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Operation of a Movable Barrier Contraflow HOV Lane on I-30 in Dallas

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Abstract

The East R.L. Thornton Freeway (I-30) Contraflow HOV lane is a demonstration project of the HOV lane concept in the Dallas area. It is a joint project between the Dallas Area Rapid Transit and the Texas Department of Transportation. Ground was broken for the new HOV lane in December 1990 and ten months later the first contraflow HOV facility in the world to use the movable barrier technology was officially opened. Twice per workday 13.8 km (8.5 miles) of barrier weighing over 9 million kilograms (20 million pounds) is laterally transferred up to 6.7 meters (22 feet) to create an additional lane for commuters into and out of Dallas.

The contraflow HOV lane is operated on the inside freeway lane of the off-peak direction during the morning and evening peak periods. The movable barrier system, comprised of two barrier transfer machines and two continuous walls of concrete barriers, provides greater safety by physically separating HOV traffic from the opposing traffic in the general-purpose lanes. While contraflow lanes have traditionally been restricted to buses and, in some cases, authorized vanpools, this new technology permits carpools to safely use the lane as well.

This paper discusses operational issues associated with using the movable barrier system for a contraflow HOV lane as well as an analysis of operational data from the first three years of usage.

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Introduction

In response to congestion and maximizing highway travel capacity in the Dallas area, emphasis has been placed on short-term transit projects that would enhance public transportation and overall mobility until permanent treatments can be implemented. Included in these short-term or interim projects are high-occupancy vehicle (HOV) lanes. The Texas Department of Transportation (TxDOT) and Dallas Area Rapid Transit (DART) identified four freeway corridors in the Dallas area to be evaluated for determining the feasibility of implementing interim HOV lane projects.

The Texas Transportation Institute (TTI) researched the feasibility of HOV lane alternatives in the four corridors. The recommended projects include two contraflow HOV lanes using the movable barrier system and two concurrent flow HOV lanes. The I-30 contraflow HOV lane has been operating for over three years while the HOV lanes in the remaining three corridors are to be constructed and operational by 1997. The I-30 contraflow HOV lane is a demonstration project of the HOV concept in the Dallas area as well as a demonstration of the movable barrier system as an approach for use in an HOV application.

Description of the I-30 Corridor

I-30, which opened in 1966, is an eight-lane radial freeway located on the east side of Dallas that primarily serves commuters destined for the central business district (CBD) or employment centers to the north of the CBD. The presence of significant volumes of commuting traffic results in a high directional split during the peak periods. Commuters were experiencing recurring congestion and average speeds were falling below 50 kph (30 mph) for extended periods of time in the morning and evening commute. Approximately 65 to 70 percent of peak hour traffic is travelling in the peak direction. This allows for a lane to be "taken away" from the off-peak direction during the peak periods and utilized as a contraflow lane while still providing sufficient capacity in the off-peak direction.

Alternative Selection

While TxDOT has long-range plans to build additional mixed-flow capacity in the I-30 corridor, TxDOT and DART were interested in short-term improvements that would increase the capacity of the freeway for buses and carpoolers. The possible alternatives for the HOV facility were identified as 1) an exclusive HOV facility in the median, 2) a concurrent flow HOV facility on the inside shoulder, or 3) a contraflow HOV facility using a lane in the off-peak direction. The intent of the intermediate facility was to provide a cost-effective improvement that could be operating in less than two years.
There are geometric design features in the I-30 corridor that present constraints in designing short-term improvements. At two locations (the Fair Park Bridge and the White Rock Creek Bridge) there exists an elevated freeway section, each more than three-quarters kilometer (one-half mile) in length, where the eastbound and westbound mainlanes are on two separate structures at different elevations. An at-grade interim HOV facility in the median would require the construction of an elevated structure over the bridge sections. The length of time required to design and construct these structures as well as the additional cost eliminated the option of an exclusive HOV lane in the median.

The option of a concurrent flow HOV lane was not feasible due to the lack of a continuous inside shoulder. The two elevated sections previously mentioned essentially have no inside shoulder. A three-meter (ten-foot) inside shoulder exists for the remainder of the freeway corridor, but long sections of the shoulder have significant cross slopes that would require extensive retaining walls. Even with considerable reconstruction and narrowing of the general-purpose lanes, a desirable buffer zone between the HOV lane and the congested general-purpose lanes could not be accommodated throughout the project. A narrow buffer zone does not allow for a vehicle to pass a disabled vehicle and hinders the ability to enforce the occupancy requirement.

A contraflow HOV lane was the preferred alternative because it required no additional construction over the bridge structures and only minimal construction at the access and egress points. The controlled access points aid in enforcement by limiting the number of locations vehicles can enter the lane and use of the inside lane of the off-peak direction also allows the contraflow lane to have a shoulder for incidents and enforcement.

Movable Barrier System

The movable barrier system consists of concrete movable barriers and two barrier transfer machines. This system allows for buses and vanpools as well as 2-or-more person carpools to use the HOV lane because the barrier physically separates the HOV lane traffic from the opposing traffic flow.

The movable barrier system being used on I-30 is the Quickchange® Movable Concrete Barrier System developed by Barrier Systems, Inc. of Carson City, Nevada. The concept was originated by Quick-Steel Engineering Pty., Ltd., of Botany, New South Wales, Australia as an eight-inch movable lane line. Barrier Systems Inc. is the North American licensee for the system. The system is a technology that provides the unique opportunity to change roadway capacity in a relatively short period of time.
Movable Concrete Barrier

The movable barrier consists of a series of safety-shaped concrete barriers connected together with heavy steel pins to form a continuous wall. The cross section of each barrier is similar to that of a Jersey-type barrier, but with a "T" shaped top which allows them to be lifted by the barrier transfer machine as shown in Figure 1. Each one-meter (3.3-foot) long barrier is 80 cm (32 inches) high, 60 cm (24 inches) wide at the base and weighs approximately 700 kg (1,500 lbs.). The continuous sections of movable barrier can be transferred laterally across a lane or lanes of traffic by the barrier transfer machine.

The movable barrier was crash tested in a federally-funded research project initiated by the California Department of Transportation (Glauz, 1990). The results showed that the barrier can successfully redirect both light and heavy passenger cars at various angles of impact. The barrier is strong enough to fully contain a 2,040 kg (4,500 lb.) vehicle, striking at 90 kph (60 mph) and 25 degrees with no structural failure and little debris generation. Additionally, a barrier deflected as much as 0.7 meters (2.24 feet) can be straightened by the transfer machine or can be pushed back into place with a pry bar by one person.

Barrier Transfer Machine

A specially designed conveyor system on the self propelled barrier transfer machine is used to shift the barrier laterally across the roadway. The diesel powered barrier transfer machine is fitted with an elongated S-shaped conveyor roller assembly mounted to the underside. Closely spaced urethane conveyor wheels fixed under the barrier transfer machine roll under the flanges of the "T" shaped cap of the movable barriers. The wheels lift the sections off the pavement, guide them along the S-shaped conveyor to the desired position, and lower the sections back down to the pavement. As the barrier transfer machine moves forward at a speed of up to 8 kph (5 mph), the barrier is transferred from the median to the lane stripe between the first and second lanes, minimizing the exposure of the barrier transfer machine to traffic as shown in Figure 2.
The Movabale Concrete Barrier System

- Direction of barrier travel
- Transfer vehicle travel
- Shoulder

Figure 2. The Movabale Concrete Barrier System
The barrier transfer machine has been designed to meet certain geometric constraints of the barrier-separated lane. Because there is a variable inside shoulder width along I-30, the transfer machine is required to move the barrier laterally from 4.6 meters (15 feet) to 6.7 meters (22 feet). The transfer machine is designed to "crab" in order to adjust the distance of the lateral transfer of the barrier. Independently steered wheels allows for the transfer machine to rotate about its vertical axis and increase or decrease the lateral transfer distance. Also, the inside shoulder has a different cross slope from the freeway mainlanes and a 10 cm (4 inch) curb in some sections. The transfer machine has, therefore, been designed to allow each wheel to independently be raised and lowered which allows for variable vertical lifts of up to 50 cm (20 inches).

Accurate positioning of the barrier is aided by a guide wire embedded in the pavement. The barrier transfer machine is equipped with sensors that reads a signal coming from the guide wire and places the barrier within a one-inch tolerance.

The two transfer machines are stored in separate storage buildings constructed specifically for this project in the median of I-30. Two areas with wide medians (near the CBD and Dolphin Road) provided the opportunity to construct these facilities. Storage facilities in the median eliminate the need for the transfer machine to disrupt freeway operations by crossing four lanes of traffic prior to and after opening and closing the HOV lane.

Overview of the Project

The design of the I-30 contraflow HOV lane allows for buses, vanpools, 2-or-more person carpools, and motorcycles to bypass congestion through the use of the barrier-separated lane. The limits of the HOV lanes are from Jim Miller Road to the Dallas CBD (8.4 km/5.2 miles) during the morning peak period and from the CBD to Dolphin Road (5.3 km/3.3 miles) in the evening peak period as shown in Figure 3. The hours of operation are from 6:00 AM to 9:00 AM in the westbound direction and from 4:00 PM to 7:00 PM in the eastbound direction.

The contraflow lane utilizes the inside freeway lane of the off-peak direction of flow. There is a movable barrier on either side of the permanent median barrier. In the morning, the movable barrier on the south side of the median is moved into position by the downtown barrier transfer machine which moves west out to Jim Miller Road, reducing the off-peak direction (eastbound) to three general purpose lanes. The inside lane and shoulder are separated from opposing traffic for commuters destined for downtown and beyond. After morning operation of the contraflow lane, the barrier is moved back to the median. In the evening, the process is reversed using a second transfer machine stored at Dolphin Road to create a barrier separated contraflow lane on the westbound general purpose lanes for eastbound commuters leaving the CBD.
Access and Egress

Access and egress to the contraflow lane is provided with median "crossovers". The crossovers consist of a short section of concurrent flow lane and a break in the median barrier. The access and egress locations are shown in Figure 3. When the contraflow lane is not in operation, all access points are closed by either gates, pylons, movable barriers, or a combination of these treatments. During hours of operation, appropriate access points are opened and eligible users are provided guidance by a combination of fixed signing, changeable message signs, and pavement markings.

Traffic Control

The traffic control system used in the I-30 corridor consists of personal computers in the field, changeable message signs, and dynamic signs. These are supplemented by lane control pylons, barrier gates, and the movable barrier system. The computers are used to operate the changeable message signs and the dynamic signs via dial-up telephone lines through a master computer located at the DART facility. The signs can be operated from three stationary locations (a master controller at the DART facility and the two transfer machine storage facilities), a mobile location consisting of a portable computer and a cellular phone, or manually at each sign.

Four changeable message signs and thirteen dynamic signs are located throughout the project to convey to motorists the status of the contraflow lane and freeway lanes (i.e. open, closed, etc.). The dynamic signs consist of a regulatory sign with yellow beacons mounted on top that flash when the message on the sign is in effect.

Enforcement

Enforcement is critical to the successful operation of an HOV facility. The contraflow lane is the first HOV project in the Dallas area and, therefore, access locations have been designed to give ample distance to divert violators (whether deliberate or accidental) out of the contraflow lane and back into the general purpose lanes. The limited access, barrier-separated design of the contraflow lane allows enforcement officers to monitor vehicles entering the lane at the median crossover access points. This has resulted in violation rates less than one percent of the total vehicles utilizing the HOV lane of the 2-or-more persons per carpool occupancy requirement.

Implementation Cost

The contraflow lane project was jointly funded by DART and TxDOT. Total implementation cost was $12.2 million with operation and enforcement costs at $600,000 per year.
Measures of HOV Lane Effectiveness

While the goal of an HOV facility is to increase the person movement capacity of the freeway and to provide trip reliability for the HOV lane users, other factors such as improved air quality and reduced fuel consumption may also result. These other factors, however, cannot easily be measured by field observations.

TTI collects data on the HOV lane and the adjacent mainlane on a quarterly basis (four times per year). The data collected includes person and vehicle volumes and travel times. A comparison of this actual data collected is presented below. The principal evaluation approaches are "before" HOV lane and "after" HOV lane comparisons as well as HOV lane versus adjacent general purpose lane comparisons.

Table 1 shows the current breakdown of the type of vehicles utilizing the HOV lane. While approximately 95 percent of vehicles utilizing the HOV lane are carpools, 35 percent of the person volumes are DART bus patrons during the AM and PM peak hour. The I-30 HOV lane moves more persons than two of the adjacent general purpose lanes during the AM and PM peak hour.

<table>
<thead>
<tr>
<th>Type of Vehicle</th>
<th>AM Peak Hour</th>
<th>PM Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Vehicle Volume</td>
<td>Person Volume</td>
</tr>
<tr>
<td>DART Buses</td>
<td>45</td>
<td>1,260</td>
</tr>
<tr>
<td>Other Buses</td>
<td>5</td>
<td>73</td>
</tr>
<tr>
<td>Vanpools</td>
<td>10</td>
<td>83</td>
</tr>
<tr>
<td>2+ Carpools</td>
<td>1,225</td>
<td>2,581</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>1,293</td>
<td>4,005</td>
</tr>
</tbody>
</table>

While the primary objective of an HOV lane is to increase the effective person-movement capacity of a roadway, implementation of an HOV lane should also improve the overall efficiency of the roadway. Table 2 shows a comparison of measures used to assess the effectiveness of the HOV lane. The volumes and occupancies shown in Table 2 are in the peak direction of travel on the freeway mainlanes in the "before HOV" and the peak direction on the mainlanes and HOV lane in the "after HOV". While the total volume has increased, the number of carpools in the corridor has also substantially increased in both the AM and PM peak hour. Additionally, for an HOV lane to generate substantial increases in person movement,
it must increase the average vehicle occupancy (persons per vehicle). That increase is largely the result of increases in ridesharing, both carpooling and transit.

Table 2. Effectiveness of the I-30 HOV Lane

<table>
<thead>
<tr>
<th></th>
<th>AM Peak Hour</th>
<th></th>
<th>PM Peak Hour</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before HOV</td>
<td>After HOV</td>
<td>Percent Change</td>
<td>Before HOV</td>
</tr>
<tr>
<td>Vehicle Volume</td>
<td>5,692</td>
<td>8,462</td>
<td>+49%</td>
<td>7,104</td>
</tr>
<tr>
<td>Passenger Volume</td>
<td>7,689</td>
<td>11,588</td>
<td>+51%</td>
<td>9,549</td>
</tr>
<tr>
<td>2+ Carpool Volume</td>
<td>596</td>
<td>1,582</td>
<td>+165%</td>
<td>954</td>
</tr>
<tr>
<td>Vehicle Occupancy</td>
<td>1.33</td>
<td>1.37</td>
<td>+3%</td>
<td>1.33</td>
</tr>
<tr>
<td>Auto Occupancy</td>
<td>1.13</td>
<td>1.22</td>
<td>+8%</td>
<td>1.15</td>
</tr>
<tr>
<td>Frwy Speed (kph)</td>
<td>35</td>
<td>47</td>
<td>+34%</td>
<td>35</td>
</tr>
<tr>
<td>HOV Lane Speed (kph)</td>
<td>35</td>
<td>75</td>
<td>+114%</td>
<td>35</td>
</tr>
</tbody>
</table>

While there may be several travel corridor characteristics that might have an impact on the decision to use an HOV facility, travel time savings over congested general purpose lanes is the primary motivation for most commuters to change modes of travel and utilize an HOV facility. The average travel speeds before and after implementation of the HOV lane are shown in Table 2. While the travel speeds on the HOV lane have substantially increased versus the before HOV freeway mainlanes, the speeds on the freeway mainlanes have also increased after implementation of the HOV lane. The data presented was collected on incident-free days in the corridor. An incident such as an accident will substantially increase the trip time on the freeway, providing additional benefits to HOV lane users.

The I-30 HOV lane has been very successful in terms of public acceptance of the project. Violations of the occupancy requirement are low (less than one percent) and bus ridership has increased eight percent after the first year of HOV lane operations. Because of the success of the HOV lane, additional DART bus routes have been diverted in order to utilize the HOV lane. Also, the operating cost of DART buses using the HOV lane has been reduced by approximately $355,000 during

Conclusion

The I-30 HOV concept in the Dallas-Fort Worth area demonstrates the value of technology for creating cost-effective, high-occupancy lane operations. The HOV lane has been shown to substantially increase travel speeds, providing travel-time savings to commuters.

References

the first year of operation because fewer buses are required to run the before HOV lane routes due to the travel time savings.

Conclusion

The I-30 Contraflow HOV lane is a demonstration project of the HOV lane concept in the Dallas area as well as a demonstration of the movable barrier technology for an HOV lane application. The predominant benefit from using a movable concrete barrier system for a contraflow HOV lane application is the ability to allow carpools on the lane. There is improved safety between HOV traffic and opposing mixed flow traffic with the addition of a physical barrier. Allowing carpools on the HOV lane increases the person movement during the peak period, increases the cost effectiveness of the lane, and greatly enhances the public perception of lane utilization. The I-30 HOV lane, which is operated on the inside freeway lane of the off-peak direction during the morning and evening peak periods, currently moves the equivalent of two freeway mainlanes of people during each of the two peak traffic hours.

References