Blending LRT into Difficult Traffic Situations on Baltimore's Central Light Rail Line

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Once a decision is made to use existing street rights-of-way as part of a new light rail transit (LRT) line, it is almost inevitable that the rail operation will have some negative impact on highway traffic. Impact of this type is likely to be more severe where the new rail line is required to pass through an intersection or other location where the existing traffic is already experiencing operating difficulties. Although this negative traffic impact usually cannot be totally avoided, it can often be reduced to a reasonable and tolerable level. At those locations where the impact is significant, mitigation often requires imaginative design that reflects sensitivity to the inherent strengths and vulnerabilities of each mode. This was the case at a number of locations on Baltimore's Central Light Rail Line.

Baltimore's Central Light Rail Line (CLRL) is a project of the Mass Transit Administration (MTA), the Maryland state agency responsible for transit service in the Baltimore metropolitan area. Now in its early stages of operation, Phase 1 of this new light rail transit (LRT) line connects the northern suburbs with those in the southeast via a route that passes directly through the heart of the city (Figure 1). In the outlying areas the tracks have been located in their own separate right-of-way. In downtown Baltimore the CLRL has been constructed largely within existing street beds.

Proponents of LRT frequently point to its ability to operate successfully in many environments. The more enthusiastic among them like to say, "Light rail goes everywhere." Although that may not be literally correct, it is close. LRT can and does operate safely in situations where other fixed guideway modes cannot. Many of these situations involve sharing the public streets. Designs for LRT operation within the public street system will often be more successful if the LRT operations are blended into preexisting traffic patterns rather than being simply superimposed upon them without full consideration of the negative effects.

The designers of the Baltimore CLRL were faced with the task of fitting a railway into a number of existing street designs that had been developed or had evolved in response to dominant traffic patterns. More often than not, some modification of street design was unavoidable, but the traffic patterns that had led to those designs could not be disregarded. This discussion will address locations in outlying areas and downtown where, for one reason or another, specific traffic patterns and LRT operation had to coexist.

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In the outlying areas some of the interfaces between the CLRL tracks and the roadway network are simple crossings and can be controlled solely by conventional, railroad-type flashers and gates. Others, because of proximity to sensitive intersections, required some innovative redesign. The first of the two locations selected for discussion lies within Baltimore City at the Clipper Mall Industrial Park. The other is in Ferndale south of the city in Anne Arundel County. At the latter location the CLRL is still under construction and passenger service has not yet commenced.

The more difficult challenges were found in downtown Baltimore where the CLRL was constructed almost entirely within the right-of-way of existing public streets. In the central business district (CBD) the streets follow the points of the compass in a grid pattern with an occasional variation. (A few streets run diagonally for short distances.) A half-mile of one east-west street, Lexington Street, has been converted into a pedestrian mall and one north-south street, Howard Street, is closed for a few blocks to all but pedestrian and bus traffic. The majority of the streets are less than 45 ft in width and are one way in the customary alternating pattern. Two adjacent north-south streets, Eutaw and Howard Streets, were never included in the pattern and remained two way.

The street that was most closely aligned with the logical route of the CLRL to the south and also well positioned to connect with the route to the north was Howard Street. As mentioned earlier, in the heart of the CBD Howard Street carried no general traffic at all. Beginning in the mid-1980s it was restricted to bus and pedestrian traffic. This made it an inviting candidate for the CLRL route. However, both north and south of the restricted area Howard Street has quite different characteristics. At the south edge of the CBD it forms a direct, end-to-end extension of Interstate 395, a freeway spur of Interstate 95. At the north edge of the downtown district, Howard Street is a heavily trafficked arterial connector that carries traffic from Martin Luther King (MLK) Boulevard to a major bridge across the Jones Falls (which is actually a river), Interstate 83 and US-1. Following an exploration of several other north-south streets as possible routes for the CLRL and with recognition that interface with existing traffic flows would have to be addressed, the Howard Street route was selected for the CLRL.

In the southern portion of the downtown area a double-track LRT line has been built along the west side of Howard Street in a trackway created by narrowing the west sidewalk and removing one traffic lane. North of there, where traffic

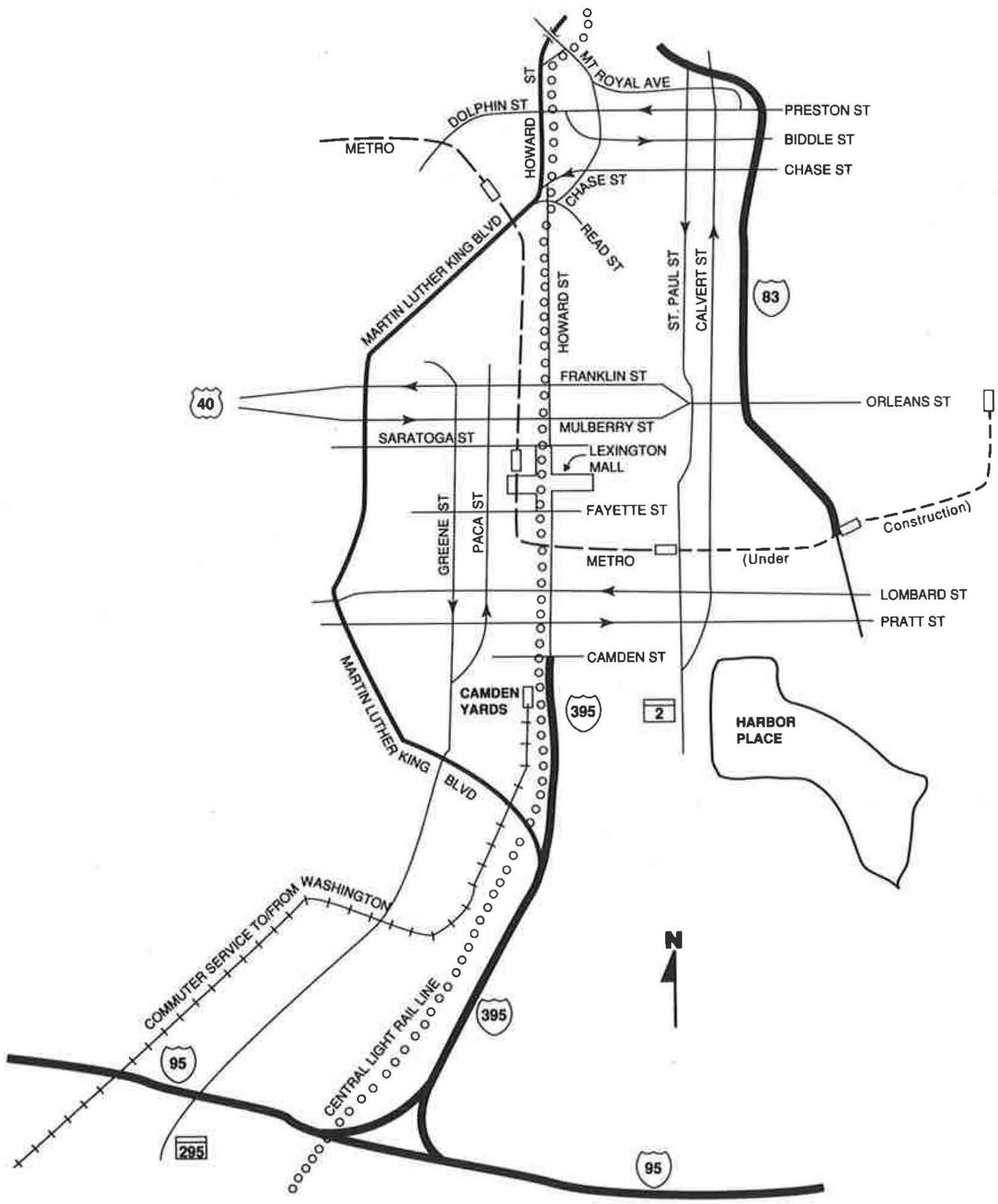

FIGURE 1 Alignment of the CLRL in downtown Baltimore.

other than buses and pedestrians was already excluded, the southbound buses have now also been diverted to make way for the southbound trains. In the northbound direction, within the traffic-free area, the trains and buses coexist, but each mode has a separate lane. To the north of that area the street widens and northbound general traffic is permitted to enter and mix with the buses whereas the tracks remain in exclusive lanes. Still farther north the trackway shifts to the center of the street and forms a median separating the two directions of general traffic. At the very north end, for the last quarter mile before they turn northeastward along Dolphin Street, the tracks move to a position east of the east sidewalk. After following a similar alignment for one block along Dolphin Street, they cross Mt. Royal Avenue onto their own right-of-way and exit the downtown area. Most of the turns from Howard Street onto cross streets that would have crossed the tracks have been prohibited. Those that remain are governed by special signal control.

Nowhere along this route will the trains operate in mixed traffic in the manner of the traditional streetcar. Nevertheless, they cross 16 intersecting streets and, at two locations, they transpose positions with rubber tired vehicles in parallel traffic lanes. Two of the more complex and challenging design problems in the CBD, Lexington Mall and Howard Street, and MLK Boulevard and Howard are discussed.

CLIPPER MILL INDUSTRIAL PARK

One special challenge was the T intersection of Union Avenue, Seneca Street, and Clipper Road in a mixed residential and industrial area a few miles north of the center of town.

The path selected for the CLRL was an existing railroad line that parallels Clipper Road and crosses Union Avenue just east of the intersection. At the time that the design effort began this line was owned and operated by the Consolidated Rail Corporation (Conrail). It was a single-track remnant of the Pennsylvania Railroad's Northern Central Line that had previously linked Baltimore and Harrisburg, Pennsylvania, with a double-track line. Following World War II both passenger and freight activity on the line diminished. Then in 1972 floods ensuing from a hurricane severed the line between the two cities and forced discontinuance of the remaining passenger and through freight service. A single track was quite sufficient to handle the surviving local freight and the northbound track was removed.

From midcentury onward the industries in the vicinity of the crossing had made increasing use of truck transport and those trucks became increasingly large. Because of their greater size it became difficult for them to turn from narrow Union Avenue onto an even narrower, privately owned industrial roadway that serves the commercial properties east of the tracks from an intersection with Union Avenue just east of the crossing. Widening of that roadway to the east was not an option because the edge of the paving was already within inches of a factory building wall. Widening to the west would also have been impossible if the railroad had remained double-tracked. However, the removal of the northbound track had rendered its bed available for other purposes. The mechanism that operated the crossing gate that controlled the westbound Union Avenue approach was a major impediment to the turning of the longer trucks and was shifted away from the aforementioned factory building to a location just east of the surviving track. Additional paving was placed on the abandoned northbound track bed to produce a wider roadway and provide more maneuvering room for the truck turn. In essence, the crossing was reconfigured to accommodate only a single track and this was the condition that existed when the MTA purchased the railroad from Conrail (Figure 2).

Although the CLRL has some single-track sections, more than half of the route will be double-tracked to provide essential operating flexibility. The Union Avenue crossing is within one of the line sections where double track is needed. This meant that, to accommodate LRT operation, the northbound track had to be restored and that the crossing had to be modified once more, this time back to a double-track configuration. The challenge was to carry this out without recreating lateral clearance restraints that would have made it virtually impossible for a modern tractor trailer to turn into and out of the private roadway.

A solution was found by providing a new location for the connection between the private industrial roadway and the public street system. In this part of Baltimore the street system has a very irregular configuration largely because of topography. Union Avenue ends just west of the crossing and, to continue farther, through traffic must turn to the north on Clipper Road. In the reverse direction through traffic must approach southward on Clipper road and turn eastward on Union Avenue. Seneca Street forms the third leg of the intersection of Union and Clipper, but leads only to a landlocked group of residential streets and is of no use to through traffic. Thus for traffic destined to or originating from businesses served by the private roadway, it was determined that a connection of that roadway to Clipper Road would serve just as well as a connection to Union Avenue. This is the design approach that was adopted (Figure 3).

In conjunction with LRT track construction and the restoration of a double-track crossing at Union Avenue, an additional crossing of the rail line was built about 100 ft north of Union Avenue. This new crossing connects the private roadway on the east side of the tracks to Clipper Road on the west side. The short section of that private road between the new crossing and Union Avenue has been abandoned.

Although the new roadway geometry creates an unorthodox double crossing of the tracks for traffic arriving from or exiting to Union Avenue, it permitted restoration of the double-

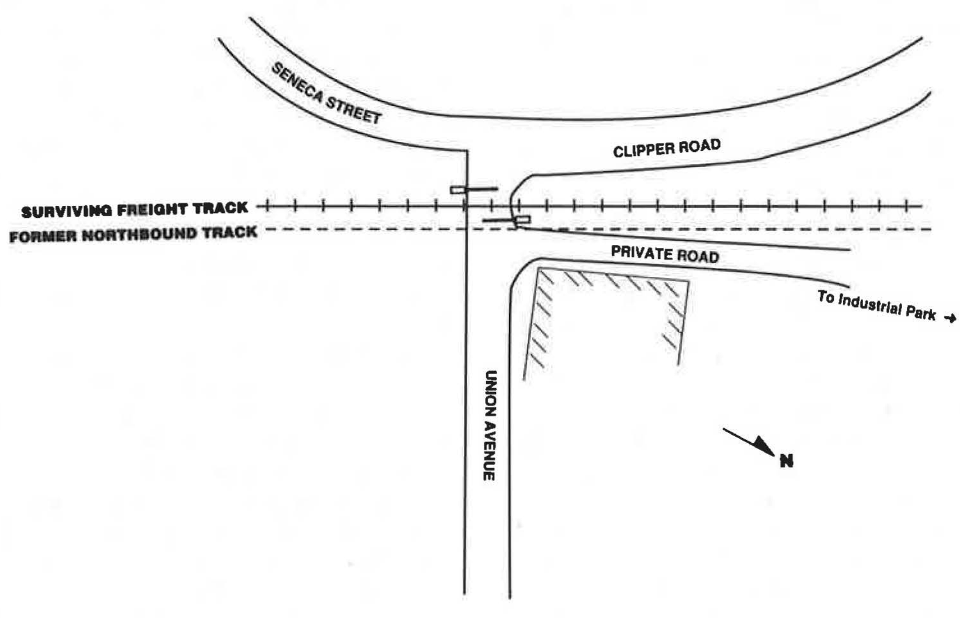

FIGURE 2 Street configuration at Clipper Mill Industrial Park when the railroad right-of-way was purchased.

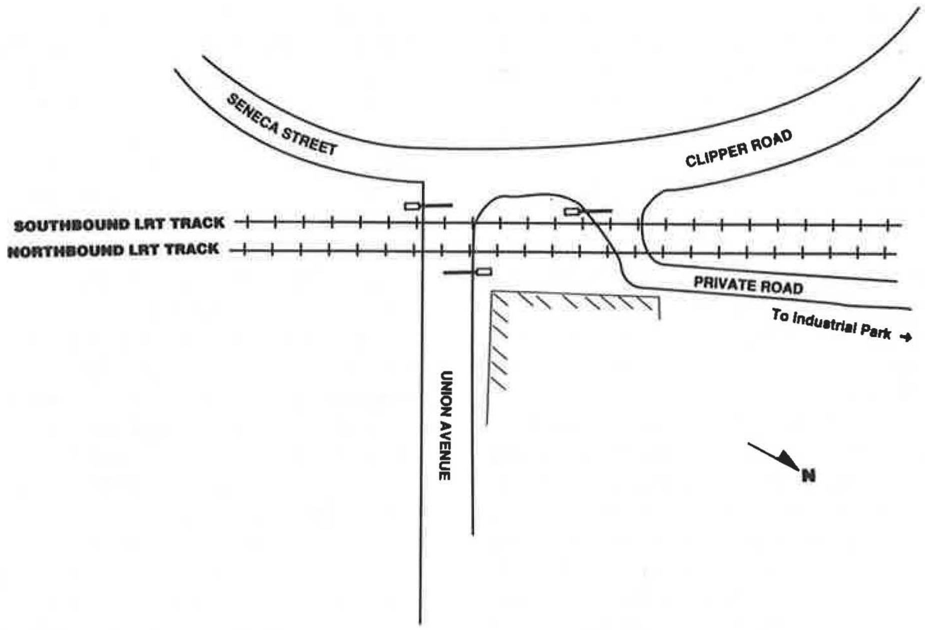

FIGURE 3 Street configuration at Clipper Mill Industrial Park when the CLRL was completed.

track crossing at Union Avenue while preserving access to the properties served by the private roadway. In fact this access is actually improved because the new crossing is designed for trailers longer than those that were able to turn, without a backup maneuver, to and from the old Union Avenue connection.

FERNDALE

Another location that required significant design modifications is in Anne Arundel County, about a mile from the south end of the line, along the Baltimore and Annapolis (B&A) Railroad in the community of Ferndale. Ironically the B&A Railroad once operated electric trains to and from downtown Baltimore, but in recent years it has served only as a local freight connector with but one significant customer. The MTA acquired the B&A Railroad and is reconstructing the trackage to accommodate LRT operation.

As the tracks pass through Ferndale they are paralleled by a public highway on each side, Baltimore-Annapolis (B-A) Boulevard on the east and Broadview Boulevard on the west. Both are two-lane roadways carrying two-way traffic (Figure 4). The traffic volume on Broadview Boulevard, a county road, is light. However, on B-A Boulevard, which is Maryland State Route 648, it is quite substantial. In the heart of the Ferndale community a cross street named Ferndale Road approaches from the west on a course perpendicular to the tracks. It intersects Broadview Boulevard, then crosses the tracks and ends in a T-type intersection with B-A Boulevard, all within a distance of less than 200 ft. Its intersection with B-A Boulevard is controlled by traffic signals, but its intersection with Broadview Boulevard is controlled by stop signs.

Over time it had become customary for eastbound traffic on Ferndale Road frequently to queue on the tracks while awaiting a green signal at B-A Boulevard. This was not problematic because of the nature of the freight operation on the B&A Railroad. Trains operated only a few times per week and approached at speeds under 15 mph. They stopped at the crossing and proceeded under the control and protection of a flagman.

When LRT operation begins passenger trains will operate four times per hour in each direction, interrupting traffic on the average of every 7.5 min for 18 or 19 hours per day, and they will carry no flagman. In light of these operating conditions attention had to be given to the queuing on the tracks.

In addressing this, the first approach was to consider some type of control that would stop eastbound traffic short of the crossing when the traffic signal for Ferndale Road at B-A Boulevard was red or about to change to red. That would have handled the track crossing itself, but it would have created a queue across Broadview Boulevard. Also, vehicles approaching from both directions on Broadview Boulevard and turning east would have needed to be stopped in some manner before they entered the intersection and the track crossing whenever they would have been unable to clear both of these potential conflicts before losing the green signal at B-A Boulevard.

All of this could not have been achieved with just signing and pavement marking. It would have necessitated signalizing the Broadview and Ferndale intersection. That in turn would have generated a new problem of westbound queuing on the tracks. To address that problem it would have been necessary during each signal cycle to stop vehicles turning from B-A Boulevard before they began to execute that turn whenever they would not have been able to clear the tracks before losing their green signal at Broadview Boulevard.

In theory, all of this would have been possible, but a five-phase signal cycle would have been required to time-separate

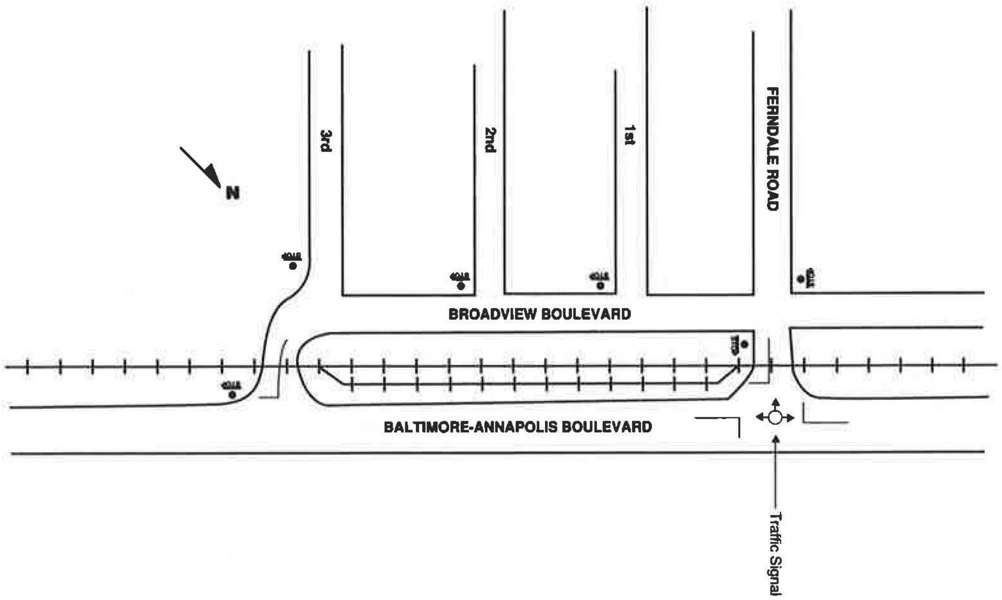

FIGURE 4 Street configuration in Ferndale when the railroad right-of-way was purchased.

all of the conflicting traffic movements. This would have resulted in an extremely inefficient signal timing that, almost inevitably, would have produced severe traffic congestion.

The root of the problem was the queuing of eastbound traffic on Ferndale Road. The method eventually chosen to eliminate the eastbound queuing was to eliminate the eastbound traffic.

The closest grade crossing to Ferndale Avenue is Third Avenue, two blocks to the south. This crossing posed no particular problem with eastbound queuing because of the roadway configuration, but with frequent LRT train operation it required new and special signalization that would hold traffic turning west from B-A Boulevard on that road whenever a train was approaching. Because B-A Boulevard is somewhat narrower there, physical widening would also have been necessary to provide separate standby lanes for the turning traffic.

In other words, the Third Avenue crossing could easily handle eastbound traffic and LRT operation, but including westbound traffic would have caused difficulty. At the Ferndale Avenue crossing, westbound traffic could be handled relatively easily, provided that eastbound traffic could be accommodated elsewhere.

Once all of this was recognized, the solution became apparent. A design was developed to discontinue two-way traffic on both crossings by making the short portions of Ferndale Road and Third Avenue between B-A and Broadview Boulevards one-way westbound and eastbound, respectively (Figure 5). The traffic displaced from each crossing could be handled at the other without difficulty. Although the two roads were farther apart than a normal one-way pair, the concept was endorsed by the county traffic engineer and was included in the final design.

As a result of these changes highway users will have better controlled and less congested movement to and from B-A Boulevard, and the trains will cross free of any traffic queues on the tracks.

LEXINGTON MALL

The exclusive bus and pedestrian section of Howard Street mentioned previously is part of what is known as Lexington Mall, a "plus sign"-shaped, traffic-free sanctuary created by removing all vehicle traffic from a three-block section of Lexington Street and all but bus traffic from a two-block stretch of Howard Street.

Howard Street has a general width between curbs of 44 ft, but where it passes through the mall area this width was reduced to a nominal 33 ft when the Lexington Mall was created (Figure 6). The purpose of this reconfiguration was to produce wider sidewalks and to facilitate pedestrian movement across Howard Street along the Lexington axis. This pedestrian-friendly design is considered by the MTA to be important and the CLRL had to be designed to retain this feature.

Equally important was the need to provide an LRT station in the mall area, the most pedestrian-oriented part of downtown Baltimore. Additionally the mall offers the shortest and most attractive walk for those passengers who transfer between the CLRL and the Lexington Market Station of the Metro, Baltimore's subway system. Not having a station on the CLRL at Lexington Mall was not an option, but the 33-ft width of Howard Street precluded any type of trackside platform.

The only way to satisfy all of these conditions was to construct the northbound track next to the east curb and the southbound track next to the west curb so that the two sidewalks could serve as passenger platforms. This design produced no problem in the southbound direction because southbound general traffic had already been removed and southbound bus operations were being relocated in favor of the rail service. The natural position for the southbound track was against the west curb with the sidewalk serving as the station platform. However, the northbound direction did present a problem.

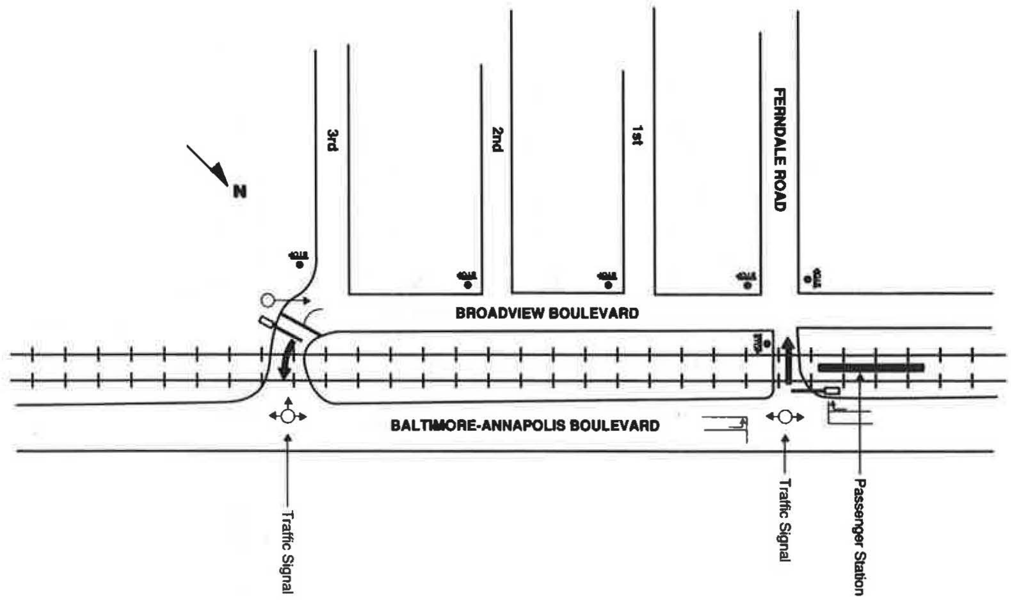

FIGURE 5 Street configuration in Ferndale when the CLRL construction is completed.

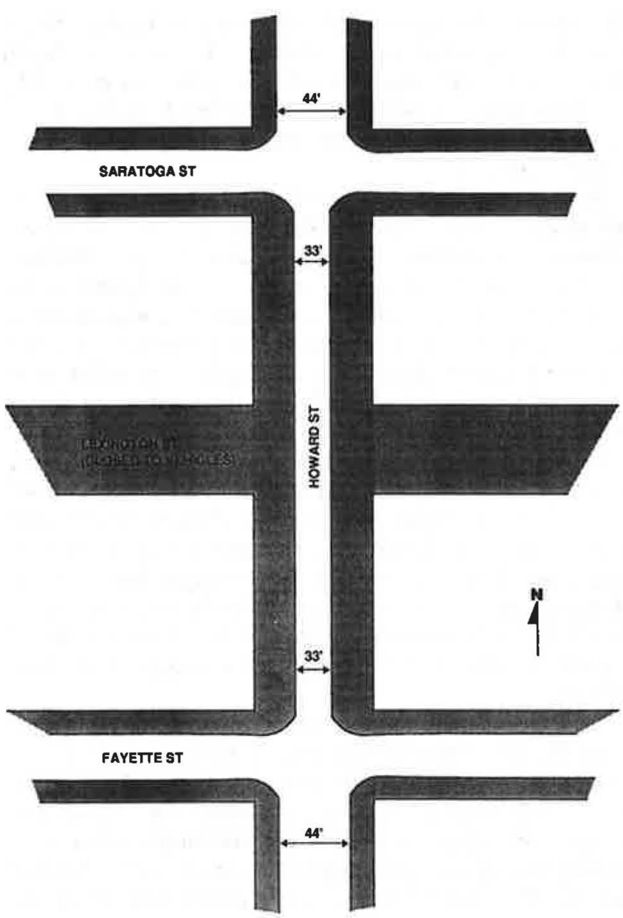

FIGURE 6 Curb and sidewalk configuration in the Lexington Mall area.

Northbound bus service was not being diverted and a stop at Lexington Mall was deemed as important for that service as it was for the LRT service. The 33 ft between curbs on Howard Street translates into three 11-ft lanes, one for the southbound trains, one for the northbound trains, and one for the northbound buses. Obviously one of those three lanes had to be positioned in the middle, not adjacent to either sidewalk. Yet both the northbound trains and buses needed access to that sidewalk to board and discharge passengers.

The solution chosen was to retain the existing northbound bus stop south of the Lexington Street walkway and to establish the northbound LRT stop north of the walkway (Figure 7). Between Fayette Street and Lexington Street, where the northbound buses load and unload from the east curb lane, the northbound trains can move in the center lane past the stopped buses. North of Lexington Street, up to Saratoga Street, the northbound trains shift to the right lane and stop at the east curb while the buses shift left and pass by in the center lane. North of Saratoga Street, where Howard Street resumes its normal 44-ft width, the trains shift back to the west side of the street and the buses, mixed with general traffic that turns on from Saratoga Street, continue northward on the east side.

Operationally this is a sound concept, but it entails crossing the paths of the trains and the northbound buses twice, once to bring the trains to the east curb and a second time to return them to the west side of the street adjacent to the southbound track. These crossings occur at intersections. The first crossing is at Lexington Street, which, although not open to vehicle traffic, is signalized to control and protect pedestrian traffic. The second crossing occurs a block to the north at Saratoga Street, which is signalized conventionally.

To control the movements of the northbound trains and buses across the paths of each other and to control the conflict

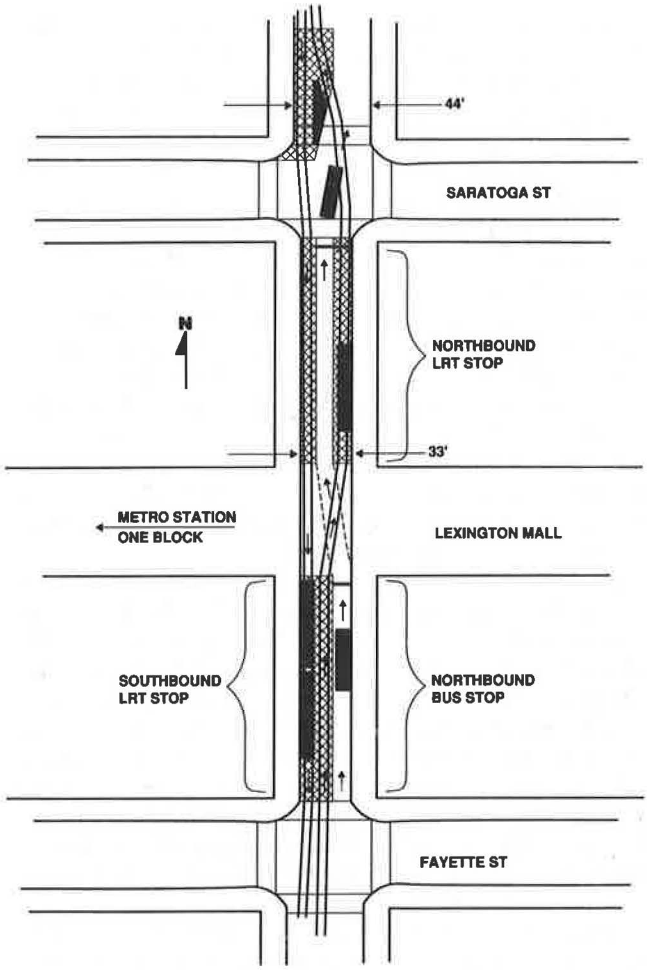

FIGURE 7 Track, lane, and transit stop configurations on Howard Street within the Lexington Mall.

of both with the cross traffic, the two-phase traffic signals have been converted to three-phase signals. Electrically this signal modification was not a problem. A number of downtown intersections require three phases and the computer-driven signal equipment can handle the extra phase.

The problem arose in the design of the signal display. The drivers of the rubber-tired vehicles and the operators of the trains approach the signals side by side in immediately adjacent lanes. When the cross street (Lexington or Saratoga) is permitted to move, both of these northbound Howard Street lanes have a stop signal. During that phase no harm would be done if the operator of a vehicle in one lane misinterpreted the signal for the other lane as his or her own because both lanes would be required to stop. However, during the other two phases, when the cross street is stopped, it is essential that each of the two northbound lanes have its own separate and discrete signals because the traffic in each must cross that in the other just beyond the intersection. Thus it is vital that the vehicles in each lane be clearly required to stop whenever those in the other parallel lane are permitted to move. The signal system had to be designed to time-separate those two movements.

The common method of restricting the lateral angle of visibility with louvers or lenses (optical programming) was considered, but the difference in viewing angle between the two lanes is insufficient to make the "wrong" signal reliably invisible. There was no choice but to accept that all northbound signals would be visible to both lanes and to provide displays that are different in appearance.

At the Saratoga Street intersection the nontrack lane is legally open to general traffic, and it was obvious from the beginning that control of that lane had to be by conventional, circular red, yellow, and green signals. This meant that the northbound track lane had to be the one controlled by some different indicator.

Very brief consideration was given to using color light signals with the lenses masked to display a special shape, such as the letter T or X. However, it was feared that this format would not be sufficient different to clearly indicate to drivers of the rubber-tired vehicles that they were not to be governed by the specially shaped signals. This general design is used on some Pacific coast systems with results that have not been encouraging. Even when white was substituted for green on one system, obedience was far from perfect because, apparently, some motorists moved when they saw a red T signal extinguished. After due consideration it was decided that for the Baltimore system the signals controlling the LRT movement must contain no colors or other elements of a conventional traffic signal whatsoever.

The design finally chosen uses a positioned bar rather than a colored light. A vertical bar indicates proceed, a horizontal bar indicates stop, and a diagonal bar warns of an impending change from the former to the latter (Figure 8). The color of the bar is the same in all positions, but that color is not red, yellow, or green. The standard railway signal color of lunar white was selected for that purpose.

The finished product displays to the highway users conventional signaling, which provides complete protection from train movements and requires no special interpretation. To the train operators it displays separate standardized indications that clearly indicate when they may move without interference. This enables the operators of both types of vehicles to determine when it is safe to enter a zone of potential conflict even though they approach the zone in parallel and immediately adjacent lanes.

FIGURE 8 The three aspects of the positioned bar LRT signals.

HOWARD STREET AND MARTIN LUTHER KING, JR. BOULEVARD

Without question the most challenging location in the entire CBD for the introduction of LRT trackage was the 350-ft section of Howard Street that encompasses its intersections with Chase and Read Streets at the south end and with Martin Luther King (MLK) Jr. Boulevard at the north end (Figure 9). The nature and function of the downtown portion of Howard Street has already been described, but from this short block northward Howard Street is quite different. It is 55 ft wide and carries significant traffic volume. A substantial portion of that volume is traffic that, south of that block, is handled by MLK Boulevard, a six-lane surface arterial that carries much of the north-south through traffic around the west edge of the city's heart. At present northbound MLK Boulevard essentially ends at Howard Street. In the long-range plan MLK Boulevard will continue on beyond Howard Street in a northeast direction, but at this time traffic must proceed over the regular street system.

Nominally half of the outbound traffic on MLK Boulevard turns northward on Howard Street. In the reverse direction an extremely high proportion of southbound Howard Street traffic turns right onto MLK Boulevard. In the initial planning of the CLRL it was hoped that this high traffic location could be bypassed entirely by the LRT route. However, problems of a different nature precluded use of the alternative path for the tracks and the Howard/MLK challenge had to be met head on.

As stated earlier, at some future date the city of Baltimore expects to extend MLK Boulevard, but a number of community and right-of-way acquisition issues will have to be resolved. At the time when the final design of the CLRL began the existing "interim" configuration of MLK Boulevard was the one with which the LRT operation had to blend.

The southbound direction (geographically southwest at this point) of MLK Boulevard is essentially completed from a point two blocks northeast of the Howard Street intersection. However, the northbound portion ends a short block southwest of Howard Street. From there outbound traffic is forced to turn eastward onto Read Street to its intersection with Howard and Chase Streets, beyond which there is a choice. The portion of that traffic destined to east and northeast continues eastward on Chase Street, at least for a few blocks, and then disperses. The portion destined for the north turns onto Howard Street but, at the time when LRT final design commenced, this was not a direct turn but rather a "jug handle"-type maneuver. Two parallel lanes of traffic, after executing the mandatory half-right turn onto Read Street then turned 90 degrees to the left, still in two lanes, onto Howard Street and proceeded northward across the completed southbound section of MLK Boulevard. Needless to say, traffic movement through these two separate, but interrelated, Howard Street intersections was less than smooth.

Constraints on property acquisition as well as both street and track design requirements meant that the tracks must remain in the center of Howard Street as far north as the Read/Chase streets intersection. North of MLK Boulevard it was possible to position them east of the east curb of Howard Street, which left the adjacent street geometry undisturbed. This required a transition from center to side that resulted in a track alignment between the two intersections that placed the rails within the paved portion of Howard Street that was also used by the traffic following the "jug handle" route from MLK Boulevard onto Howard Street and by northbound Howard Street through traffic.

Although it was not particularly desirable, a plan was developed to accomplish this but leaving the geometry of the streets untouched. This plan used signals to time-separate the two modes where they shared the same physical space in

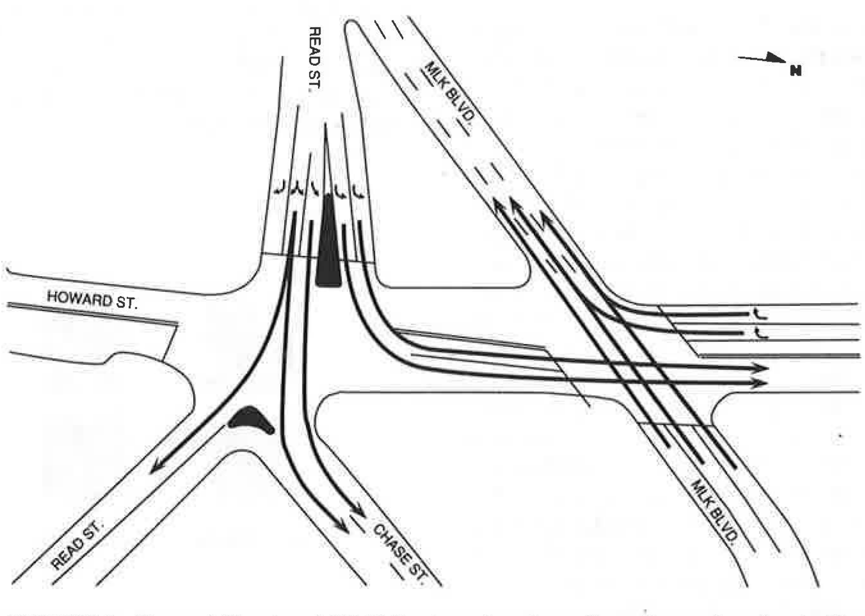

FIGURE 9 Howard Street and MLK Boulevard curb configuration and major traffic movements before construction.

the short section of Howard Street between Read/Chase streets and MLK Boulevard. These interrelated intersections were already overloaded in the peak hours, particularly in the afternoon, and adding an additional signal phase for the rail movement obviously would have exacerbated the situation. Of even greater concern was the possibility that some northbound traffic might be stranded between the two intersections during the portion of the signal cycle intended for exclusive movement of the trains through this area. This could have caused the train to lose an entire signal cycle or to enter this short block behind the stranded vehicles and possibly become stranded itself, resulting in a blockage of cross traffic.

These concerns led to the development of three alternative plans that, unlike the original plan, called for some modification of the street geometry, although they still avoided acquisition of any significant amount of private property. The three new plans were then compared against the original plan and against each other.

By the usual methods of measuring traffic capacity for signalized locations the levels of service (LOS) at the two intersections were, as implied earlier, at or near the bottom of the scale. More significantly those methods were not precise enough to measure the differences in efficiency of the four plans being evaluated. An unconventional method was developed to achieve this.

Signal phasing was developed for each of the plans, tailored to the geometry of that plan and not exceeding three phases at either intersection. (One of the plans did propose a four-phase operation at the more lightly trafficked [south] intersection by using the signal controller at the north intersection to provide the fourth phase.) Baltimore's computer-driven downtown signal system is unusual if not unique. For all intents and purposes it cannot feasibly provide more than three phases at any one intersection. Even without that constraint, the advisability of a four-phase signal timing at an intersection already operating at or above capacity was questionable.

During both peaks the traffic signals in the CBD operate on a 110-sec cycle, which is the longest cycle deemed practical considering the diversity of requirements at more than 100 other downtown intersections that are part of a common system. This translates into 33 cycles per hour.

The next step was to determine the passage time for each movement (general traffic and LRT) through one or both intersections, whichever was applicable. Based on the 33 cycles per hour, traffic volumes were translated into vehicles per cycle and from that, using industry-accepted methods for determining vehicle departure headways, the passage time was calculated. For LRT movements, trains of maximum length (three cars) were assumed and their performance characteristics when fully loaded were used to compute their passage time.

When this was completed the movement requiring the longest time in each phase was identified and the sum (under each plan) was calculated. This sum was, in essence, the cycle length for each plan that would have been necessary to accommodate all vehicles passing through the intersection(s) without requiring some to wait for the next cycle.

In all cases this sum exceeded 110 sec at one or both intersections, which came as no surprise. The purpose of the process was not to confirm that theoretical capacity was exceeded, but rather to provide a measurement of the relative efficiency (or inefficiency) of the four plans. The most efficient plans were those with their sum closer to 110 sec. Other factors, such as relative cost and the likelihood of stranding vehicles on the tracks at the end of a signal phase, were also included in the evaluation.

The plan finally selected was one that created a new, two-lane, northbound roadway on an unused piece of city-owned property at the northeast corner of Howard and Chase Streets (Figure 10). This new roadway accommodated northbound traffic and freed the northbound side of Howard Street itself for the exclusive use of the trains.

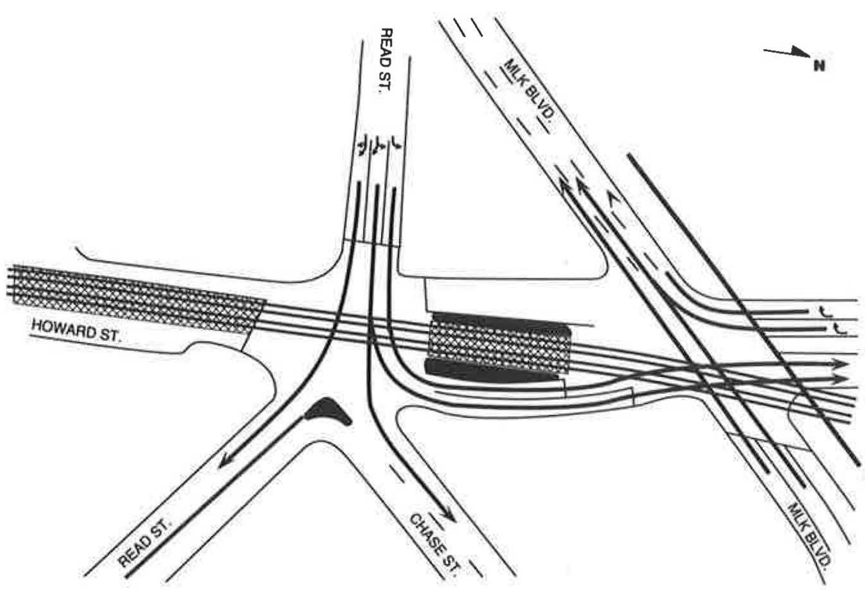

FIGURE 10 Current curb configuration and major traffic movements at Howard Street and MLK Boulevard.

Until MLK Boulevard is extended or other highway improvements are constructed to relieve pressure on this location, both the LRT and traffic operations here will have to coexist with little breathing room for either. During that time the designs that emerged from the combined efforts of the MTA, the city and its several consultants will provide a safe operating plan that maximizes traffic efficiency at this very critical location to the greatest extent possible.

CONCLUSION

One of the things that sets LRT apart from most of the modes that are sometimes considered as alternatives is its ability to interface with street and highway traffic rather than avoid it. Modes dependent upon physical elements such as guide beams, linear induction propulsion, and third-rail power distribution demand grade separation at all roadway crossings. This invariably increases capital costs severely and often creates passenger inconvenience, undesirable visual intrusion, or other environmental problems. Because of its versatility and economy it would appear that, for the foreseeable future, LRT will continue to be a mode frequently considered for new transit lines and systems. A significant percentage of these will involve design problems relating to interfacing with streets and highway traffic in some manner. Although no two problems are absolutely identical, elements of solutions that proved successful in one application may be the key to successful solutions in other applications. The locations discussed here are not the only ones in the CLRL project that contain unique elements. However they do demonstrate some of the diverse problems and solutions involved. Perhaps some elements of the solutions that evolved here will be found useful in the development of other LRT projects in the future.