22. Manual on Uniform Traffic Control Devices. FHWA, 1978.
23. AASHTO. A Policy on Geometric Design of Highways and Streets. NCHRP, Project 20-7, Task 14, Review Draft 2, Dec. 1979.

Publication of this paper sponsored by Committee on Geometric Design.

Notice: The opinions, findings, and conclusions expressed in this paper are those of the author and do not necessarily reflect those of the FHWA.

Designing Highways for Buses: The New Jersey Experience

STEVEN R. FITTANTE

In this paper a procedure and set of criteria for accommodating bus operations through transit-sensitive highway design are described. A set of bus operational needs (including bus stopping, passenger waiting, and bus priority requirements) are compared with the current arterial highway design standards and features used by the New Jersey Department of Transportation. Bus needs that are not accommodated by standard highway design are described, including bus turnouts, pedestrian-actuated crossing signals, and bus priority lanes. The transit impact review process includes an evaluation of current and future bus needs, a determination of whether the proposed highway design will serve those needs, and identification of those highway projects that require highway design changes to better accommodate bus needs. The approach taken stresses the joint effort of highway engineers and transit planners in order to (a) evaluate the transit impact of proposed highway improvement projects and (b) suggest workable design modifications.

The provision of bus priority measures through highway design has received considerable attention in transportation research literature during the past decade. Demonstration projects that involve bus priority lanes, bus preferential ramp metering, and traffic signal preemption are among the specialized design elements through which highway design engineers have shaped the transit system environment (1).

Despite the increased interest in strategies for bus operating performance through highway design, most highway designs that are sensitive to bus operating needs involve specialized additions or modifications to the original highway elements. In New Jersey the design of state highways has not specifically considered the needs of existing or future (potential) bus operations. Although the highway project approval process traditionally called for an evaluation of impacts on transit, this review admittedly did not relate the needs of a bus operation to the highway design standards as required by the state.

Criteria for establishing an approach to better accommodate bus operations are outlined in this paper, and a modified highway project approval process for determining situations where existing highway design standards can accommodate bus operations is described. The process further requires that both the lead unit of the New Jersey Department of Transportation (NJDOT) for the highway project and transit planners from the New Jersey Transit Corporation (NJ TRANSIT) share the task of identifying those projects that may require specialized highway design elements in order to properly accommodate bus operating needs. Other states should find this planning approach to transit-sensitive highway design applicable to their respective transportation departments' procedures.

BACKGROUND

The motivation to develop a transit sensitivity process came from an arterial highway project that affected a major commuter bus corridor. Route 9 is a north-south arterial highway that runs the length of eastern New Jersey. The central portion, which traverses Middlesex, Monmouth, and Ocean counties, varies in paved width from a two-lane undivided roadway to a six-lane arterial highway with a median barrier.

The most heavily traveled commuter bus corridor in New Jersey operates on nearly 40 miles of Route 9 in central New Jersey. The various routes operating on Route 9 serve daily passenger trips to and from destinations in Newark, Jersey City, and New York City. Commuter bus passengers represent more than 50 percent of the total passenger volume carried on Route 9 during the peak period.

For these reasons, the impact of highway widening projects on Route 9 became a concern of transit planners at NJ TRANSIT. Because NJ TRANSIT is a new agency, this concern developed after the highway design process for widening Route 9 in Middlesex County had been completed. The particular project replaced an existing grass median with a concrete median barrier and created an additional travel lane by removing the existing shoulder lanes. The completed project had several adverse impacts on bus operations. The removal of the shoulder lanes resulted in the elimination of two major commuter bus stops and the discontinuance of a bus priority lane on the shoulder during the morning peak period. The concrete barrier, which was unbroken for a distance of 1.5 miles, prevented bus passengers from safely crossing the highway, which contributed to the elimination of a southbound bus stop.

Because the project did not require additional right-of-way acquisition, it was classified as a categorical exclusion project. As such, the project was excluded from the more detailed environmental reviews required for major projects because of the relatively minor impacts on the community. However, the waiving of standard highway design features such as shoulder lanes and vehicle turnarounds (which afford breaks in the median barrier) resulted in adverse impacts on existing bus operations.

To cope with the dislocation created by the highway improvements, NJDOT staff worked with NJ TRANSIT staff to negotiate needed accommodations, which included temporary bus loading areas, a permanent bus turnout, and a commuter priority lane for high-occupancy vehicles during the commuter peak period. This cooperative effort led to the development of evaluation criteria and a process for accommodating bus operating needs in the highway design process.

TRANSIT NEEDS CRITERIA AND REVIEW PROCESS

The criteria for evaluating the impact of highway

design on transit operations are classified according to the following categories:

1. Bus operating needs: What are the physical roadway characteristics that a bus operation requires to operate safely and effectively?
2. Highway design standards: What are the existing arterial highway design standards that also accommodate bus operating needs?
3. Specially designed features for transit: What specialized design features are required to meet bus operating needs not served by the highway design standards?

The joint review process complements the existing NJDOT highway project review procedures. These existing guidelines, outlined in the NJDOT Action Plan, provide for the review of highway project transit impacts so that modifications to standard highway designs can be made to meet the bus operating requirements at the particular project location (2).

Bus Operation Needs

The physical highway features required by bus operations will vary with the type of bus route and the level of service provided at a particular location. For example, the ability of a bus to easily exit and enter a highway is of greater importance to an express commuter route that serves off-line park-and-ride facilities than to a local arterial route. The following highway design requirements are critical to most bus operations.

Basic to any arterial highway operation, areas are needed, which are separated from the travel lane, where passengers can be picked up and discharged by the buses. As an absolute minimum, a 40-ft commuter bus requires 80 ft to pull off the highway and merge back into the travel lane. Generally, a 96-in.-wide bus requires at least a 9-ft lane to be safely separated from highway traffic and to allow passenger boarding. (Note that these dimensions are intended not as standards but to indicate minimum acceptable values for a bus operation.)

At locations where headways are frequent (generally more than 10 buses/hr), it may be necessary to have a stacking lane at major stops. This is particularly true at bus stops where express buses run and at locations where passenger loading is particularly heavy. At major intersections that have heavy traffic volumes, this lane should extend through the intersection to allow buses to accelerate and merge from an exclusive lane.

Occasionally, buses may need to exit the highway to serve park-and-ride facilities located several hundred feet from the highway. This is easily accommodated by reverse loops or diamond interchanges, which allow all turns to be made from the right lane. On undivided highways where left turns are permitted, channelization or left-turn signals may be needed to accommodate the turning radius of buses, particularly where service headways are frequent.

Bus passengers need to be able to wait safely out of traffic when boarding and disembarking; they must also be able to safely cross a highway to reach cars or residences. This is particularly important where major park-and-ride facilities are located adjacent to a divided highway. Accommodation for bus shelters adjacent to the roadway shoulder lane is needed where passenger waiting occurs.

Finally, some form of signalization, such as green-cycle timing, may be required at intersections near a bus garage so that buses can easily depart from the garage during peak times. In certain cases a signal at the garage itself may be needed in order to properly meter a heavy flow of buses onto a highway.

Highway Design Standards That Serve Transit

The NJDOT Bureau of Design uses a set of standards for highway design elements that can serve some basic bus operating needs. Some of these standards include warrants that specify the frequency or minimum conditions for using the particular design feature.

Generally, where available right-of-way exists, state highways include 12-ft shoulder lanes. These lanes, ostensibly designed for emergency stopping, can also serve as acceptable bus stop areas. The standard width is more than sufficient to meet bus needs.

A standard of 0.5 mile between vehicle turnarounds on divided highways is another standard that unintentionally benefits bus operations. This standard was used to ensure convenient access to adjacent land uses and allow for U-turns, particularly for emergency vehicles. The turnaround or jughandle provides a break in the median barrier and may have a traffic signal, which can also serve pedestrian traffic, particularly bus passengers who cross a highway. The transit industry standard for maximum walking distance between a bus stop and either a passenger's home or car is usually 0.25 mile. Therefore, the highway design standard roughly conforms with the standard of transit needs. Adherence to such a standard can reduce the dangerous incidence of bus patrons climbing over a concrete barrier to cross a four- or six-lane highway.

There are several other highway features for which specific standards or warrants are unavailable. Grass medians, which are sometimes traversed by a concrete sidewalk, are a convenient way of preserving the median for future widening and at the same time benefiting bus passengers who must cross a divided highway. At locations with pedestrian-actuated signals, the median can serve as a safe waiting area for pedestrians crossing the highway at the end of the green cycle. Diamond interchanges, which allow a bus to exit off a ramp to reach an intersection bus stop and immediately merge back onto the highway, are excellent for bus operations. They allow the bus the time to decelerate and accelerate when leaving and entering the highway and provide a safe point at which to stop and pick up or discharge passengers.

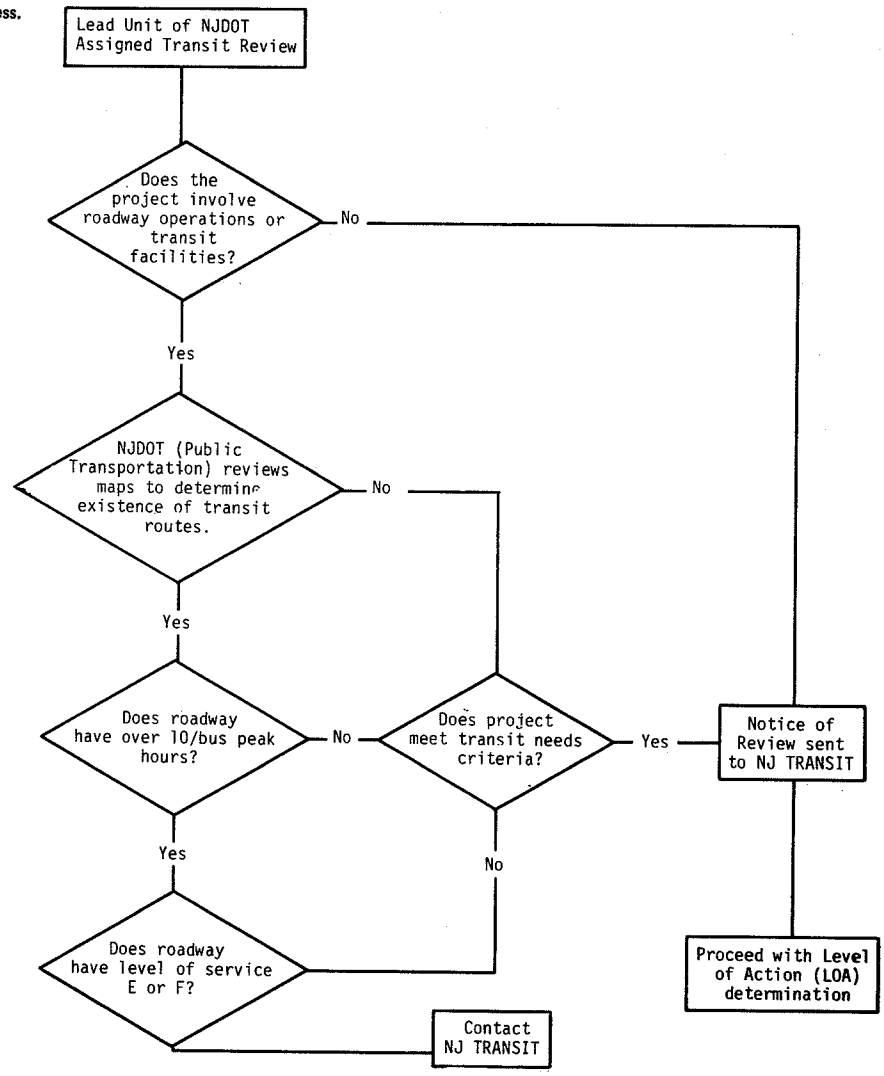
Specially Designed Features for Transit

In most cases highway design standards serve the basic needs of bus operations. There are times, however, when these elements have either been waived or a particular transit need is present that cannot be accommodated by the standard design.

In areas where shoulder lanes are not present or are of a substandard width, a bus turnout may be required to allow buses to stop outside of the travel lanes. The length of bus turnouts varies from 130 to 180 ft, depending on whether the location is midblock, near side, or far side of an intersection. The width of the loading area may be from 10 to 12 ft, and acceleration and deceleration tapers should be at least 3:1 and 5:1, respectively (3).

When a traditional bus stop is located between intersections on a divided highway, some specialized form of pedestrian access may be desirable. Two available options are a pedestrian overpass and a pedestrian-actuated signal. Pedestrian overpasses suffer from high cost and the reluctance of pedes-

Figure 1. Proposed transit impact review process.



trians to climb steps or ramps in order to reach the overpass. Accessibility requirements, when inclined ramps are used instead of stairways, increase this distance and may also eliminate any safety incentive for pedestrians to use the overpass.

Pedestrian-actuated signals provide a relatively low-cost means of affording access across a divided highway. Problems result from the warrants (1,000 passengers/hr), which are rarely attained on arterial highways, and the dangers to pedestrians from automobiles not heeding the infrequent red signal when such warrants are not met. Nevertheless, there are examples of such pedestrian-actuated signals at locations of less than 1,000 crossings/day where such signals have been operated successfully. In these cases most of the crossings are concentrated in the peak period.

In some cases, such as the previously described Route 9 corridor, frequent bus service accounts for a majority of the passenger volume during the peak period. Under these circumstances bus priority may be warranted through either a reversible (contraflow) lane or a dedicated right lane or shoulder. Such measures should be considered where a roadway level-of-service E or F exists and the bus passenger volumes carried in a dedicated lane are greater than the capacity of the mixed-use travel lanes (4).

Transit Impact Review Process

The process outlined in Figure 1 is designed to involve both highway project engineers and transit planners in recognizing the need for specialized highway designs to accommodate transit needs. Unlike the existing transit impact review for highway projects, this process identifies the aforementioned bus operation characteristics that necessitate special design treatment. Project planners also evaluate highway projects with respect to their capacity for meeting the needs of existing as well as future transit operations.

The staff responsible for initiating the highway project initially determines whether a project involves either a roadway operation or a transit facility. Any project that involves one of the following types of actions can affect roadway operations or a transit facility (5):

1. Approval of utility installation along or across a transportation facility;
2. Reconstruction or modification of an existing bridge structure on essentially the same alignment or location;
3. Modernization of an existing highway by resurfacing, restoration, rehabilitation, widening

less than a single lane width, adding auxilliary lanes, or correcting substandard curbs and intersections;

4. Highway safety or traffic operations improvement projects;
5. Corridor fringe parking facilities; or
6. Installation of signs, passenger and bus shelters, and traffic signs.

Once a project is determined to involve roadway operations or transit facilities, the NJDOT lead unit responsible for managing the project reviews the route maps provided by the transit agency and determines whether any bus operations currently operate in the project area. The maps for New Jersey include the routes operated by NJ TRANSIT, subsidized bus carriers, and private (unsubsidized) bus carriers.

If no existing routes are identified, the project design standards are reviewed to see if they meet the transit needs criteria (bus stops, pedestrian access, and so on). This step ensures that the transit agency is aware of projects that would be constructed at less-than-standard design levels and might not accommodate future transit development.

A decision involving bus frequency is designed to identify express bus loading points that would require bus stacking areas and possible bus priority treatments. Similarly, the roadway level-of-service question identifies those projects that might be candidates for bus priority design improvements. The lead unit reviews bus schedules and traffic volume data to make these determinations.

As noted in Figure 1, projects that meet the criteria for specialized design accommodations are sent to the transit planning section for further review. Bus operations personnel and transit planners then determine whether such improvements would be beneficial, and if so, they contact the Bureau of Design at NJDOT to negotiate what design improvements could be made, given cost and other constraints. Projects that will be constructed at less-than-usual design standards are also reviewed by NJ TRANSIT.

It is expected that most projects will not involve adverse impacts and that they will meet the transit needs criteria. Once the review is completed by the lead unit at NJDOT, a notice of review is sent to NJ TRANSIT through the usual Level of Action process.

RECENT DEVELOPMENTS

A task force consisting of representatives from NJDOT lead units and Planning and Bus Operations from NJ TRANSIT has been charged with the task of modifying and implementing the proposed criteria and process. Currently, task force members have agreed to develop additional criteria for local-aid projects that involve secondary roads and to simplify the notification procedure for those projects that are reviewed and have no impact on existing or future bus operations.

The task force intends to conduct a series of workshop sessions to explain the review process to NJDOT project managers and engineering staff who will perform the actual evaluation of project impacts.

CONCLUSIONS

Although implementation of the formal process is not yet complete, the increased cooperation between highway engineers and transit planners is already evident. Transit planners can now anticipate highway design impacts on heavily traveled corridors by reviewing the capital programming documents for highway projects. Highway engineers make greater efforts to notify NJ TRANSIT of construction staging that may temporarily affect bus operations, and they cooperate to minimize these impacts. The negotiation between NJ TRANSIT and NJDOT design engineering staff on ameliorating specific problems such as pedestrian access is currently conducted with both staffs being more aware of the respective constraints on highway design and bus operations.

Regardless of the final form that the implementation process takes, the mutual cooperation fostered to date should result in a highway design process in which recognition of bus operating needs results in a more effective highway operation.

REFERENCES

1. M. Yedlin and E.B. Lieberman. Analytic and Simu- lation Studies of Factors That Influence Bus Signal Priority Strategies. TRB, Transportation Research Record 798, 1981, pp. 26-29.
2. New Jersey Action Plan. Bureau of Program Evaluation and Coordination (in cooperation with FHWA), New Jersey Department of Transportation, Trenton, April 1975.
3. A Policy on Design of Urban Highways and Arterial Streets. AASHO, Washington, D.C., 1973, pp. 661-674.
4. Highway Capacity Manual--1965. HRB, Special Rept. 87, 1965, 411 pp.
5. FHWA. Environmental Impact and Related Procedures: Final Rule and Revised Policy on Major Urban Mass Transportation Investments and Policy Toward Rail Transit. Federal Register, Vol. 45, No. 212, Oct. 30, 1980, pp. 71980, Paragraph 771.115(b).

Publication of this paper sponsored by Committee on Geometric Design.