIES

Four case study cities are identified from the list of 21 that show above average performance in their high intensity bus systems while also achieving above average performance in their transit systems overall. Los Angeles is a a case with both exclusive and managed lane components in its system and is one of the largest US cities. Houston is one of the first cities to identify high intensity bus as its primary mode of suburban to urban travel, only adding light rail to its transit system in 2004. Access is primarily via park and ride. Minneapolis offers a contrast to Houston as most of their routes operate in a local of skip-stop bus configuration and then access managed lanes. Charlotte shows the contribution of a limited length high intensity bus system applied principally to by-pass a congested segment.

Los Angeles

The Service Planning Director from Los Angeles Metropolitan Authority (LA Metro) defined their high intensity bus service as follows:

> "Express Bus service in our system is any service where a major portion of service goes onto the freeway. In most cases, passengers are charged an additional fare for the freeway portion of the trip. The Silver Line is our primary express lane bus service. It is designated as one of two Metro Liner Bus lines."(13)

The LA Metro system serves an urban population of 9,324,741. For high intensity bus, total system route miles are 252.1, annual passenger miles are 7,767,779, and annual vehicle miles are 411,094. The annual operating cost of their high intensity bus system is $2,897,017 ($2012).

Passengers access high intensity bus on managed lanes via several options: parking lots, on-line stations, and on-street access. Los Angeles Metro uses the Route Performance Index (RPI) to measure the performance of the high intensity bus route. The RPI is a composite line performance index comprising average weekday boardings, average subsidy per boarding, average boardings per mile, and average passenger miles per seat mile.

There are two key advantages of LA Metro's high intensity bus service. It is usually faster than adjacent mixed flow lanes, and some of the toll revenue can be used to operate additional service on the Silver Line. However, travel speeds were higher when only carpools were allowed in the managed lanes. Because of the popularity of high intensity bus in managed lanes, vehicle speeds have frequently dropped below the 45 mile-per-hour floor set by policy, consequently slowing down the buses. The agency recently completed a one-year Express Lanes Demonstration Program to examine the impact of using express lanes, raising toll rates, and raising HOV occupancy rates (14). Preliminary results showed that implementing these options resulted in reduced travel times and travel speeds, increased use of express lanes, and increased ridership.

Houston/Harris County Metropolitan Transit Authority

The Harris County METRO system services an urban population of 4,944, 332. METRO began high intensity express bus service in 1979 with a contra-flow lane on the IH-45 North Freeway, then termed a transitway. Thereafter, METRO added transitways on US 290 Northwest Freeway, IH-10 Katy Freeway and US 59 Southwest Freeway. All operations initially were one-lane inbound during the morning peak and outbound during the afternoon peak. The morning bus service begins at the lot and discharges passengers in the downtown with the reverse trip for the evening peak. Between 3 and 5 park and ride lots per corridor provide primary access for bus riders. There are a few routes METRO calls Express that travel in a local condition and then access the HOV. Several corridors are serviced by mid-day park and ride buses to the lot and others have regular local routes that service the lots during mid-day. Initially all facilities were in Texas Department of Transportation (TxDOT) right-of-way, but were paid for and operated by METRO. As HOV became an accepted transportation term, METRO began calling its facilities HOV.

In April 2009, a change occurred as the Katy HOV transitioned to the Katy Managed Lanes constructed by TxDOT and operated by the Harris County Toll Road Authority (HCTRA). The concept merged the HOV with the option to add tolled single occupant vehicles. The Katy Managed Lanes include two lanes in each direction between State Highway 6 and Interstate Highway 610 West. There are four park and ride routes that operate in the Katy Managed Lanes – Grand Parkway, Kingsland, Addicks and the mid-day route that services Addicks and Kingsland. Annual ridership for the 4 park and ride routes that utilize the Katy Managed Lanes is about 1.6 million with annual operating costs estimated at $18 million ($2012). The fare is distanced base which results in 47% of the operating costs covered by fares.

Minneapolis

The Minneapolis Metro and Minneapolis Council systems serve an urban population of 2,650,890. Metro Transit created a public transit system that touts a frequent network system, shoulder bus-only lanes, express bus service, and HOV/HOT lane. This cadre of services is viewed as a benefit to using public transit, a way to ensure priority to carpoolers and buses, a means of controlling congestion, and an opportunity to utilize excess freeway capacity in the Twin City region. Currently, Metro Transit reports over 300 miles of bus-only shoulder, thus making it one of the largest exclusive HOV/HOT systems examined in this study. Shoulder bus-only lanes are reserved for routes that operate more than six buses daily, experience at least a 35 minute traffic delay for the bus once weekly, and report a minimum savings of eight minutes per mile in travel time from using the shoulder.

To better serve the Minneapolis area, Minnesota Department of Transportation (MnDOT) opened 11 miles of HOV/HOT lanes along I-394 in 2005 and 16 miles of HOV/HOT lanes along I-35W in 2009. Buses and cars gain access to these managed lanes using diamond lane non-barrier entrances. Dynamic pricing determines toll costs for single occupancy vehicles during peak hours, while carpoolers and buses do not pay. Over 35 transit routes utilize I-394, while another 11 routes use the I-35W. About 80% of the routes operate locally before accessing the HOV/HOT lanes to travel downtown. Per route cost can vary greatly, however, assessment of several sampled routes that utilize the HOV/HOT system shows average annual ridership per route of more than 75,000 at a cost of roughly $430,000 ($2012).

Charlotte

The Charlotte Area Transit System (CATS) system serves an urban population of 1,249,442. Annual vehicle miles for the high intensity bus system are 284,674 as of 2012. The CATS Transit Operations Manager explained that their high intensity bus system was designed only to bypass congestion:

> "Our busway is located in the center of U.S. 74. These lanes are separated from the general purpose lanes by a retaining wall. There is one entrance to the busway and one exit (in each direction). There are no stations or other passenger amenities along the busway. It is simply a travel lane (in each direction) that permits the bus to bypass congestion."(15)

CATS measures the performance of its six express routes just like its non-express routes: by passengers per hour (PPH) and cost per passenger (CPP). Five of these express routes operate on busways. Express routes in other corridors that do not operate on busways are also in the express category. CATS tracks each of its five busway express routes to compare PPH and CPP against the system in general and against other routes in the express category. All express routes, regardless of whether they use a busway, are handled in this way. The sixth route is a Regional Express that operates in mixed traffic and is evaluated based on the same metrics.

The advantage of the CATS high intensity bus system is that the express routes on busways gain an edge on traffic. A shortcoming is that the current system is too short and there are no stations along the busway for people to park and ride. Transit operations management wants the busway to be extended and improved into a full bus rapid transit (BRT) system.

DISCUSSION

Transit planners and operations professional seek to provide efficient service to their passenger base within the financial capacity available to them. Several elements are known to attract patrons, including the speed at which the vehicle ferries the individual to the destination. The patron also wants reliability, that is to reasonably count on that travel time each time the vehicle is boarded. One way to increase the reliability and the speed is to operate the vehicle in a right of way that is relatively unimpeded. For some agencies that leads to exclusivity, but to a high number others it means shared use with high occupancy or tolled vehicles. Map 21 suggests that this category of service is High Intensity Bus (HIB). The definition offers the opportunity to mesh a variety of terms and facilitate communication and comparison of this service type across agencies. HIB may operate in a variety of ways. Some systems may allow patron access only by park and ride. Others may have stations, similar to rail. Still others may circulate in communities, then travel non-stop to the destination via the managed lane. Cost, efficiency and ridership information experienced by varying agencies reported to and by NTD would facilitate decision-making about new or expanding service. Currently, cost, ridership and efficiency measures lump all bus together. Therefore, the strengths or areas for potential modification of HIB cannot be distinctly viewed.

Our examination of the growth in HIB shows definite upward trend. Because funding for fixed guideway is limited and extremely competitive, it is likely this trend will continue. This is especially the case if improved transit service can occur with the capital cost accruing to another agency, as was the case for Houston's Katy Freeway Managed Lanes. The review of the NTD reported HIB systems showed 46 of 55 with more than 50% of their system in mixed flow operation. Only nine have more than 50% of system length in exclusive service.

The case studies show that any number of scenarios can be successful for HIB service. HIB works well for a range of city sizes and whether lane miles are short or extensive. Planners can consider routes where patrons drive their vehicle – park and ride or patrons can board at an on-line station. It is also reasonable to provide circulator buses to the HIB access point or design the bus to act as a circulator collecting passengers, then accessing the HIB facility. This work shows positive experiences of many HIB systems and provides information for communities considering new or expanded HIB facilities.

CONCLUSION

While the concepts and jargon of high intensity bus can be debated across the transportation industry, its functionality and benefits can be seen throughout transit agencies. Transit agencies are design to give patrons access to faster and reliable transit option; HIB, its facets, and managed lanes make these goals achievable. The insight provided in this paper was meant for transit authorities to see comparable practices and evaluate, in some instance re-evaluate, emerging and existing express bus operations across the U.S.

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