CHAPTER **2**

# OPERATIONAL FACTORS

## FACTORS INFLUENCING OBSERVATION APPROACHES

### Observation Distance

Table 8 lists the operational parameters for various rapid transit systems. This list summarizes the characteristics of the 17 systems visited during the study as well as 13 systems that responded to the questionnaire. Included is information relating to door observation tasks, such as consist sizes, maximum operator observation distances, the location of the door operator controls within the consist, and a general listing of the types of aids currently used.

San Francisco's BART requires the single-person crew to observe, without aids, the car side doors over 700 ft—the longest distance of any operation in the study; however, because the platforms are constructed in a straight line with minimal obstructions and effective lighting in underground and above-ground stations, observation aids are not required. WMATA, with the second highest passenger volume of North American operations, also requires the operator to observe the car side doors directly but at a maximum distance of 600 ft. Mirrors are installed at two outlying stations, where there is concave curvature of the platform edge. In Montreal, single-person crews use vehicle-mounted mirrors to see the side of the train up to a distance of 500 ft, while at MARTA and on the Metro-Dade Metrorail, the operator must directly observe 450 ft without aids. The average heavy rail single-person crew observes the doors over a distance of slightly more than 440 ft.

For transit properties with two-person crews, the conductor must observe relatively shorter distances. Of these systems, the maximum observation distance is PATH at 350 ft, followed closely by MTA-NYCT at 300 ft. Observations aids are used at both systems but only for curved or obstructed platforms. On average, conductors at the five two-person crew systems observe the side doors over a distance of 275 ft.

For light rail operations, the observation distance is primarily a function of the transit authority's operating procedures. At Pittsburgh's PAT, SF Municipal, and the GCRTA Green and Blue lines, a crew member is used in every car operated. As a result the maximum observation distance is 80 ft. The other five light rail operations use single-person crews for each train. For these systems, observation distances range from 240 ft to 300 ft; this makes them consistent with two-person heavy rail operations.

### Observation Aids

Platform- and vehicle-based mirrors are used extensively throughout the industry to assist operators in observing car side doors under difficult conditions. Proper installation location and alignment can enable an operator to observe along the side of the train when the platform is curved or obstructed.

Excluding MTA-NYCT, three heavy rail transit systems with manned operations are using CCTV as an observation aid. In each of these cases, CCTV has been installed in a single location. MTA-NYCT makes the most extensive use of CCTV-based observation aids in North America, with CCTV being installed at a relatively large number of stations. In each case where MTA-NYCT uses CCTV, direct observation or mirroraided observation is not possible because of platform curvature or structures. MTA-NYCT is committed to the use of CCTV and plans to expand its use to additional stations throughout the system. A detailed discussion on the present application of both mirror and CCTV-based observation aids was provided in the preceding chapter of this report.

### Operational Factors

Table 9 lists the characteristics of door operations and controls. The list incorporates the characteristics of the 17 systems visited during the study as well as 13 systems that responded to the questionnaire.

Once a train is berthed in a station, the train crew must address eight basic issues related to door operation. In all of the observed cases, these issues are addressed by the train crew member responsible for door operation. These issues are as follows:

- Train alignment verification,
- Door opening cycle,
- Door observation,
- Door closure announcement and warning,
- Door closure cycle,
- Interlocked door signal,
- Closed door observation, and
- Platform departure observation.

The details of the actions required to address each of these issues vary among transit systems depending on vehicle and operating characteristics. The complexity of these actions also varies with train crew sizes and vehicle control methodologies. For example, the door control workload for a single-person crew is much different than that for a two-person crew. For unmanned transit operations, door control functions are automated with door control operations relying on the response and input of sensory devices.

Eighteen of the transit systems included in the survey are

**TABLE 8 Summary of reviewed transit system operations and observational data**

| Transit System | Sys. Type | Pass/ Wkdy (1000s) | Max Cars | Car Length | Max Consist Length | Crew Size | Observation Location | Approx. Observ. Distance | Observation Aids: Mirror | Observation Aids: CCTV |
|---|---|---|---|---|---|---|---|---|---|---|
| BART | HR | 255 | 10 | 70 | 700 | 1 | Lead Car | 700 | None | None |
| LA-HR | HR | 40 | 4 | 80 | 320 | 1 | Lead Car | 320 | Vehicle | None |
| LA-LR | LR | New | 4 | 75 | 300 | 1 | Lead Car | 300 | None | None |
| CTA | HR | 473 | 8 | 48 | 384 | 2 | Mid Consist | 250 | 2 Sta | One Sta |
| GCRTA-LR | LR | 19 | 3 | 80 | 240 | 1/car | Per Car | 80 | Vehicle | None |
| GCRTA-HR | HR | 22 | 3 | 75 | 225 | 1 | Lead Car | 220 | None | None |
| MARTA | HR | 235 | 6 | 75 | 450 | 1 | Lead Car | 450 | None | None |
| MBTA | HR | 315 | 6 | 70 | 420 | 2 | 2 cars from Rear | 280 | Some Sta. | None |
| Toronto-Scar | HR | 26 | 4 | 42 | 168 | 1 | Lead Car | 168 | None | None |
| Toronto-HR | HR | 237 | 6 | 57 | 342 | 2 | 2 cars from Rear | 230 | Platform | Test Loc |
| NYCTA | HR | 3500 | 10 | 60 | 600 | 2 | Mid Consist | 300 | Some Sta | Some Sta |
| PATH | HR | 197 | 8 | 51 | 408 | 2 | Lead Car - Aft | 350 | 1 Sta | None |
| BC Transit | HR | 124 | 4 | 42 | 168 | 0 | Not Staffed | N/A | None | Cont Ctr |
| Jacksonville | HR | 2 | 2 | 50 | 100 | 0 | Not Staffed | N/A | None | Cont Ctr |
| Miami-HR | HR | 49 | 6 | 75 | 450 | 1 | Lead Car | 450 | None | Cont Ctr |
| Miami-PM | PM | 11 | 2 | 40 | 80 | 0 | Not Staffed | N/A | None | Cont Ctr |
| WMATA | HR | 500 | 8 | 75 | 600 | 1 | Lead Car | 600 | 2 Sta | None |
| Baltimore-LR | LR | 5 | 3 | 95 | 285 | 1 | Lead Car | 285 | Veh/Plat | None |
| Baltimore-HR | HR | 45 | 6 | 75 | 450 | 1 | Lead Car | 450 | None | None |
| SEPTA-Orange | HR | 114 | 5 | 68 | 340 | 1 | Lead Car | 340 | None | None |
| SEPTA-Blue | HR | 76 | 6 | 55 | 330 | 2 | Mid Consist | 200 | None | Future |
| PATCO | HR | 40 | 6 | 68 | 408 | 1 | Lead Car | 400 | 1 Sta | 1 Sta |
| Edmonton | LR | 35 | 3 | 80 | 240 | 1 | Lead Car | 240 | Vehicle | None |
| Calgary | LR | 114 | 3 | 80 | 240 | 1 | Lead Car | 240 | Veh/Plat | None |
| Metro-North | HR | 200 | 12 | 85 | 1020 | 2+ | Multiple | 250 | None | None |
| Sacramento | LR | 24 | 4 | 80 | 320 | 1 | Lead Car | 320 | Vehicle | None |
| PAT | LR | 30 | 2 | 80 | 160 | 1/car | Lead Car | 80 | Vehicle | None |
| SF MUNI | LR | 130 | 4 | 80 | 320 | 1/car | Lead Car | 80 | Vehicle | One Sta |
| LIRR | HR | 200 | 10 | 85 | 850 | 2+ | Multiple | 250 | None | None |
| Montreal | HR | 625 | 9 | 57 | 513 | 1 | Lead Car | 500 | Vehicle | None |

operated under manual control. Of these 18, 10 are normally operated by single-person crews; the other 8 employ two or more crew members. Eight of the visited lines use automatic train controls and single-person crews. Other systems, such as SF Municipal's light rail system, operate in an automatic mode when traveling in the subway portion of the system and a manual mode on the street-level section of the line. PATCO, which normally operates under automatic control, requires its train operators to make at least one run per day under manual control to maintain operational proficiency.

## Alignment Verification

All staffed operations verify that the train is properly berthed before the doors are opened. For the four staffed systems that have automatic door operation, (i.e., BART, Toronto Scarborough, WMATA, and Montreal), berthing-related observations are made as the train decelerates to its final stopping location. In MTA-NYCT, the conductor verifies proper train berthing by observing a platform-mounted marker board before opening the doors.

When correctly aligned, this white and black board is directly opposite the door control location. Its length is subject to the constraints of the trains and the platform requirements but averages approximately 6 ft in length. For platforms with multiple berthing locations, multiple marker boards are used.

On TTC's Yonge-University-Spadina and Bloor-Danforth lines, a set of three 6-in.-diameter circles of different colors are affixed to the platform wall. The train crew uses them to position the train. A red circle, at the train exit end of the platform, marks the stopping location for the train operator. A green circle indicates to the conductor that the train is properly berthed. The conductor uses an orange circle to define the duration of train departure observation; this is discussed further at the end of this chapter.

Unstaffed systems verify proper platform alignment through sensors that serve as inputs to computerized train control systems. BC Transit is investigating the use of infrared sensors at the ends of the platforms to ensure accurate train berthing and further enhance safety.

## Door Operation

The four staffed systems operating with automatic door opening controls have speed and brake sensors operating in

**TABLE 9 Summary of door control operating systems**

| Transit System | Sys. Type | Crew Size | Normal System Control | Door Open Control | Door Close Signal/ Announcement | Nominal Dwell Time (Sec) | Observation During Departure |
|---|---|---|---|---|---|---|---|
| BART | HR | 1 | Auto | Auto | Announcement | 15 | Y - Direct |
| LA-HR | HR | 1 | Manual | Manual | Chime | 10 | Y - Mirror |
| LA-LR | LR | 1 | Manual | Manual | Announcement | 15 | N |
| CTA | HR | 2 | Manual | Manual | Announcement | 15 | Y |
| GCRTA-LR | LR | 1/car | Manual | Manual | Announcement | 15 | Y - Mirror |
| GCRTA-HR | HR | 1 | Manual | Manual | Chime | 15 | N |
| MARTA | HR | 1 | Auto | Manual | Announcement | 15 | N |
| MBTA | HR | 2 | Manual | Manual | Chime | 15 | Y |
| Toronto-Scar | HR | 1 | Auto | Auto | Announcement | 15 | N |
| Toronto-HR | HR | 2 | Manual | Manual | Annou + Whistle | 15 | Y |
| NYCTA | HR | 2 | Manual | Manual | Announcement | 10 | Y |
| PATH | HR | 2 | Manual | Manual | Chime | 15 | Y |
| BC Transit | HR | 0 | Auto | Auto | 3 Chime | 10 | N/A |
| Jacksonville | HR | 0 | Auto | Auto | Annou + Chime | 15 | N/A |
| Miami-HR | HR | 1 | Auto | Manual | Announcement | 15 | N |
| Miami-PM | PM | 0 | Auto | Auto | Announcement | 15 | N/A |
| WMATA | HR | 1 | Auto | Auto | Annou + Chime | 12 | N |
| Baltimore-LR | LR | 1 | Manual | Manual | Chime | 15 | Y - Mirror |
| Baltimore-HR | HR | 1 | Auto | Manual | 2 Chime | 15 | N |
| SEPTA-Orange | HR | 1 | Manual | Manual | Announcement | 15 | N |
| SEPTA-Blue | HR | 2 | Manual | Manual | Announcement | 15 | Y |
| PATCO | HR | 1 | Auto | Manual | Buzzer | 15 | N |
| Edmonton | LR | 1 | Manual | Manual | Chime | 20 | Y - Mirror |
| Calgary | LR | 1 | Manual | Manual | Chime | 15 | Y - Mirror |
| Metro-North | HR | 2+ | Manual | Manual | Annou + Chime | 30 | N |
| Sacramento | LR | 1 | Manual | Manual | Chime | 20 | Y - Mirror |
| PAT | LR | 1/car | Manual | Manual | Chime | 20 | Y - Mirror |
| SF MUNI | LR | 1/car | Auto/Man | Manual | Chime | 30 | Y - Mirror |
| LIRR | HR | 2+ | Manual | Manual | Annou + Chime | 30 | N |
| Montreal | HR | 1 | Auto | Auto | Chime | 15 | Y - Mirror |

conjunction to verify that the train is stationary before the doors are opened. In addition, the system controls at Montreal allow the doors to be opened only if the train speed is under 1.5 mph. At WMATA, the control system verifies that zero speed has been obtained and the brakes are applied before the command to open the doors is acted upon. For the systems not staffed, multiple control and feedback signals are all received by the train control computers before initiation of door opening.

All manually controlled systems require the operator to activate controls to open the doors. For systems operating with two-person crews, the crew member responsible for door operation is first required to insert and turn a key, which provides system control to the specific panel, and to then push individual door-open buttons. Nearly all single-person crews press the door control button after the train has stopped and then open the cab window to observe the platform. On Baltimore's heavy rail system, the operator opens the cab window and observes the platform before opening the doors.

## Platform Observation

All staffed operations require the operator to observe the platform and the car side doors while boarding is underway. For heavy rail systems, the most common approach is by unaided visual observation through the operator's cab window. Figure 59 depicts a conductor at MTA-NYCT observing rear car side doors. This technique enables the operator to evaluate boarding most effectively.

At stations where the operator cannot view the entire length of the train, aids have been installed to expand the conductor's field-of-vision. Many of the transit systems, especially older ones, have stations with concave platform edges. At the time of system design, the surrounding structures and existing building techniques, combined with the prevailing operational methodology of having one crew member per rail car, resulted in the construction of platforms with sometimes severe curvatures. To compensate for the obstructions created by the curves, transit systems have employed mirrors or CCTV. When employed properly and consistently, these aids allow the train crews to make informed decisions regarding door status.

At all the light rail systems observed, vehicle- and/or platform-mounted mirrors are provided for the operator to view the doors. Because most light rail vehicles have cabs with centrally located operators, these mirrors allow the operator to view the doors without leaving his or her position to look out a window.

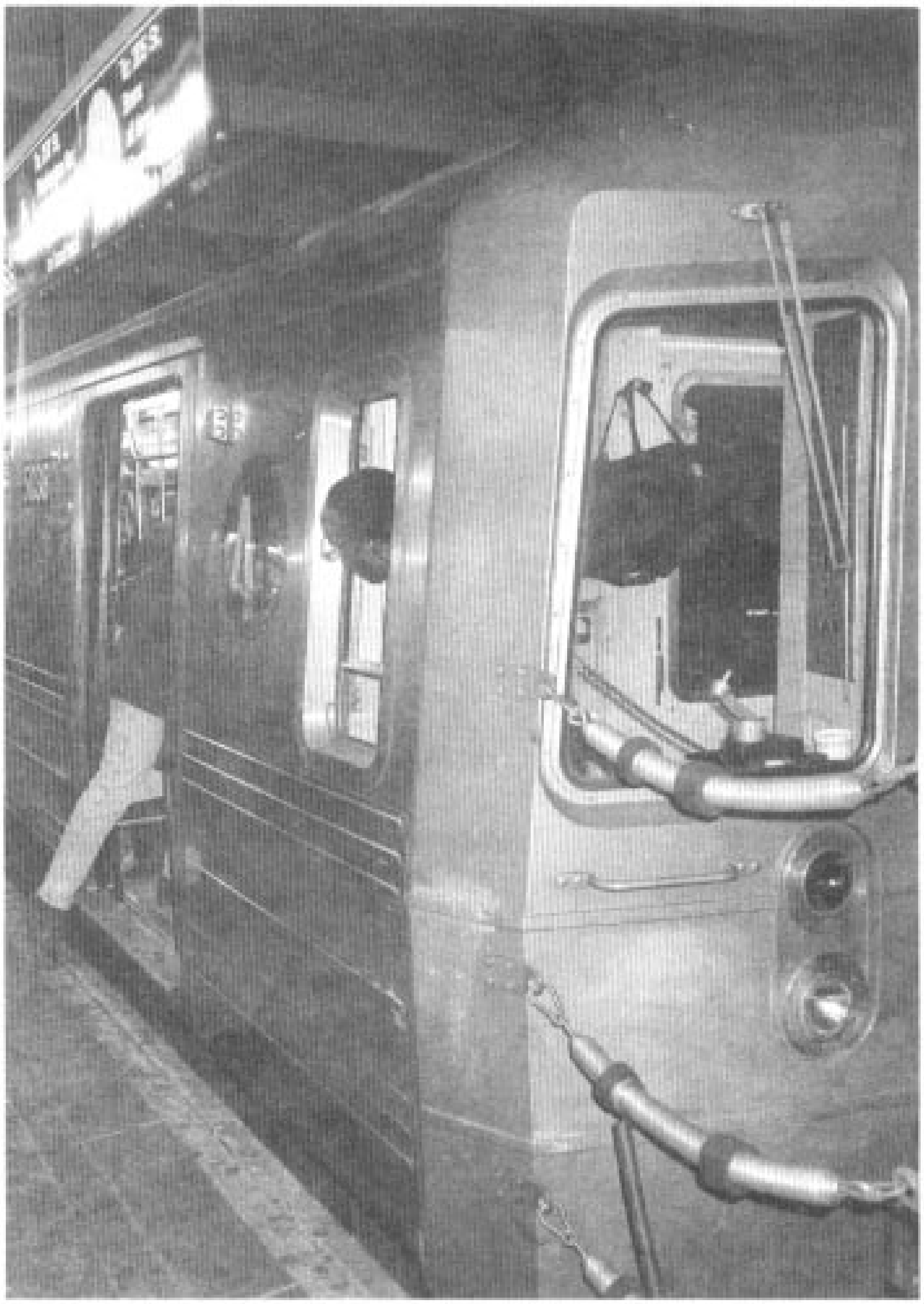

*Figure 59. MTA-NYCT conductor observing rear car side doors.*

For unstaffed operations, platform-mounted CCTV cameras are continuously observed by personnel in a central operations control center. At BC Transit, each station contains at least two cameras, which are used to ensure the safety and security of the passengers. Personnel at the center can take immediate action in train operation if any condition so warrants, whether it be for an extension in time to the automatic station dwell time, or for any emergency condition. In most cases, door operation alarm signals are interconnected to video signal switching matrices to instantly display video images on control center monitors. This allowsthe control center operators to assess the situation rapidly and respond accordingly.

### Station Dwell Time

At all staffed operations, operators observe the doors until passenger boarding is complete. Table 9 includes dwell time indications for the transit properties that provided this information. In these cases, the dwell time is defined as the time between door opening and when the door interlocked signal is received. For staffed systems, the dwell time can vary according to passenger loads. During the site visits, the researchers observed dwell times as short as 5 secs at outlying stations during off-peak hours.

In Calgary, the train control system has a minimum 15-sec door open interval—this is implemented by the train control system and cannot be reduced by the operator. For the BC SkyTrain system, the station dwell time is under computer control and nominally set at 10 sec. As operational conditions and passenger loadings warrant, the dwell time can be adjusted on a real-time basis by control center personnel observing the platforms through a series of CCTV cameras.

### Door Closing—Warnings and Announcement

After the crew member responsible for door operation has determined that boarding is complete, the crew prepares to close the doors. On several staffed systems, the operator makes an announcement over the public address system. On MTA-NYCT, the conductor is instructed to announce "Stand clear of the closing doors, please." After making the announcement, the operator returns to the door viewing area to close the doors. On MTA-NYCT and other systems with two-zone door control systems, the conductor must first look in one direction and close the doors. After the indicator lights have gone out, the conductor observes the other zone and closes the doors. For several transit properties, removal of the conductor's key from the door control panel provides a signal to the train operator that it is clear to proceed. In other cases, the conductor presses a button to activate a buzzer notifying the train operator to proceed.

Toronto's TTC is somewhat different because the train conductor uses a whistle to provide warning on the platform that the doors are about to close. Once the doors on Toronto's Yonge-University-Spadina and Bloor-Danforth lines are ready to be closed, the conductor looks to the rear, blows a whistle, and closes the door. This process is repeated for the doors forward of the designated location.

Most other systems use automatically generated warning tones or announcements played through speakers on the interior of the vehicles. While these audio cues can be heard on the platform, this is incidental and is at reduced levels. Once an operator has determined the doors are clear to close and the door-close button has been pressed, the audible chime is heard, followed by the physical closing of the doors. The tones provide a clear notification to passengers that the doors are closing and are superior to public announcement by the crew member responsible for door operation, because such announcements may not be clear or heard by passengers, especially on crowded trains.

### Closed Door and Platform Observation

After door closure and interlock signals have been received, the operator makes a final check of the doors to ensure no passenger or object is caught between the panels. After final check of the doors, single-person crews on heavy rail systems (depending on the control system) can 1) close the cab window and press the return to automatic operation button (e.g., WMATA, BART, and Montreal) or 2) return to the train control panel to resume manual operations (e.g., GCRTA Red and SEPTA Orange lines). On these systems, the operator generally does not or cannot observe the station platform as the train departs. The exception is BART, where the operator views the platform for a short distance, generally one to two cars in length.

For light rail operations, the operator performs a final check of the doors before initiating departure from the station. At Calgary, there is a 3-sec delay in the train control system between when the doors are closed and locked and when the operator can initiate train movement. The operator is notified by two separate audible signals of each event. During this time, the operator is instructed to observe along the side of the car for passengers near or possibly caught in a door.

Light rail operations with car-mounted mirrors allow operators to continue observation of the platform as the train departs. If the light rail system is interacting with automobile traffic, the observation time is shared with, and generally takes a back seat to, forward viewing requirements.

For two-person crews, the crew member responsible for door operation is instructed to observe the platform as the train departs the station for a specific distance, generally three car lengths. When the conductor is in the center of the train, multiple views fore and aft are generally required until the train has departed the station or a prescribed distance has been covered. In addition to the required viewing distance of three car lengths, MTA-NYCT requires the conductor to observe both sections of the train at least twice while the train is departing the station. At CTA, the conductors are instructed to look forward to avoid being struck in the head by disgruntled passengers as the train departs the station.

On Toronto's Yonge-University-Spadina and Bloor-Danforth lines, the orange circle on the wall of the station indicates where the conductor can cease observations. At this point, the conductor pulls his or her head inside the vehicle and closes the cab window.

### Additional Safety Systems

Several rapid transit systems have employed various technologies to ensure passenger safety when boarding trains or waiting on the platform. Some of these systems provide detection devices to warn operating personnel of dangerous conditions. On the BC Transit SkyTrain, a unique track intrusion sensor has been installed that operates in the proximity of the stations. The Platform Intrusion Emergency Stop system (PIES) is a vibration-based sensing device. When a person or object enters the trackbed, sensors generate signals that are sent to the control center, and train movements within the general area are automatically halted.

On Jacksonville's Skyway a series of openings in a fence rail system along the edge of the platform align with the doors of the trains. The railing prevents passengers from approaching

**TABLE 10 Summary of door operating systems**

| Transit System | Sys. Type | Crew Size | Observation Location | Zone/ Single | Door Edges | Reaction to Obstruction |
|---|---|---|---|---|---|---|
| BART | HR | 1 | Lead Car | All | | |
| LA-HR | HR | 1 | Lead Car | All Release | Y | Close |
| LA-LR | LR | 1 | Lead Car | All | Y | Close |
| CTA | HR | 2 | Mid Consist | Zone | Y | Open/Close Repeat |
| GCRTA-LR | LR | 1/car | Per Car | Zone | Y | Open |
| GCRTA-HR | HR | 1 | Lead Car | All | N | Maintain Press. |
| MARTA | HR | 1 | Lead Car | All | - | - |
| MBTA | HR | 2 | 2 cars from Rear | Zone | - | - |
| Toronto-Scar | HR | 1 | Lead Car | All | - | - |
| Toronto-HR | HR | 2 | 2 cars from Rear | Zone | - | - |
| NYCTA | HR | 2 | Mid Consist | Zone | N | Maintain Press. |
| PATH | HR | 2 | Lead Car - Aft | Zone | - | - |
| BC Transit | HR | 0 | Not Staffed | All | Y | |
| Jacksonville | HR | 0 | Not Staffed | All | Y | Open/Close 3 Times |
| Miami-HR | HR | 1 | Lead Car | All | Y | Open/Close |
| Miami-PM | PM | 0 | Not Staffed | All | Y | Open-10Secs/Close |
| WMATA | HR | 1 | Lead Car | All | N | Maintain Press. |
| Baltimore-LR | LR | 1 | Lead Car | All Release | - | - |
| Baltimore-HR | HR | 1 | Lead Car | All | Y | Open/Close Repeat |
| SEPTA-Orange | HR | 1 | Lead Car | All | - | - |
| SEPTA-Blue | HR | 2 | Mid Consist | Zone | - | - |
| PATCO | HR | 1 | Lead Car | All | N | Close |
| Edmonton | LR | 1 | Lead Car | Single | Y w/Photoeye | Open |
| Calgary | LR | 1 | Lead Car | Single | Y w/Photoeye | Open/Close |
| Metro-North | HR | 2+ | Multiple | Zone | N | N/A |
| Sacramento | LR | 1 | Lead Car | All | Y w/Photoeye | Stop/Close |
| PAT | LR | 1/car | Lead Car | Zone | Y | Open-1Sec/Close |
| SF MUNI | LR | 1/car | Lead Car | Zone | Y | Open |
| LIRR | HR | 2+ | Multiple | All/Zone | N | Close |
| Montreal | HR | 1 | Lead Car | All | Y | Maintain Press. |

the edge of the platform where no doors will be positioned when a train is properly berthed. There are two sets of photoeyes in the openings in the railing gate to detect when persons are present and no train is present. This system was described in the preceding chapter of this report.

## OPERATIONAL CONTROL SYSTEMS AND PROCEDURES

### Door Control Location

Table 10 lists the characteristics of door control systems for 17 systems visited during the study as well as 13 systems that responded to the questionnaire. For those systems using singleperson crews, the door functions are controlled by train operators in the lead cars. For one-person systems where the trains berth on either the right or left side of the platform and the doors open automatically under the train control system (e.g., WMATA and BART), the operator is not required to move to the opposite side of the cab before the doors open. However, the operator must observe the doors from the appropriate side before closing the doors. At particular stations in these systems, the platform is on the opposite sideof the train console location. To observe the car side doors, the operator must move to a position on the platform side. Once the operator sees through the cab window that the side doors are clear, a set of door controls on the respective side of the cab enables the operator to activate the door closure controls safely while observation continues.

On SEPTA's Orange line, the doors are controlled manually by the train operator. For center-island platforms, the train operator must move from the control position on the right side of the cab to the left side to operate the doors. This causes delays of approximately 4 sec in opening the doors after the train has come to a stop in the station. There is an equivalent delay in the initiation of train movement while the operator returns to the console.

In light rail vehicle operations at Maryland MTA, the cab console is in the center of the full-width cab. On the LACMTA and GCRTA light rail operations, the cab console is slightly to the left of the vehicle center line. Figure 60 illustrates the GCRTA's light rail cab console layout and shows the offset to the left side of the car. In both scenarios, the operator can perform all door control functions from the seated location. Side-door observation is performed using mirrors on both sides of the outside corners of the cars.

*Figure 60. GCRTA light rail vehicle cab console layout.*

On Baltimore's MTA light rail line, large convex mirrors are installed on the platforms to assist operators in side-door observation. These mirrors, used in conjunction with vehiclemounted mirrors, provide superior views of the vehicle sides. At some multiple light rail vehicle operations (e.g., GCRTA, PAT, and SF Municipal), the consist operates with one conductor per light rail vehicle for observation, door control, and (for GCRTA) fare collection.

For all two-person crew operations, the conductor or guard operates the doors. The location from which the conductor operates the door controls and observes the car side doors varies considerably among the transit systems visited. For MTA-NYCT, SEPTA's Blue line, and CTA, the conductor is close to the center of the consist. This allows the conductor to observe the sides of both ends of the train over the shortest distance possible. The door control panel at MTA-NYCT is in an enclosed cab. The cab door is secured when the conductor is operating the doors.

Most conductors can operate the door controls by feel and intuition, even with their heads out the windows to observe. Figure 61 illustrates a common MTA-NYCT door control panel and its proximity to the conductor's cab window. For CTA, the door control panel is on the side wall of the cab at the head end of the designated car. It is not in a cab enclosure but next to the side window to allow the operator to observe the side doors. Master control of the panel is provided via a key switch on the panel. Separate door controls are directly across the width of the car to allow the conductor to perform the necessary door control and observation tasks with platforms on either side of the train.

For MBTA and TTC (Yonge-University-Spadina and Bloor-

*Figure 61. MTA-NYCT door control panel.*

Danforth lines), the conductor is generally two cars from the trailing end of the train. TTC consists always have six cars; MBTA operates four or six cars throughout the day. On TTC, train operators and conductors are cross-trained and switch positions and associated responsibilities each time the train reaches the end of the line.

The conductor for each two-person crew at PATH is in the rear of the first car for safety and communication purposes. The keyed door control panel is on the side wall in the passenger area and not within a cab enclosure. For right-side platforms, the conductor employs the control panel in the lead end of the second car.

### Door Operations

For all single-person crew heavy rail operations, door operation controls and indicators are trainlined. Separate door-open and -close controls are provided for each side of the train, and these controls affect all doors on the respective side of the vehicle. For two-person crew heavy rail systems, the doors are zoned relative to the position in the consist of the person responsible for door operation. Separate controls operate the doors fore and aft of this location. By segmenting the doors into two zones, the conductor's workload is eased and more effective observation can be made.

For light rail systems, the front set of doors is generally operated independently of the rear doors. On GCRTA, the operator in each light rail vehicle has controls to open and close the first set of doors separately from the rear two sets. The operator directly observes the front doors before mirror observation and closure of the two rear doors. At LACMTA, Maryland MTA, Calgary, Edmonton, and SF Municipal (subway operations), the door interlocks are released by the operator on arriving at a station. Passengers can then open individual doors by pressing a button or strip next to the specific door on the outside of the car or on the inside of the car. The train operators also can open all doors with a single button. The train operator closes the doors after observing the side doors. Demand-based door controls are beneficial because they limit the number of doors open on the vehicle and can help prevent people from running to enter the train at the last minute.

At SF Municipal, the front doors are constructed with low stairs for surface and street operation only. An operator in each car independently controls the open and close operation of the front doors. The rear doors contain high stairs for subway operations and have trainlined controls. These doors operate using the release interlock methodology described above. On the Baltimore MTA's high-floor light rail vehicles, the front doors are equipped with special car floor platforms to enable mobility-impaired passengers to use the rail system. The stations have special platforms with ramps to raise passengers to the proper elevation. These access platforms are operated only by the train operator. The use of the platform requires the operator to exit from the cab into the passenger area to physically position the platform for passenger ingress and egress. After the passenger has entered or exited and the platform has been returned to its stored location, the operator returns to the cab to resume operations.

Door control for the BC Transit SkyTrain, Jacksonville Skyway, and Metro-Dade Metromover unstaffed systems is managed by the train control systems. All doors on a side are opened and closed simultaneously for all three systems.

## DOOR SAFETY OPERATIONS

### Door Interlock Control Systems

For the rapid transit systems visited and those responding to the questionnaire, all door control systems have interlocks that interact with the train control system. As a result, the train doors cannot be opened if the train is moving. If the doors are open at a station, the propulsion system of the train cannot be activated, the brake system cannot be released, or both. Some minor variations exist among the transit authorities, because of specific car designs and the overall train control operation. For example, at Calgary, the train will not operate if the doors are open. If the train speed is greater than 5 kph, the doors of the light rail vehicle will not open. If the drive command is initiated before the door cycle is completed, the main circuit breaker is opened, and visual and auditory warning devices are activated in the train operator's cab.

### Door Pushback

During normal train operation and movement, the doors are interlocked with the train control system. Several transit systems allow the door panels to be pushed open up to 6 in. per leaf. This feature enables passengers to extricate limbs or personal items stuck in the doors as they close. For most systems surveyed, the nominal pushback is approximately 3 in. As an example of door pushback, SEPTA's Orange line has doors that allow 6 in. of pushback. With two doors, the total opening provided by the pushback will be 12 in.

### Sensitive Door Edges

Most of the rapid transit systems reviewed during the program contain one form or another of sensitive edges in the doors. The area sensed, the sensitivity of the device, and the reaction of the control systems vary. When an obstruction is sensed between the door panels at CTA and Maryland MTA, the door control system immediately opens the panels and then automatically attempts to reclose them. If the obstruction remains after the doors have recycled, the panels reopen. This process continues until the object is cleared from the doors. The doors of the unstaffed operation of the Metro-Dade Transit's Metromover contain sensitive edges, which reopen, remain open for 10 secs, and then attempt to close. During the 10-sec delay, a warning message automatically plays inside the vehicle. The text of this message is "The doors are being held. Please clear the doors." For the unstaffed Jacksonville Skyway, the doors feature an obstruction sensing system that measures door actuator motor field current. When there is an obstruction, the current surges. This surge is detected and door recycling occurs. Three attempts will be made to recycle the doors before an alarm is generated and sent to the control center. The control center is equipped with video displays of each platform to allow personnel to assess the situation. As required, the control center operator can dispatch maintenance personnel to clear the doors or can initiate a control override.

At the unstaffed BC Transit SkyTrain, the edges of the doors contain pneumatic sensors. These sensors are set to an active state when the gap between the door edges is 350 mm (13.8 in). If an obstruction is encountered within this zone, the doors maintain their closing pressure for 2 to 3 secs. If the obstruction is not cleared, the doors open completely and then immediately attempt to close. This cycling occurs five times, after which the doors remain open. An alarm is sent to the control center and the train is disabled until service personnel arrive to determine the reason for door timeout. The Metro-Dade Transit's Metrorail employs air pressure wave technology for sensing an obstruction in the doors. If activated, the doors will continually recycle until the obstruction is cleared.

For GCRTA light rail operations, the doors are of the bifold design, with the doors opening outward. If an obstruction is sensed as the doors are closing, the lateral closing pressure (estimated at 30 to 40 lb) will be maintained for 2 to 3 secs. If the doors have not completely closed during this period, they recycle open. The train operator activates the close button after the doors have been observed and are determined to be clear.

In Calgary, the bifold doors on the light rail vehicles open inward to the car. A stanchion in the center of the passageway between the door panels contains a photoelectric sensing device approximately 6 in. above the car floor. It contains two photoeyes directed at reflective material mounted on the base of the bifold door. If an object is detected within this field, the doors cannot be closed. The door edges contain an air bladder device, capable of sensing an obstruction down to 0.4 in. (10 mm). If these sensors detect an object as they are closing, they will recycle open. At Edmonton Municipal, the door edges contain photoelectric eyes and sensitive edges. If obstructed, the doors reopen until the operator activates the close-door control button. If the doors are closed and an obstruction is sensed between the panels, the main propulsion circuit breaker will open if the train receives a drive command signal or if the train is traveling between 0 and 10 mph. Sacramento also contains photoeyes and sensitive edges, but they only halt he closing of the doors and the operator must manually recycle the doors.

At PAT, the sensitive door edges open the doors for 1 sec, then attempt to reclose. The Montreal door control system contains an electric signal device. If an obstruction is sensed, the doors maintain pressure on the object until the operator recycles the doors. For the LACMTA Red and Blue line operations, the doors pause if an object is encountered between the panels, allowing the object to be removed. On MTA-NYCT, most of the nearly 6,000 cars do not contain active sensitive edges. Three hundred R-62A cars do contain door obstruction sensing devices. In addition, the new technology trains that are under evaluation have automatic recycling of the door panels if an obstruction is sensed.

WMATA, GCRTA Red line, PATCO, Metro-North, and the LIRR do not contain sensitive edges or obstruction detection devices in their door control systems. If an object becomes trapped between the doors, there is no recycling of the doors. The electromechanical and pneumatic positioning devices acting on the door panels remain activated by the door control system. This maintains the pressure on the object trapped between the doors. The lateral pressure applied by the panels is substantial, although not severe enough to cause injury.

At MTA-NYCT and WMATA, the lateral pressure and mechanical design of the door mechanisms prevent pushback of the panels, making it difficult for passengers to clear an object caught between the panels. The train crew member responsible for door operation recycles the doors if the obstruction is observed. The crew members also recycle the doors if the control panel indicator light is not illuminated in an appropriate time, indicating that the side doors are not closed and locked. During the site observation at WMATA, a passenger failing to exercise due caution and taking an unnecessary risk, attempted to board the train after the doors had begun their closing cycle and became trapped between the panels. The passenger could not clear himself, so the operator had to recycle the doors.

At the time of the site investigation to GCRTA, the Red line did not contain any sensitive edge or obstruction detection devices in the door control systems. However, discussion with safety personnel indicated that internal investigations were underway to determine the feasibility of modifying the existing heavy rail cars to include some form of sensitive edges in the doors. It was expressed that inclusion of sensitive edges would satisfy primary concerns with door safety issues.

CHAPTER **3**

# FACILITY DESIGN AND ENVIRONMENTAL CHARACTERISTICS

## FACILITY DESIGN CONSIDERATIONS

Facility design can enhance passenger safety and train crew ability to observe the platform. In assessing the need for observation aids and what type to use, the following factors should be considered:

- Platform configuration,
- Station obstructions,
- Platform construction,
- Platform edge identification,
- Platform edge and door gap, and
- Platform lighting.

These factors are discussed in the following sections.

### Platform Configuration

Platform configuration is one of the most significant factors affecting rail car side-door observation. The influence of the platform configuration on door observation can be felt in two ways. Depending on the curvature of the platform edge, portions of the rail vehicle may be obscured from the train operator's view. Also, the platform configuration can affect passenger movements and behavior. Straight platforms provide the optimum design for observation. From the site visits and the questionnaire responses, it can be surmised that stations of more recently developed transit systems adhere to good design practices and include platforms with straight edges. Table 11 lists the general platform characteristics influencing rail car side-door observation at the 17 systems visited as well as 13 systems that responded to the questionnaire.

On BART, all stations have platforms with straight edges. This is beneficial because BART uses single-person crews with trains up to 700 ft long. This is also generally true for newer systems such as WMATA, MARTA, Baltimore's heavy rail operation, and the LACMTA Red line opened in 1993.

For the light rail systems visited and those that responded to the questionnaire, most platforms are configured in a straight line. At light rail systems having curved platforms, most have only one or two such stations. On GCRTA's Blue line light rail system, only one station (Farnsleigh), was observed as being curved. Because the curvature at this station is not severe, the train operator does not have to use an aid to observe the doors.

During the site investigations, many stations with curved platforms were observed. In most cases, the severity of curvature affected the operational procedures and observation techniques employed by the systems. Two stations on the CTA system were observed as requiring observation aids because of the severe concave curvature of the platform. When a train is berthed on the southbound side of the Loyola station on the Howard-Dan Ryan line, curvature requires the use of multiple observation aids—mirrors are used to assist the conductor in observing the passenger loading of the forward cars (see Figure 62) and CCTV is used to provide observation of the rear cars.

At the Addison station on the O'Hare-Congress-Douglas line, the eastbound side of the platform requires the use of a mirror to observe the rear cars. In another case on CTA, the extent of curvature in a station limits how much the platform is used. The Chicago Avenue station on CTA's Ravenswood line exhibited the most significant curvature of all stations seen during the site visits. Because of the extent of the curvature, only approximately half of the platform is used to ensure that the conductor can see the entire length of the train. If this limitation did not exist, trains of twice the length operated could be berthed in this station.

The PATCO transit system has a single above-ground station that is curved to the extent that observation aids are required. This station, in Haddonfield in southern New Jersey, employs CCTV as the sole means of door observation on both the eastbound and westbound platform sides. PATCO's Woodcrest station also uses mirrors; however, they are used where a single track is serviced by platforms on both sides.

At PATH's Journal Square station in Jersey City, the edge of the platform adjacent to Track 4 is an S curve. The initial section of the platform edge from the conductor's location in the back of the first car is slightly concave relative to the plane of the rail car side. From approximately the fourth car back, the curvature becomes concave. Starting with the sixth car and through to the end of the train, the platform again is concave.

Observation problems on this platform are compounded by station structures that make it difficult to see the last car of the train. Two mirrors have been installed adjacent to the conductor's position to provide visibility of the car doors in the convex portion of the platform curve. These mirrors are installed at the conductor's position at the eight- and seven-car stop markers.

Observation difficulties in this station are compounded by dawn and dusk lighting conditions because of the east-west orientation of the station. At times, the ambient light level at one end of the station is very high. Because of the extreme conditions at this location, the researchers used it for the mirror and CCTV demonstrations described in this report.

**TABLE 11 Summary of station and platform configurations**

| Transit System | Qty Stations | Subway/ Grade/ Elevated (percent) | Platform Straight/ Curve/ Mix | Concave/ Convex/ Both | Stations Concave (Percent) | Degree of Platform Obstruction | Platform Edge Identification |
|---|---|---|---|---|---|---|---|
| BART | 34 | 33/33/33 | STR | - | - | Minimal | Yellow-Detect |
| LA-HR | 19 | 5/95/0 | STR | - | - | Minimal | Yellow-Detect |
| LA-LR | 5 | 100/0/0 | STR | - | - | Minimal | Yellow-Detect |
| CTA | 142 | 25/60/15 | MIX | Concave | 2 | Minimal | Yellow Stripe |
| GCRTA-LR | 29 | 5/95/0 | MIX | Both | 5 | Minimal | Stripe/Det |
| GCRTA-HR | 18 | 17/83/0 | STR | - | - | Minimal | Stripe/Det |
| MARTA | 33 | 48/48/4 | STR | - | - | Minimal | Yellow Stripe |
| MBTA | 50 | 33/63/4 | MIX | Both | Minimal | Minimal | Stripe |
| Toronto-Scar | 6 | 0/0/100 | STR | - | - | Minimal | Stripe |
| Toronto-HR | 60 | 70/30/0 | STR | - | - | Minimal | Stripe |
| NYCTA | 469 | 59/8/33 | MIX | Both | 20 | Med - 10" min | Yel Str/Det |
| PATH | 13 | 65/20/15 | MIX | Both | 5 | Medium | Yel Str/Det |
| BC Transit | 17 | 20/20/60 | STR | - | - | Minimal | Yel Str/Det |
| Jacksonville | 3 | 0/0/100 | STR | - | - | None | Yellow-Detect |
| Miami-HR | 21 | 0/0/100 | STR | - | - | None | Yellow-Detect |
| Miami-PM | 9 | 0/0/100 | STR | - | - | None | Yellow Stripe |
| WMATA | 70 | 50/30/20 | MIX | Both | 4 | Minimal | Flashing Lights |
| Baltimore-LR | 24 | 0/100/0 | STR | - | - | None | Stripe |
| Baltimore-HR | 12 | 50/25/25 | STR | - | - | None | Stripe |
| SEPTA-Orange | 26 | 95/5/0 | STR | - | - | Medium | Yel Str/Det |
| SEPTA-Blue | 36 | 40/0/60 | STR | - | - | Medium | Yel Str/Det |
| PATCO | 13 | 40/40/20 | MIX | Concave | 10 | Minimal | Stripe |
| Edmonton | 10 | 38/62/0 | STR | - | - | None | Stripe |
| Calgary | 30 | 10/80/10 | MIX | Both | 10 | Minimal | Yellow Stripe |
| Metro-North | 118 | 2/98/0 | STR | - | - | Minimal | Yellow Stripe |
| Sacramento | 28 | 0/100/0 | MIX | Convex | 5 | None | Yellow Dots |
| PAT | 15 | 10/85/5 | STR | - | - | None | Stripe |
| SF MUNI | 9+ | 29/71/0 | MIX | Concave | 10 | None | Yellow-Detect |
| LIRR | 134 | 3/75/22 | MIX | Both | 4 | Minimal | Yellow Stripe |
| Montreal | 65 | 100/0/0 | STR | | | None | Yellow Stripe |

More than 20 percent of MTA-NYCT's 469 stations have curved platform edges. The extent and type of curvature vary considerably among the approximately 100 stations affected. Several of the concave platforms are limited in curvature, and, as such, do not require any type of observation aid.

Figure 63 shows a concave platform on the limits of requiring an observation aid. With the operator in the center of the train, he or she can observe the side doors fore and aft of the door control panel. Conditions in other stations necessitate the use of one or more mirrors to assist the conductor in observing the car side doors.

A smaller number of stations have such severe platform curvature that the use of CCTV is necessary to provide the needed field-of-view.

## Station Obstructions

Table 11 provides a general assessment of the extent of the platform obstructions noted on 30 mass transit systems. The information in the table is based on the researchers' observations during the site visits and general assessments made by the persons responding to the questionnaire.

Most of the newer transit systems with generally straight platforms have few obstructions within 2 to 3 ft of the platform edge. Most do have, to some extent, passenger stairways and escalators within 4 to 5 ft of the edge.

Figure 64 illustrates the location of access stairways in a station on SEPTA's Orange line in Philadelphia. As discussed in the section on general observation requirements, the train crew may be able to view the area clearly 2 to 3 ft in front of the side doors but may not be able to observe passengers running to board the train from nearby stairways or escalators that do not face their location.

Older transit systems, especially those operating underground, have many obstructions that restrict the field-of-view of the train crew member responsible for door operation. Columns next to the edge of the platform are the most common obstructions.

Minimal spacing between the columns can further restrict the train crew's ability to observe the doors. MTA-NYCT has columns as close as 10 in. to the platform edge (see Figure 65). Above-ground and elevated platforms generally have some form of canopy, light stanchion, or both. These columns, which are generally not spaced as densely as building support columns, are set back farther from the edge and, therefore, do not obstruct the operator's required viewing area as severely as underground designs (see Figure 66).

Passenger movement on a platform can obscure an operator's field-of-view. Individuals who stand next to a train or exit the

*Figure 62. CTA mirrors/CCTV observation at Loyola station.*

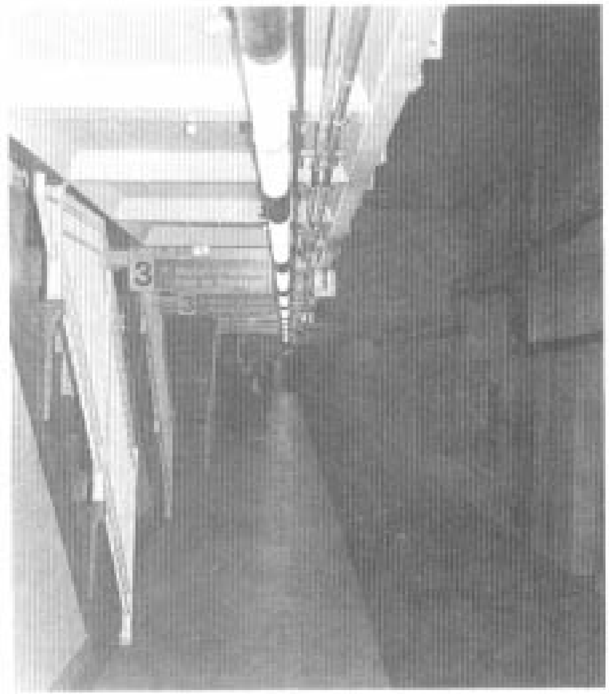

*Figure 64. SEPTA station with limited platform access.*

platform along the side of the train obscure the observation of the side doors. Figure 67 shows passengers next to the train, limiting the operator's field-of-vision and ability to observe the doors adequately.

*Figure 63. MTA-NYCT 55th Street station (B line) with minor curvature.*


*Figure 65. MTA-NYCT columns close to platform edge.*

### Platform Construction

The platforms observed during the site visits are built from three types of construction materials. The most prevalent type is poured concrete with expansion joints as needed. The general condition of those platforms seen ranged from good to excellent.

The second most common platform design uses tile surfaces. Various tile materials are used, with the design principally a rectangle or octagon. This is normally found only in underground stations, primarily on newer systems and at some recently renovated platforms. Wood was used on a few older transit system operations (such as CTA as shown in Figure 68) and in a few elevated stations.

### Platform Edge Identification

Clear identification of the platform edges serves several passenger safety purposes. Such identification physically and psychologically establishes the line behind which passengers should stand when a train is not within the station (see Figure 69, which shows an MTA-NYCT station). A bright color highlights the demarcation of the platform edge for passengers by defining the gap between the platform and the door of the train. The physical design and construction of the warning area can influence passengers to stay away from the edge of the platform when leaving the station—this results in an unobstructed area along the train, which assists the operator in determining if the doors are clear before closing. As discussed earlier, passengers standing near the edge of a train can obscure the view of the crew member responsible for door operation. Figure 70 illustrates a passenger departing the station in MARTA, away from the edge of the platform and the area marked by the edge warning design, allowing the operator a clear view of the side of the train.

All platforms at all transit systems visited have some form of edge identification. The change in color, the type of surface material, and the physical design varied significantly among the many transit systems. Variances from one station to the next were noticed on many lines.

The most commonly used edge warning system is a yellow line painted on the existing surface along the entire edge of the platform. It can range in width from 4 to 12 in. At some MTA-NYCT stations, the single line along the edge is supplemented with an additional warning line 2 ft from the edge, as illustrated in Figure 71.

On the LACMTA Red line, the edge of the platform is an 18-in.-wide, unpainted concrete slab. This differs from the rest of the platform, which is tiled flooring. The LACMTA Blue line light rail system uses 18-in.-wide, scalloped concrete slabs for warning area identification, as seen in Figure 72.

At Toronto, an alternating yellow and black striped line set 2 ft from the edge is used to caution passengers. The unstaffed BC SkyTrain platform edges contain high-contrast yellow ep-

*Figure 66. CTA Addison station with minimal platform column obstruction.*

*Figure 67. Passengers obscuring operator's view of car side doors.*

oxy tactile safety strips along the entire platform length. The tiles are 4 in. wide and are set back from the platform edge approximately 1 ft. As mandated by the requirements of the ADA, most rapid transit systems visited had warning tiles installed along the edge of the platform. These tiles are commonly referred to as tactiles.

Figure 73 shows a close-up layout of the tiles along the edge of the platform on the Maryland MTA's heavy rail line. The 1- by 1-ft tiles are made of heavy rubberized material in bright yellow with raised, 1-in.-diameter, truncated domes.

When walking on these tiles, people can feel the rough surface through their shoes. Most passengers find this uncomfortable to walk or stand on and will naturally step away from the tiles. Because of the relatively low height and close spacing of the truncated domes, tripping on the tiles is unlikely.

The tactiles were generally observed along the edges of the platforms of newer rapid transit systems and at recently renovated stations of older systems. Some variation was observed in the patterned layout of the tiles. At BART, a series of six black tiles were regularly intermixed with the standard yellow tiles. This particular patterned spacing, as seen in Figure 74, coincides with the location of the passenger doors when a train is properly berthed at a station.

Figure 75 illustrates an alternate approach used on the Metro-Dade Metrorail line, where additional tiles have been installed at the corresponding door locations along the platform. The 4- by 6-ft area can be readily detected by visually impaired passengers. The advance detection of the anticipated door opening location reduces the uncertainty of passengers and the time required for boarding through the opening. It also minimizes the potential for mistaking the gap between the cars as an entrance to the train.

WMATA uses a unique platform edge identification and warning method. Embedded in the 2-ft-wide, flame-cut, granite slab along the edge of the platform is a series of level lights. The lights are visible through thick glass enclosures and are readily accessible from below by maintenance personnel. The 6-in.-diameter housings are spaced every 5 ft, as exhibited in Figure 76.

In operation, the lights remain continuously lit at a constant illumination when no train is at or approaching the station. Approximately 10 sec before a train enters the station, the lights begin flashing, alternating between the low level illumination and a higher level of illumination. The lights continue to flash while the train is berthed at the platform and stop flashing once the train has left the station.

### Platform Edge and Door Gap

The distance between the edge of the door of the train and the edge of the platform can create a serious hazard if the gap

*Figure 68. CTA outlying station with wood platform.*

*Figure 69. Passenger waiting behind platform edge warning.*

*Figure 70. Passenger walking next to platform edge warning.*

is large. It can slow boarding because passengers must be careful to step over an extra wide gap. Wheelchair-bound persons may find it difficult to cross the gap without assistance. Baby strollers can become caught in the gap, although the transit systems commonly recommend that passengers should hold children in their arms and should fold and carry strollers.

The size of the gap varies among the numerous systems observed. It was generally observed to be a function of car design, condition and age of the platform, and, most of all, the curvature of the platform. The average gap ranged from 2 to 3 in. for straight line platforms. In selected instances, platform curvature created a gap of 6 in.

The most serious gap distance exists at MTA-NYCT on the last southbound station of the Number 1/9 line. The South Ferry station includes a continuous reversing loop that results in the train being on a 180° curve when properly berthed. Because of the severe curvature of the platform, the gap between the platform and the rail car doors approaches 1 ft. To compensate for this, moveable platform extensions are at every door location (see Figure 77). When a train arrives at a station, the movable section of the platform is extended before the conductor opens the doors. The pneumatic extensions are retracted by sensor detection after the doors are closed and the train has begun leaving the station.

Most transit systems attempt to minimize the distance between the doors and the platform edge. Some platforms were

Figure 71. MTA-NYCT double line edge marking.

Figure 72. LACMTA Blue line scalloped concrete detectable edge warning.

observed with wood secured along the outer edge face to minimize gap distances.

On the BC Transit SkyTrain, the gap is held to 2 in. or less along all platforms of the entire line. Many transit systems attempt to maintain passenger awareness of the gap by posting signs and providing pamphlets advising passengers of the danger. BC Transit SkyTrain's passenger safety and security brochure contains the statement "MIND THE GAP. When boarding or leaving a train, be aware of the small gap between the train and the platform."

## Platform Lighting

Illumination can be expressed in terms of a foot candle (fc), which is the illumination on a surface one square ft in area on which there is a uniformly distributed flux of one lumen. A lumen represents one unit of the time rate of flow of light.

Minimum levels of illumination are required along platform edges to ensure proper observation by train crews. This is especially true for systems where an operator views the side doors over a lengthy distance. Levels of illumination below acceptable limits can seriously impair an operator's vision and the resulting determination of whether the doors are clear before and after closure.

For stations underground and enclosed from external environmental influences, minimum levels of lighting can be established and readily maintained throughout all hours of operation. For above-ground platforms, exposure to changes in illumination from environmental factors can complicate the ability to maintain these levels. Platform layout, configuration of canopies and lighting, reflectivity from the platform surface and surrounding structures, and general weather conditions all affect the intensity of platform brightness as perceived by the operator. Light reflecting from surrounding structures and sides of train cars can impair an operator's vision and must be considered.

Numerous transit systems have established minimum levels of light for station platforms. At Calgary, 15 to 20 fc on average are required at downtown stations. For outlying stations, 10 fc on average are required on the platforms. PAT requires a slightly lower level—5 fc, where Edmonton has established levels of 10 fc as acceptable illumination at station platforms. Montreal used 25 fc but recently increased the standard to 27 fc. MTA-NYCT uses 7.7 fc for open platforms and 10.8 fc for covered stations.

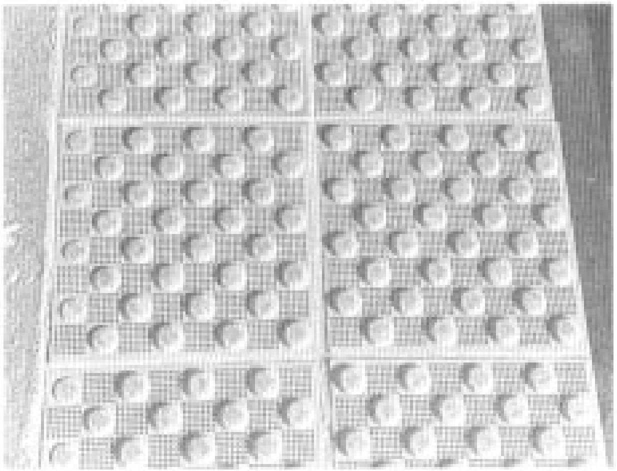

*Figure 73. Detailed view of detectable edge warning at Maryland MTA Red line.*

*Figure 74. Patterned spacing of detectable edge warning tiles at BART.*

*Figure 75. Metro-Dade Metrorail door positioning detectable tiles.*

Various lighting types are used throughout the industry. Fluorescent and sodium vapor are the most commonly used lights, estimated at 80 percent. Incandescent, tungsten, halogen, and various others make up the remaining 20 percent of installed platform lighting systems.

Lighting fixtures for underground stations are generally in the ceiling and near the platform edge. This concentrates the greatest amount of illumination along the edge of the platform. At WMATA's underground platforms, two sets of fluorescent lighting fixtures are employed to illuminate the station. One set is at platform level along the outer wall and reflects light off the outer wall into the station. A second set of fluorescent lights is at platform level between the two sets of tracks and directs light upward toward the ceiling, where it disperses to the rest of the station.

During the mirror and CCTV demonstrations at PATH, lighting levels, along the full length of the platform, were measured at various times of the day. In general, the lighting on the platform was relatively inconsistent and there were fairly large swings in illumination levels. These changes occurred over relatively short distances on the platform. In one case, the light level went from 5 to 15 fc in a span of approximately 10 ft. The observed lighting levels ranged from 2 fc in the center portions of the platform to 40 fc in an area of the platform

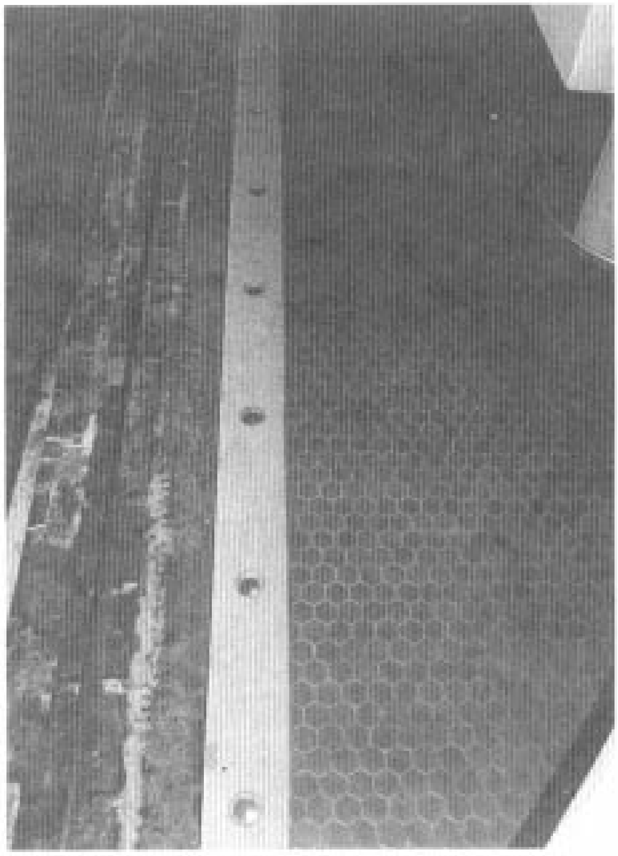

*Figure 76. WMATA platform edge warning lights.*

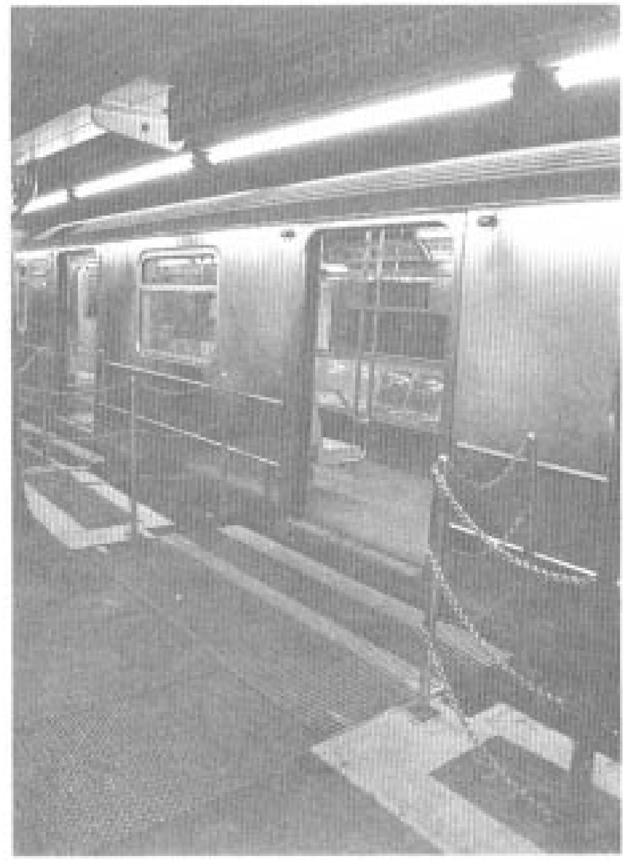

*Figure 77. MTA-NYCT South Ferry station extendible platforms.*

with a low ceiling and numerous fluorescent lighting fixtures. At the ends of the platform where there is some exposure to natural light, the daytime lighting level on an overcast day was 20 fc.

The significant swings in the lighting levels posed problems with the CCTV camera because they respond to an average of the lighting level within their field-of-vision. In areas of high illumination, the picture has little contrast and is virtually unusable. With this in mind, transit facilities designers should strive to provide consistent levels of illumination across the full length of station platforms.

## ENVIRONMENTAL CONSIDERATIONS

Above-ground stations are subject to a range of environmental factors that influence observation of the car side doors and passenger movements. These environmental factors include:

- Temperature,
- Humidity and precipitation,
- Wind, and
- Natural light and darkness.

Underground stations are affected by these environmental factors but to a significantly lesser degree. These factors are discussed in the following sections.

### Temperature

The transit systems in the northern part of North America generally experience the widest range of temperatures and the most severe weather. In Calgary, the temperature ranges from -33° to 95° F. On average, systems operating in the northeastern United States encounter temperatures ranging from 0° to 105° F. Systems operating in warmer climates generally experience stable weather with a narrower temperature range and a higher annual average temperature. For example, SF Municipal's temperature range is a more moderate 50° to 90° F.

### Humidity and Precipitation

All forms of precipitation are encountered at many of the surveyed transit systems. Average precipitation levels do not normally affect system operations because their designs account for the conditions. Difficulty arises in operations and in operator observation when snow, rain, or fog exist. For example, heavy rain may obscure an operator's vision or inhibit a conductor from leaning out the cab window.

### Wind

Cities in North America can experience winds up to 50 mph and higher, although under rare circumstances. Maximum wind speeds during normal severe weather conditions approach an average of 30 mph. In general, wind conditions will not affect door observation unless they cause particulate matter (e.g., dust and sand) movements, which can affect people and equipment.

### Natural Light and Darkness

All above-ground stations experience natural sunlight to some extent. Several platforms were observed where nearby buildings and other structures restricted the sunlight. The intensity and angle of the light, shadows, and glare—throughout the day and the year—must be addressed.

In addition, platform structures were found to provide significant shade and, as a result, variations in lighting levels. For example, SEPTA's Blue line in Philadelphia has above-ground platforms with partial canopies.

During daylight hours, portions of the platform will be in direct sunlight while other parts will be in shade. As a result, there is a significant difference in image contrast between the two regions that may impair door observation.

## ENVIRONMENTAL CONSIDERATIONS SPECIFIC TO UNDERGROUND STATIONS

### Temperature and Humidity

Although underground stations generally do not have direct contact with the elements, changes in outside temperature and humidity will affect these stations, although sometimes on a delayed basis. For example, it generally takes 1 to 2 days for the MTA-NYCT's underground stations to adjust to outside changes in temperature. The heat and cold retention of the surrounding structures, combined with minimal air circulation, tends to delay any sudden change in temperature.

### Underground Air Flow

On the eastbound side of the Exchange Place station on the PATH system, a unique air flow condition was observed. The underground station contains a large air exhaust vent (approximately 8 ft in diameter) at the conductor's end of the platform. Natural air currents create a wind tunnel effect along the side of the train cars at this location, making it sometimes difficult for the operator to look directly into the air flow and simultaneously observe passenger loading.

CHAPTER **4**

# PASSENGER BEHAVIORAL CONSIDERATIONS

## FACTORS INFLUENCING PASSENGER BOARDING

To solve a problem, it is necessary to understand all activities contributing to the problem, so that all potential solutions can be tested against the full range and scope of the problem. This is particularly true of door observation systems because they are designed to address a wide range of human behavior among transit system passengers.

Generally, transit system passenger behavior falls into readily definable patterns. Most passengers adhere to these patterns and make prudent, safe use of the transit systems; however, the true measure of the capability of door observation approaches and aids is how well they handle behavior deviating from these norms.

In collecting data during the initial phases of this program, observation of various operating scenarios provided a high degree of definition of passenger movement patterns and the factors influencing them. As discussed, most of the information was collected from visits to multiple stations on the transit properties visited and from discussions with operations personnel.

The following paragraphs identify the major factors that influence the operations and observation techniques established by the transit systems. Many of the factors defined as influencing the system operations were directly observed during the site visits or were readily derived from basic operational procedures. The relative importance of each criterion varies among the transit systems because no two systems operate identically or are configured the same. Even within a particular system, the factors can vary to a considerable degree and can influence established procedures on a particular line or even at a specific station.

### Station Facility Considerations

Observation of car side doors is affected by the physical characteristics of the station and the surrounding environment. Straight or curved, obstructed or not, the physical layout plays a major role in the boarding and observation process. Figures 78 and 79 illustrate multiple station and platform scenarios that affect passenger loading.

*Platform Configuration*

The configuration of the platform edge where trains berth is the largest influential factor in the observation of car side doors. No other element obstructs the operator's vision of the car side doors as severely as the design of the platform edge. Whether direct observation aids are used, a station platform with a concave curvature or an obstructed convex curvature can entirely block an operator's field-of-view of selected portions of the train.

For nearly all heavy rail transit systems visited, the crew member responsible for determining if the doors are clear does so by leaning his or her head out the cab window of the train to directly observe along the edge of the train or to view an observation aid mounted on the platform. Most platform edges in the visited stations are designed and constructed in a relatively straight line configuration. To observe the car side doors, the responsible operator, whether the train operator or conductor, will observe the area directly in front of the car side doors by viewing along the edge of the train (see Figure 78, Position A). Depending on his or her location in the consist, the operator can view fore, aft, or in both directions of the designated position to observe the car doors. Once an operator has extended his or her head through the window, further extension is generally not beneficial. This is also true where the platform edge is convex, i.e., the train curves inward on the side where the doors are to be observed (see Figure 79, Position A-1).

For concave platforms, where no observation aids exist, the operator's ability to observe the car side doors is restricted by the curvature of the train (see Figure 79, Position A-2). The distance that an operator leans out the window directly affects the operator's ability to observe the area in front of the car side doors for cars aft of the operator's position. The farther an operator can lean out from the edge of the control location, the smaller the angle between the tangency of the farthest car to the point of the operator's control position (see Figure 79, Position A-3). The size of the window, the operator's physical ability to lean out the window, and how near the control panel is to the operator combine to restrict how far the operator can extend from the car.

Further discussion of and calculations for determining the distance that an operator can observe on concave platforms were discussed in Part I, Chapter 2, Observation Requirements.

*Obstructions*

Facility structures, supporting platform hardware and equipment (e.g., signs and lights), and even passengers on the platform can affect the field-of-view of an operator. This can occur for both straight and curved platforms, whether designed with concave or convex curvature.

Facility structures near the edge of the platform can limit the operator's viewing area—even when the platform edge is

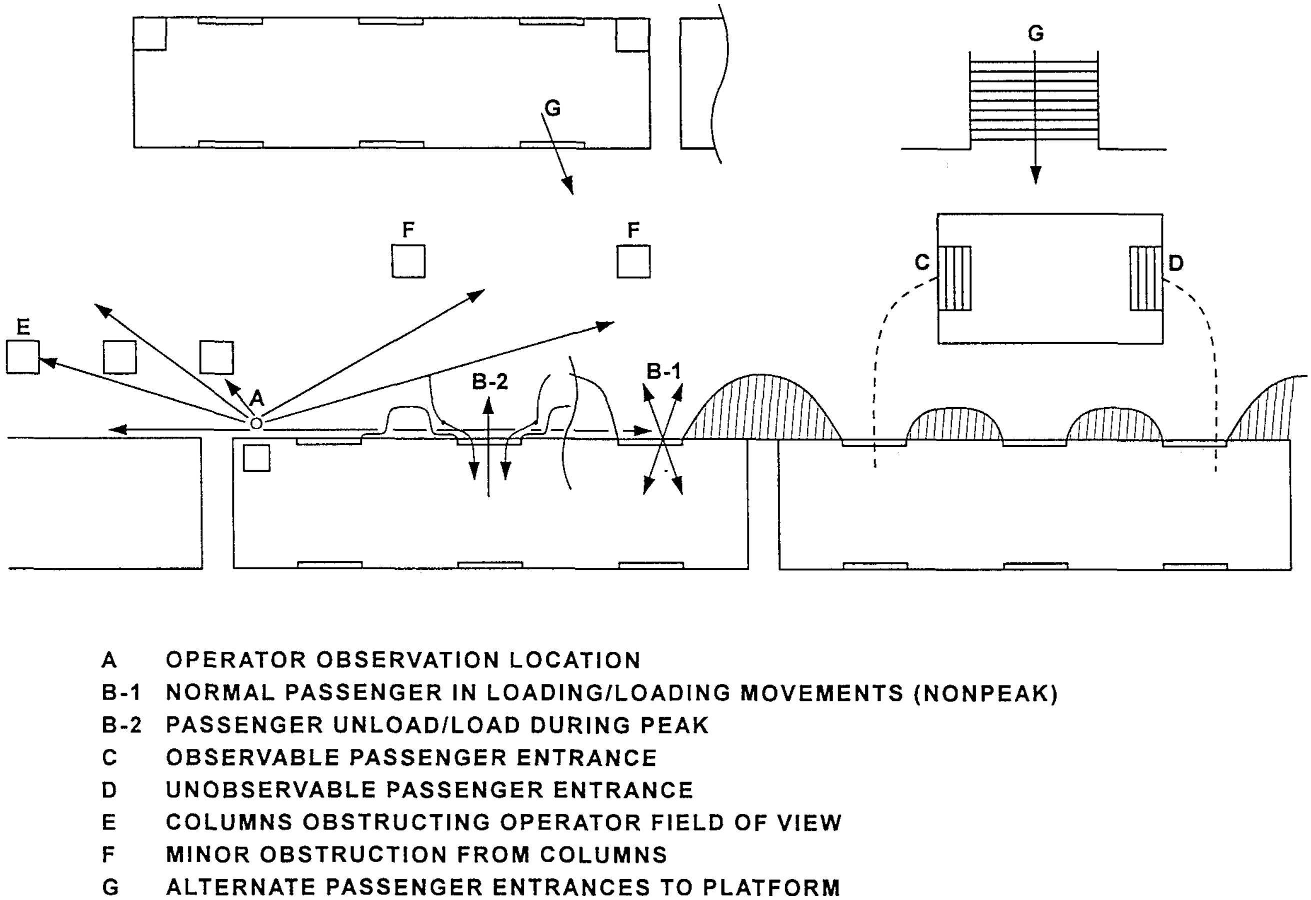


*Figure 78. Passenger motion analysis at straight platforms.*

configured in a straight line. Although the operator may be able to observe the area directly in front of the doors, obstructions can restrict the ability to observe passengers approaching the train in an attempt to board. This is especially true of facility structures that provide access to the platform in a direction opposite to that which can be directly viewed by the crew member (see Figure 78, Item D and Figure 79, Item C). This is also true where there is an enclosed waiting area.

Supporting hardware and equipment installed near the platform edge can restrict an operator's field-of-view. Signs identifying the system line or indicating exits or recommended waiting areas are often installed from the ceiling or canopy structure along the platform edge. Sign placement and the use of ceilingmounted observation aids can obstruct the operator's field-of-view, if so aligned with the platform edge. The observation of doors on trains positioned furthest from the viewpoint is specifically influenced, because the viewed image is compressed in proportion to the rest of the field.

Multiple columns along the edge of the platform can restrict the operator's view as severely as an access-way. A series of columns spaced in a frequent and patterned alignment along the edge of the platform can block the observable approach area of all doors except those nearest to the operator (see Figure 78, Item E). Figure 80 shows densely spaced columns at an MTA-NYCT station. The operator must pay particular attention to determine when to close the doors and must always be ready to reopen the doors for a passenger attempting to board the train at the last moment.

During peak operating conditions, passengers attempting to exit the platform through an access-way congregate at that exit. If this location is near the edge of the platform, the operator's field-of-view along the side of the train can be obstructed. This will increase the station dwell time because the operator will have to wait for a clear view of the side doors. Also, passengers waiting for another train may stand in the operator's field-of-view. To obtain a clear view, the operator can either wait for the passengers to move from the specific location or, using the train announcement system, ask that passengers step away from the edge of the platform.

### *Lighting*

For underground stations and for operations conducted during darkness, sufficient levels of illumination from platform lighting are required for proper operation. The entire length of platform where the trains berth should be fully illuminated to minimal acceptable levels to ensure that the operator can see

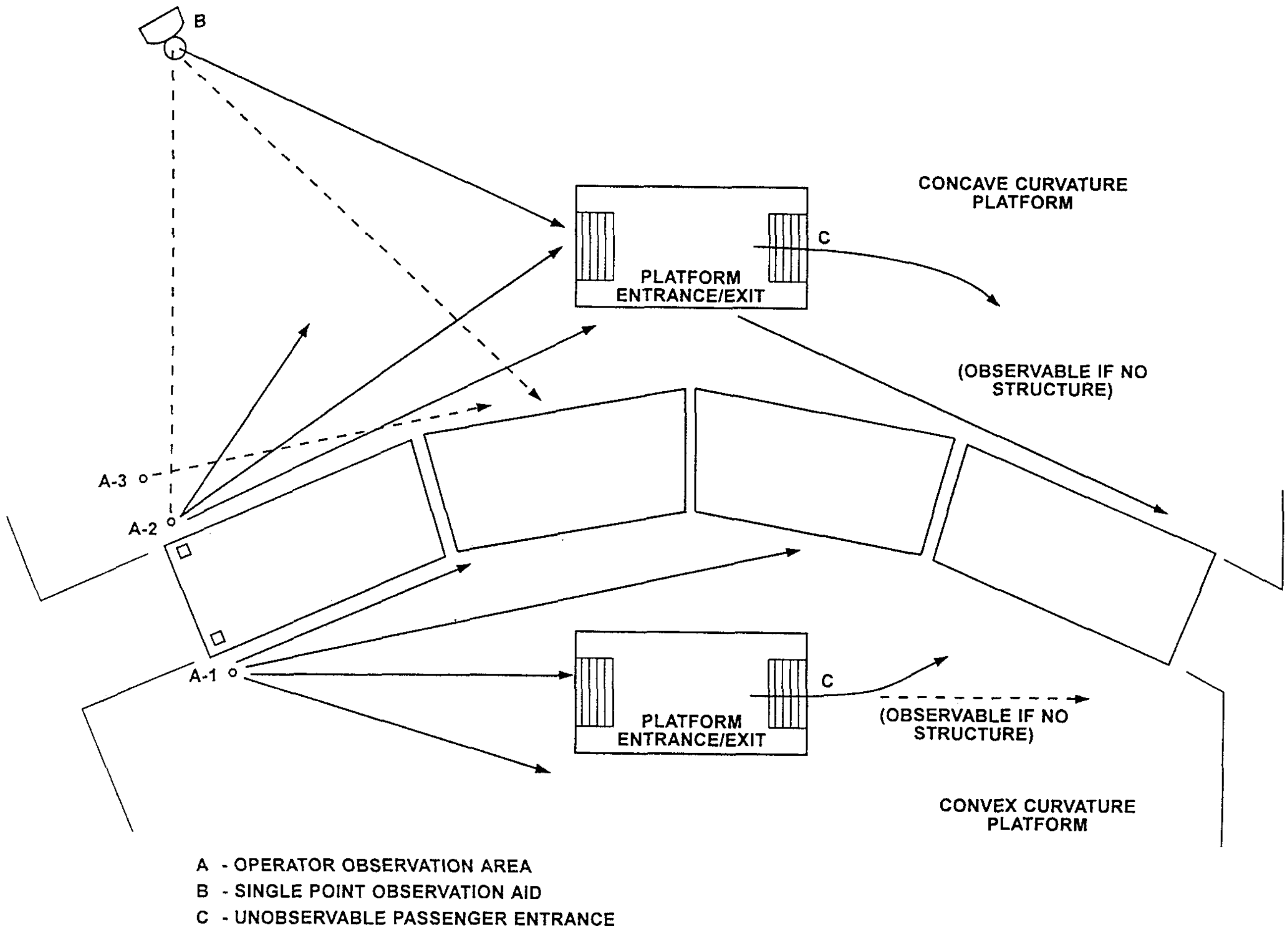


*Figure 79. Passenger motion analysis at curved platforms.*

clearly. Improper lighting, especially when the field of observation is considerable, can be as detrimental to obtaining acceptable observation as a fixed structure blocking the viewing area.

*Platform Edge Warnings*

Edge warning markers and devices, such as yellow, striped lines and tactiles, influence passengers to move from the edge of the platform. This is true when a train approaches the station and when passengers disembark from the train and move parallel to the train as they proceed to station exits. Clearing the edge of the platform allows the operator to obtain a clear line-of-sight along the edge of the car doors.

*Platform and Train Interface*

The elevation alignment of the train floor and the platform edge should be as consistent as possible. Variations in walking surface levels create caution in passengers, thereby slowing down loading and unloading. Excessive gaps between the platform edge and the car door edge also create caution in passenger movements and should be minimized as much as possible.

*Platform Accessibility*

The number and location of entrance and exit points in relation to the berthing of the trains affects passenger movements on the platforms and, subsequently, boarding. A single access point for a crowded station during peak operating hours delays passengers from leaving the platform. This, in turn, restricts the orderly flow of passengers attempting to gain access to the platform to board the train. Certain access designs, combined with heavy passenger load levels, can affect station dwell time. Under peak loads, passengers are deposited from an escalator onto the platform surface at a steady rate. This constant flow continues directly to the nearest available car side door. The constant stream of boarding passengers prevents the operator from attempting to close the doors because unsafe conditions exist. The station dwell time increases until an operator can determine that it is safe to close the doors.

To assist in disembarking, clear identification of all exits is

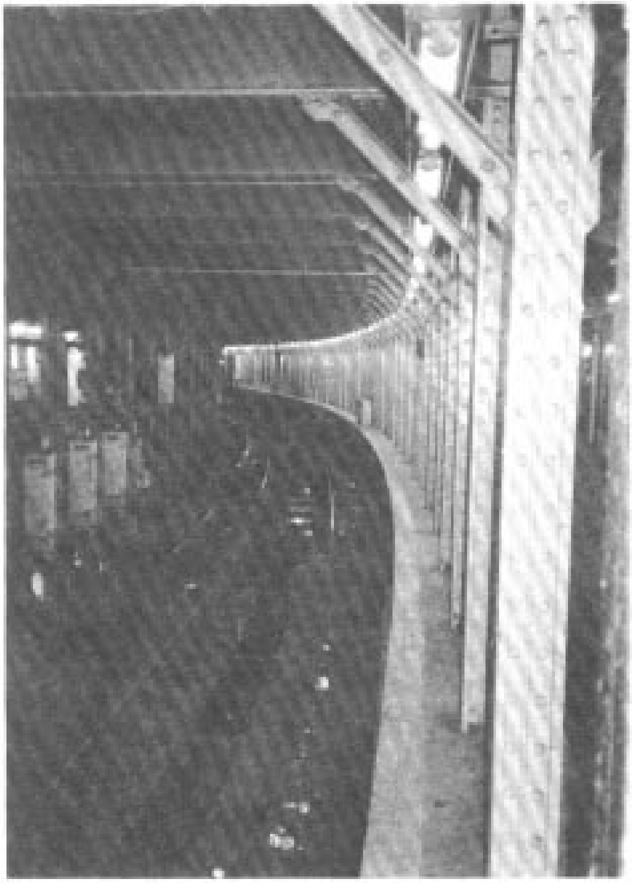

*Figure 80. Dense column spacing on platform edge at MTA-NYCT.*

required. Passengers who do not know the appropriate exit impede the movements of other passengers on the platform, which subsequently delays boarding.

*Environment*

The environmental changes experienced in many aboveground stations affect passenger boarding and operator performance. To a much lesser extent, stations that are underground or completely covered and, therefore, protected from the elements also can be affected by changes in external environment.

*Above-ground.* Stations exposed to the environment can be affected in many ways. Clear, sunny weather can produce glare. During sunrise and sunset hours, observation into the sun can impair the operator's ability to assess that the side doors are clear. Nighttime conditions, with limited illumination from platform-mounted lights, reduce the distance that an operator can see. Overcast skies and platform lights without ambient-light-sensitive switches can limit the operator's ability to observe. Severe rain and snow limit observable distances.

Platform conditions experienced by passengers will also affect boarding routines. Under certain severe weather conditions, passengers will remain in enclosed waiting areas until the train has arrived in the station. Slippery conditions (caused by snow and ice on platforms) slow boarding because passengers take additional time to ensure safe footing.

*Underground.* To a lesser extent, underground enclosed stations can be affected by severe weather. For transit routes that cover both underground and above-ground trackage and platforms, snow, slush, and rain will be tracked onto the floor of the cars and subsequently tracked onto underground platforms when passengers exit the train, creating cautious conditions for passengers boarding the trains. If the ambient air is below freezing at these stations, ice may form.

### Platform Announcements

Clear announcements on public address systems by platform-or train-based transit operations personnel can assist all passengers in using the system. Such announcements are especially beneficial to passengers when multiple routes operate on a single track or temporary system changes are in effect.

## FACTORS INFLUENCING PASSENGER MOTION

### Load Level

Load levels influence the movement and flow of passengers during loading and unloading. Under light load conditions, passengers can exit the train easily because passengers waiting to board will stand clear of the exit path (see Figure 78, Note B-1). After an orderly exit, passengers waiting to board can do so without hindrance.

During peak operations, when load levels are highest, passengers waiting to board will crowd the doors in an attempt to board as rapidly as possible (see Figure 78, Note B-2). This chokes the normal flow of the passengers attempting to exit the train. Passengers attempting to board the train from the side of the doors before the exit of all passengers interrupts the orderly exit flow. This, in turn, impedes the boarding flow, thereby increasing the station dwell time.

### Attitude and Awareness

An important factor in passenger boarding on transit systems is the attitude and awareness of the individuals to the operations of the system. Individuals who understand and are generally familiar with the standard procedures used in the particular transit system are generally expeditious in boarding; however, these same individuals may, at times, delay boarding by attempting to hold the doors open. Passengers who are not familiar with the specifics of the operation or who willingly exceed its intrinsic operational safeties are the most cause for concern. These passengers will run to catch a departing train and, in an attempt to board while doors are closing, will place an object between the door panels in order to impede the process. The objects can range from the person's entire body to an arm or leg to an inanimate object. On systems where the interlocking mechanism is engaged although the doors are not completely closed, there is considerable potential for a dragging incident to occur.

### Car Selection

Several factors affect which car a passenger enters when multiple cars are available. Primary among these are the number and location of entrances to the platform and the number of passengers waiting to board. In analyzing a platform loading location, the standard bell curve for distribution of passengers along the platform can be applied for normal situations where there is a single entrance to the platform from center location. Most passengers will attempt to board at the location nearest the platform entrance to minimize the walking distance and for the added sense of security of being nearest the exit if an emergency should occur. Where multiple entrances are available, with an assumption that all provide similar passenger counts, the distribution curve will be spread more evenly over the platform length.

Several factors will influence this greatly. Primary among these is the perceived sense of security that a passenger envisions with varying situations. The level of perceived security can vary among operating systems and along portions of the same operating line. The time of day correspondingly influences the perceived security by passengers. Passengers concerned with safety will congregate near police officers and uniformed transit personnel on the platform. Passengers causing disturbances or perception of type of personnel on the platform will influence passenger location.

Passengers congregate in waiting areas (e.g., enclosed areas for exposed stations, location of benches, and designated areas for off-hour waiting); however, the use of these areas depends on frequency of operation. Longer waits between trains will have passengers seeking areas to sit and wait, especially at above-ground stations experiencing severe weather.

Commuters or passengers who frequently ride the same line and are familiar with the berthing location and exit ramps of the train at the passenger's departure station will board a train knowing where they want to position themselves in anticipation of departure.

Crew complement and designated locations on board the train influence passenger boarding decisions. Individuals concerned with safety on board the train, especially during nonpeak evening and late-night hours of operation, will select cars where a recognizable uniformed member of the transit or police authority is located. For two-person crew operations, this location will be the conductor's car and the train operator's car; for a one-person crew operation, this will be the lead car where the train operator is located.

### Train Schedules and Frequency of Operations

The frequency of trains and the adherence to published schedules influences passenger boarding. Shorter time between trains will minimize late passengers attempting to enter the train when doors are closing. With trains that run less frequently, but follow published schedules, passengers are better able to ensure adequate time to position themselves in anticipation of boarding the particular train.

Multiple system routes that berth at a specific track can increase overall boarding time, especially during peak loads. The number of passengers on the platform—some of whom are waiting for trains other than the one berthed—increases the overall traffic on the platform, which affects the optimum flow of passengers.

### Door Closure Signal

To assist the operator in notifying passengers that the car side doors are closing, a public announcement or audible chime is generally heard just before the actual closing of the doors. This alerts individuals to be aware of the doors, especially if the train has been at the station for longer than usual. An audible chime that is part of the sequence of operations of the closing door function provides a consistent approach to notifying passengers that the doors are about to close. The audible chime, especially a two-part chime at two different frequencies, is a clear, distinguishable sound that provides a distinct signal that the doors are closing.

# APPENDIX A

## TRANSIT AUTHORITY QUESTIONNAIRE



A significant element in any research program is to fully understand the state of existing practices. The attached questionnaire is designed to collect information toward this end regarding aids for car side-door observation. Upon completion of the research, a report will be issued through the TCRP to allow the results of the research to be shared within the transit community.

The questionnaire addresses numerous disciplines including operations, equipment engineering and safety. It is the experience of the research team that the information requested by this questionnaire can be provided by operations supervision personnel. Some assistance may be required from personnel in equipment engineering and facilities however it is expected that this will be limited. In general, the information requested in this questionnaire includes:

- System Statistics: General characteristics of the system, management structure, incident/injury statistics and passenger volume.
- Operations/Equipment: Operating characteristics such as train and crew size as well as rail equipment characteristics such as rail car configurations, door controls and existing observation aids.
- Facilities: General characteristics of stations on the system including platform configurations and environment.
- Safety: Details of operational and safety related procedures, crew member responsibilities, car side-door observation aids and operator training.

In responding to these questions, any applicable supporting information such as maps, drawings, procedures and manuals would be greatly appreciated. In addition, it is requested that points of contact be identified in the event further information or discussion relative to the responses is required.

The questionnaire is designed to require minimal effort on the part of the respondents. The vast majority of the questions require simple yes/no or one word answers. The intent of this research effort is to share knowledge and experience with the entire transit community to enhance passenger safety and operational efficiency. The support of your system is greatly appreciated in this effort.

In the event that there are any questions regarding the research project or this questionnaire, please contact one of the following:

Mr. Clark Porterfield, Telephonics Corporation
Phone: (516) 755-7669
Fax: (516) 755-7046

Mr. Paul J. Smith, Telephonics Corporation
Phone: (516) 755-7661
Fax: (516) 755-7046



1.0 System Statistics: These questions are intended to obtain a general description of the transit system, its management structure, passenger volume and any car side-door incident/injury statistics.

1.1) How many different lines does the system operate? ______

(Please provide a system map if available. Passenger oriented materials are useful for purposes of this study.)

1.2) What types of service are provided?

Heavy Rail ___ Light Rail ___ Streetcars ___ People Mover ___ Other (Please

Describe) ____________________________________________________________

1.3) Is the system right of way:

subway ___ elevated___ grade level___ combination___

If the system is a combination, please provide approximate percentages of each type.

% subway ___ % elevated ___ % grade level ___

1.4) Is each line autonomous from a management standpoint or is management centralized?

autonomous___ centralized___ other (please describe) _________________

____________________________________________________________

1.5) What is the average weekday daily rail ridership? ____________

If possible, please provide breakdowns of passengers handled by individual line and station.

1.6) Does the system collect incident/injury statistics relative to door operation?

Yes ___ No ___

If so, please provide statistics and incident descriptive data for the last 3-5 years as available. If possible, please provide a statistical breakdown which identifies door operation related injuries.

2.0 Operations: This section of the questionnaire is divided into parts addressing transit operations, equipment characteristics.

2.1) Train Sizes/Consists

2.1.1) What is the standard train length in cars? _____

2.1.2) Do train lengths vary according to line or time of day?

Yes _____ No _____

If so, please characterize the variations.

____________________________________________________________

____________________________________________________________

____________________________________________________________

2.2) Train Crews

2.2.1) What is the normal train crew complement?

Number of Crew Members _____

Crew Member Roles__________________________________________

____________________________________________________________

2.2.2) Does the crew complement vary with train length, day of the week or time of day?

Yes____ No _____

If so, please characterize the variations.

____________________________________________________________

____________________________________________________________



2.3) Train Operations

2.3.1) What train control method is used (normal conditions)?

Manual _____ Automatic _____

2.3.2) Do trains stop at fixed locations within a station?

Yes _____ No _____

If so, what is the nominal positioning error? _____ feet

2.3.3) Are markers provided for stopping locations?

Yes _____ No _____

2.3.4) Do stopping locations vary with train lengths and factors such as time of day?

Yes _____ No _____

If so, please characterize the variations.

____________________________________________________________

____________________________________________________________

____________________________________________________________

2.3.5) What is the nominal dwell time for a train in a station? _______ (seconds)

3.0 Equipment Characteristics

3.1 Rail Vehicle Characteristics

3.1.1 Please provide outline and floor plan drawings for each type of rail car operated. It is requested that these drawings include dimensions such as overall car length, width and height and door width and height.

3.1.2 Is a particular type of car captive to a specific system line or are they used on all lines?

Yes (captive) _____ No (not captive) _____

3.1.3 What is the width of the gap between cars in a train consist? _____

3.1.4 Do the trains feature guards (springs, gates, etc) to prevent passengers from falling into this gap?

Yes _____ No _____

If so, please provide a description or illustrative material (drawings, photos, etc) if available.

______________________________________________________________

______________________________________________________________

______________________________________________________________

3.2 Door Controls

3.2.1 Where are the door controls located?

______________________________________________________________

______________________________________________________________

3.2.2 What action does the crew member perform to open or close the doors? (Please provide a detailed description of events from the time of train arrival in a station.)

______________________________________________________________

______________________________________________________________

______________________________________________________________

______________________________________________________________



3.2.3 Do the controls open/close all doors (per side) simultaneously or is an alternate scheme such as zones or control of individual car doors provided?

All Doors _____ Zones _____ Single Doors _____

If doors operate in zones, please provide your definition of a zone.

______________________________________________________________

______________________________________________________________

3.2.4 Are the door controls linked to the overall train control system?

Yes ____ No ____

If so, how is the event of door opening and closing used in the train control logic?

______________________________________________________________

______________________________________________________________

______________________________________________________________

3.2.5 Do the doors or their actuators have a means for sensing an obstruction?

Yes ___ No ___

If so, what type(s) are used?

______________________________________________________________

______________________________________________________________

3.2.6 How do the doors react when an obstruction is sensed?

______________________________________________________________

______________________________________________________________

______________________________________________________________

3.3 Train Communications

3.3.1 What means of communications is provided between members of the train crew?

Intercom ____ Radio ____ Other (Describe) __________________________

__________________________________________________________

3.3.2 What means of communication is provided between members of the train crew and the train control center?

__________________________________________________________

__________________________________________________________

3.3.3 Is an intercom provided to allow passengers to speak to the train crew?

Yes _____ No _____

3.4 Existing Door Observation Aids

**Note: If the answer to question 3.4.1 is no, skip to section 4.0 of the questionnaire.**

3.4.1 Are car side-door observation aids are currently in use on the system?

Yes _____ No _____

3.4.2 If car side-door aids have been implemented:

Do comparative incident statistics exist to support their effectiveness?

Yes _____ No_____

If yes, please provide these statistics for the last 3-5 years.

3.4.3 Have standards been developed for their application and use?

Yes _____ No _____

In the event standards exist, please provide any available documentation.

3.4.4 Is the use of these aids mandatory for train crews?

Yes _____ No _____

3.4.5 Are inspections/reviews carried out to insure their use?

Yes _____ No _____

3.4.6 What is the extent of acceptance of these devices by operational personnel?
All _____ Some (Approx %) _____



3.4.7 What types of aids have been implemented? (Check all that apply)

Mirrors ___ Video Systems ____ Other (Please Describe) ____________

__________________________________________________________

__________________________________________________________

3.4.8 For visual based aids (mirrors and video), what is the field of vision provided by the devices?

__________________________________________________________

__________________________________________________________

3.4.9 Where are these aids located?

Rail vehicles ____ Station Platforms ____ Both ____ Other (Please Describe)

__________________________________________________________

__________________________________________________________

3.4.10 Are these aids integrated with the train control system?

Yes _____ No _____

If so, Please describe methodology.

__________________________________________________________

__________________________________________________________

__________________________________________________________

3.4.11 Has your system performed any internal research on aids for car side-door observation?

Yes _____ No _____

If so, what types were studied and what were your findings?

__________________________________________________________

__________________________________________________________

__________________________________________________________

## 4.0 Rail Facilities

### 4.1 Station Characteristics

4.1.1 What is the range of station platform lengths (feet)? Maximum ____ Minimum ____

4.1.2 What is the average platform length? _____ feet

4.1.3 Are the station platforms straight, curved or a mixture of types?

Straight _____ Curved _____ Mixture _____

If the platforms are a mixture, what percentage of the platforms are curved? ___

4.1.4 In the event that the system has stations with curved platforms:

Is the curvature convex, concave or a mixture of both types relative to the plane of the side of the car (see attached diagram)?

Convex _____ Concave _____ Both _____

What percentage of the curved platforms are concave? _____

What is the minimum radius of curvature for the platforms? _____

4.1.6 Do any stations include obstructions (columns, etc) near the edge of station platforms?

Yes _____ No _____ If so, what percentage of the stations? _____

What is the minimum distance between the obstruction and the edge of the platform? _____

4.1.7 Does the edge of the platform feature any colored striped or tactile warnings?

Yes _____ No _____

If so, please describe or provide photos or drawings if available. _________

____________________________________________________________

### 4.2 Environmental Conditions

4.2.1 What is the annual range of temperature and humidity experienced at system facilities?

Temperature: Max. _____ Min. _____ Humidity: Average _____

4.2.2 What lighting standards (light levels, etc) are used for station platforms? ____ Lux

4.2.3 What types of lighting are employed (fluorescent, tungsten, halogen, sodium, etc) at the facilities in the system?
Fluorescent ____ Tungsten ____ Halogen ____ Sodium Vapor ____ Other ____



## 5.0 Safety

### 5.1 Safety Procedures

5.1.1 Does the system employ standardized operational procedures?

Yes _____ No _____

If so, what organization(s) within the authority is tasked with their development, approval and dissemination?

____________________________________________________________

____________________________________________________________

5.1.2 Do standardized procedures exist for the operation of rail car side doors? (If available, please provide copies of these procedures.)

Yes _____ No _____

In the event that procedures exist, do these procedures include provisions for insuring that the doors are clear?

Yes _____ No _____

Are these procedures standard across the entire system or do they vary according to line?

Standard _____ Vary by Line _____

5.1.3 Do you have any specific programs in place to enhance car door safety through public awareness or other means?

Yes _____ No _____

If so, please provide brief details of these programs. ______________

____________________________________________________________

## 6.0 Training

6.1 What types of training is provided to the personnel responsible for car door control?

____________________________________________________________

____________________________________________________________

6.2 Is periodic recertification required for train operators?

Yes _____ No _____ If so, how frequently is this required? _____ months

# APPENDIX B

## VIEWPOINT OFFSET CALCULATIONS FOR VARYING PLATFORM CURVATURE RADII



**THEORETICAL BASIS**

In general, the train crew member responsible for door observation will look from their location along a plane running parallel to the side of the rail car. The operator can readily make observations in the required field of view when the edge of the platform is a straight line. It is also true when the platform edge has a convex curvature and no significant obstructions exist within the field of vision. In this case, the ends of the rail car are closer to the train crew's position than in the case of a straight platform, facilitating observation. In the opposite case, where the platform edge is concave, the severity of curvature can impact the ability of the operator to view the doors beyond their location.

For a single car or vehicle train, the outside edge where the doors are located is always a straight line. The operator can observe along the entire length by leaning out of the cab window a minimal distance. For two or more cars per train, the distance that the operator can observe is a function of the curvature of the outside edge of the train and the linear distance the operator leans out of the window. By leaning out of the window of the rail car, the operator projects their viewpoint out from the side of the rail car allowing them to see around the curvature. Effectively, the viewpoint is projected away from the vehicle to the point where the observer can sight along a plane parallel to the side of the rail car furthest from the observer's location. An observation device such as a mirror or CCTV camera can be placed at the viewpoint location to obtain the required field of vision.

**CALCULATION BASIS**

**Figure B-1** is a representation of the physical scenario addressed by the calculations. The variables in the figure are defined as follows:

T - The distance from the location of the person responsible for operation of the doors to the outside edge of the rail car furthest from their location. This distance is calculated using train length and the observers location as input.

R - The platform curvature radius.

A - The distance the viewpoint is setback from the edge of the platform (i.e. observer's location).

DEG - The angle formed between the observer's position and the outside edge of the rail car furthest from the observers position.

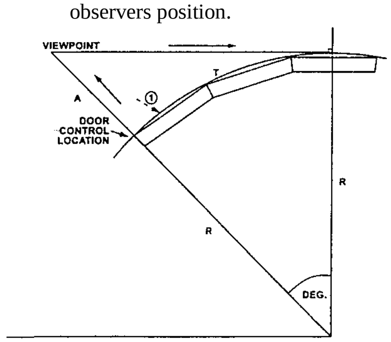


**Figure B-1 Viewpoint Setback on Concave Curved Platforms**



It should be noted that the program assumes a constant radius of platform curvature. Where the platform has a compound curvature (i.e. segments with varying radii), the minimum or smallest radius will determine the required viewpoint setback. Using the known value of T and assuming a range of values of A from 1 to 10, the program uses an iterative process to determine the value of R. The successive approximate process used to determine the value of R for a given viewpoint setback is conducted in four stages (1000's, 100's, 10's and 1's) has an accuracy of 1 foot. Effectively, the value of R is adjusted until the trigonometric relationships of the triangle formed by the vertex of the angle degree, the viewpoint location and the center of the rear car apply.

**PROGRAM EXECUTION**

**Figure B-2** is a listing of a Microsoft Quick Basic program which will perform the calculations described above. This program will run on any MS-DOS operating system (version 5.0 or greater) based computer. This program uses standard Basic language constructs and may be readily adapted to other computers and versions of the basic language.

When running the program, the user will be prompted to enter the following information:

- Car/Vehicle Length in Feet
- Consist Length in Cars/Vehicles
- Observer's Car (i.e. the car in the consist where the observer is located)
- Observer's Position in the Car (Front or Back)

This information is used to develop an accurate value for the distance T as shown in **Figure B-1**.

As output, the program will provide a listing of values of A (Viewpoint Offset) and corresponding values of R (platform curvature radius). **Figure B-3** is a sample program output. As provided in **Figure B-2,** the program will output its results to the screen of the computer on which it is executed. In the event a hard copy printout of the results is desired, the Basic keyword "PRINT" should be changed to "LPRINT" from line 47 to the end of the program.

```
                   'Program to determine minimum platform
                   'radius for given viewpoint
                   'Date: 8 February 1995
                   'For Hardcopy Printout Change PRINT to LPRINT on
                   'all lines starting with 47.
1 CLS
2 DIM PI AS SINGLE
  DIM DEG AS SINGLE
  DIM RE AS SINGLE
10 INPUT "CAR/VEHICLE LENGTH IN FEET: ", CL
15 INPUT "CONSIST LENGTH IN CARS/VEHICLES: ", MC
20 INPUT "OBSERVER'S CAR :", OC
25 PRINT "OBSERVERS POSITION IN CAR"
30 INPUT "ENTER 1 FOR FRONT OR 2 FOR BACK: ", PO
35 IF PO = 1 THEN CAR1 = CL - 4
40 IF PO = 2 THEN CAR1 = 4           'ASSUME WINDOW IS 4 FEET IN FROM CAR EDGE
42 TL = MC * CL
45 T = CAR1 + ((MC - OC - 1) * CL) + (CL / 2)
46 CLS
47 PRINT "CAR/VEHICLE LENGTH IN FEET =", CL
48 PRINT "CONSIST LENGTH IN CARS/VEHICLES =", MC
49 PRINT
50 PRINT "TOTAL CONSIST LENGTH =", TL
51 PRINT "TOTAL OBSERVATION DISTANCE (FEET) = ", T
53 PRINT
55 PRINT "A = SETBACK FROM PLATFORM EDGE (FEET)"
60 PRINT "R = MAXIMUM PLATFORM CURVATURE RADIUS (FEET)"
63 PRINT
65 IF PO = 1 THEN PRINT "OBSERVER LOCATED IN THE FRONT OF CAR NUMBER "; OC
70 IF PO = 2 THEN PRINT "OBSERVER LOCATED IN THE BACK OF CAR NUMBER "; OC
75 PRINT
99 REM
100 PI = 3.141593#
110 A = 0                          'INITIALIZE VIEWPOITN SETBACK
120 PRINT " A", "   R"             'TITLES FOR REPORT
199 REM
200 R = 0                          'INITIALIZE RADIUS
210 A = A + 1                     'A = VIEWPONT DISTANCE ITERATION
215 LE = T                         'METRIC FOR USE DURING APPROXIMATIONS
219 REM
300 R = 1000 + R                   'GROSS INCREMENT OF RADIUS
310 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R))  'R TIMES THETA IN RADIANS
320 IF LE > RE GOTO 300            'RADIUS TOO SMALL - INCREMENT
330 IF LE = RE GOTO 900            'MATCH (RELATIONSHIP APPLIES)
399 REM                            'LE < RE
400 R = R - 100
410 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R))  'RADIUS x THETA IN RAD.= ARC
420 IF LE < RE GOTO 400             'RADIUS TOO BIG - DECREMENT
430 IF LE = RE GOTO 900             'MATCH (RELATIONSHIP APPLIES)
499 REM                             'LE > RE - NEED VERNIER ADJUSTMENT OF R
500 R = R + 10
510 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R))  'RADIUS x THETA IN RAD.= ARC
520 IF LE > RE GOTO 500             'RADIUS TOO SMALL - INCREMENT
530 IF LE = RE GOTO 900             'MATCH (RELATIONSHIP APPLIES)
599 REM                             'LE < RE - NEED VERNIER ADJUSTMENT OF R
600 R = R - 1
610 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R))  'RADIUS x THETA IN RAD.= ARC
620 IF LE < RE GOTO 600             'RADIUS TOO LARGE - DECREMENT R
630 IF LE = RE GOTO 900             'MATCH (RELATIONSHIP APPLIES)
699 REM                             'LE > RE - MISMATCH LESS THAN 1 FT.
900 DEG = 180 * T / (R * PI)        'THETA VALUE (NOT USED)
1000 PRINT A, R                    'OUTPUT SETBACK AND CURVE RADIUS VALUES
1010 IF A = 10 GOTO 3000            'DONE TRYING VIEWPOINT LOCATIONS
1020 GOTO 200                       'LOOP TO INCREMENT VIEWPOINT LOCATION
3000 END
```

**Figure B-2 Microsoft Quick Basic Program Listing**



```
CAR/VEHICLE LENGTH IN FEET =                 55
CONSIST LENGTH IN CARS/VEHICLES =            6

TOTAL CONSIST LENGTH =        330
TOTAL OBSERVATION DISTANCE (FEET) =          141.5

A = SETBACK FROM PLATFORM EDGE (FEET)
R = MAXIMUM PLATFORM CURVATURE RADIUS (FEET)

OBSERVER LOCATED IN THE BACK OF CAR NUMBER  3

 A              R
 1              10011
 2              5007
 3              3339
 4              2506
 5              2006
 6              1673
 7              1435
 8              1258
 9              1119
 10             1009
```

**Figure B-3 Sample Program Output**

# APPENDIX C

## MINIMUM STRUCTURAL OBSTRUCTION OFFSET CALCULATIONS

**C-1**

### THEORETICAL BASIS

In Appendix B, calculations of the viewpoint setback distance for a specific radius platform curvature were calculated. The line tangent to the last car, the side of the train and the viewpoint setback define a triangular region which needs to be clear if the train crew is to be able to see passenger movements and the side of the rail car. Regardless of the observation methodology or the use of observation aids, this region needs to be kept clear.

To insure that there are no obstructions in this region which block the view, a minimum structural obstruction offset relative to the platform edge needs to be defined. In addition, it is desirable to define a minimum structure distance from the platform edge. Effectively, this insures that the train crew will have a clear view of the train and platform passenger movements at the rearmost rail car from their location.

### CALCULATION BASIS

Figure C-1 is a graphical representation of the scenario addressed by the calculations. The variables illustrated in the figure are defined as follows:

T - The distance from the location of the person responsible for operation of the doors to the outside edge of the rail car furthest from their location. This distance is calculated using the length of the train and the observers location as input.

R - The radius of curvature of the platform.

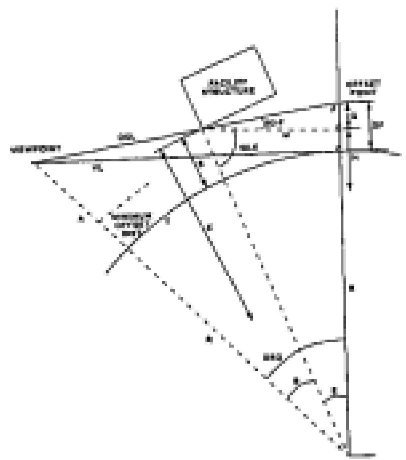

**Figure C-1 Platform Structure Offset Zone**

A - The distance the viewpoint is setback from the edge of the platform (i.e. observer's location).

DEG - The angle formed between the observer's position and the outside edge of the rail car furthest from the observers position.

OF - Minimum Platform Obstruction Offset.

S - Obstruction Offset at a given point along the platform.

**C-2**

The remaining values in the figure are used in calculations made within the program and are not germane to the required inputs or significant program outputs. Like the program in Appendix B, this the program assumes a constant radius of platform curvature. Where the platform has a compound curvature (i.e. segments with varying radii), the minimum or smallest radius will determine the required obstruction offset.

Using the known value of T and assuming a range of values of A, the program uses an iterative process to determine the value of R. The successive approximate process used to determine the value of R for a given viewpoint setback is conducted in four stages (1000's, 100's, 10's and 1's) has an accuracy of 1 foot. Effectively, the value of R is adjusted until the trigonometric relationships of the triangle formed by the vertex of the angle degree, the viewpoint location and the center of the rear car apply.

### PROGRAM EXECUTION

Figure C-2 is a listing of a Microsoft Quick Basic program which will perform the calculations described above. This program will run on any MS-DOS operating system (version 5.0 or greater) based computer. This program uses standard Basic language constructs and may be readily adapted to other computers and versions of the basic language.

When running the program, the user will be prompted to enter the following information:

- Car/Vehicle Length in Feet
- Consist Length in Cars/Vehicles - Observer's Car (i.e. the car in the consist where the observer is located)
- Observer's Position in the Car (Front or Back)
- Minimum Structure Distance From Platform Edge in Feet

This information is used to develop an accurate value for the distance T as shown in figure C-1.

As output, the program will provide a listing of obstruction offset distances at various points along the platform back from the observers location. Multiple sets of values are provided based on varying values of viewpoint setback distances. Figure C-3 is a sample program output. As provided in figure C-2, the program will output its results to the screen of the computer on which it is executed. In the event a hard copy printout of the results is desired, the Basic keyword "PRINT" should be changed to "LPRINT" from line 47 to the end of the program.

### OUTPUT ANALYSIS

The program provides multiple sets of numbers. The most significant factor influencing the different sets of numbers is the distance of the viewpoint from the observer. As with the program in appendix B, the output also provides the minimum platform curvature radius. The program also provides a listing of Obstruction Offset Distances for a given distance along the platform. The distances are with respect to the observers location and define the line OSL (see figure C-1) which is one of the edges of the field of vision. The other edges of this region include the line perpendicular to the observer's position and the arc defined by the platform edge (rail car sides).

```
'Program to determine minimum structural offsets for
'a variety of train lengths, minimum structural offests
'and platform curvature radii.
'Date: 23 February 1995
'For Hardcopy Printout, Change PRINT to LPRINT on
'All Lines starting with 15

1 CLS
2 DIM DEG AS SINGLE
  DIM SDEG AS SINGLE
  DIM L AS SINGLE
  DIM M AS SINGLE
  DIM S AS SINGLE
  DIM R AS SINGLE
  DIM F AS SINGLE
  DIM OF AS SINGLE
  DIM E AS SINGLE
  DIM PI AS SINGLE
  DIM Q AS SINGLE
  DIM B AS SINGLE
  DIM BD AS SINGLE
3 INPUT "CAR/VEHICLE LENGTH IN FEET: ", TL
4 INPUT "CONSIST LENGTH IN CARS/VEHICLES: ", CL
5 INPUT "OBSERVER'S CAR :", OC
6 PRINT "OBSERVERS POSITION IN CAR"
7 INPUT "ENTER 1 FOR FRONT OR 2 FOR BACK: ", PO
8 IF PO = 1 THEN CAR1 = TL - 4
9 IF PO = 2 THEN CAR1 = 4                           'ASSUME WINDOW IS 4 FEET IN FRO
10 L = MC * CL + ((CL - 1) * 4)
11 T = CAR1 + ((CL - OC - 1) * TL) + (TL / 2)
12 CLS
13 INPUT "Minimum Structure Distance From Platform Edge (Feet)"; SM
14 CLS
15 PRINT "CAR/VEHICLE LENGTH IN FEET =", TL
16 PRINT "CONSIST LENGTH IN CARS/VEHICLES =", CL
17 PRINT "TOTAL CONSIST LENGTH =", , L
18 PRINT "TOTAL OBSERVATION DISTANCE (FEET) = ", T
19 PRINT
20 IF PO = 1 THEN PRINT "OBSERVER LOCATED IN THE FRONT OF CAR NUMBER "; OC
21 IF PO = 2 THEN PRINT "OBSERVER LOCATED IN THE BACK OF CAR NUMBER "; OC
22 PRINT
23 PRINT "MINIMUM STRUCTURE DISTANCE FROM PLATFORM EDGE = "; SM
24 PI = 3.14159
25 A = 0
26 MS = SM
30 R = 0                    'R = RADIUS OF CURVE (TBD-SET INITAILLY TO 0
31 IF A < SM GOTO 5000      ' DISTANCE FROM OPER. LESS THAN MIN. OFFSET POINT
32 IF A = SM GOTO 5001      ' DISTANCE FROM OPER = MIN. OFFEST POINT
37 IF A = SM + 8 GOTO 3000
40 R = 1000 + R
60 LE = (180) * (T / PI)
70 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R)) * 180 / PI
80 IF LE > RE GOTO 40
90 IF LE = RE GOTO 300
100 R = R - 100
110 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R)) * 180 / PI
120 IF LE < RE GOTO 100
130 IF LE = RE GOTO 300
140 R = R + 10
150 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R)) * 180 / PI
160 IF LE > RE GOTO 140
170 IF LE = RE GOTO 300
180 R = R - 1
190 RE = R * (ATN(SQR((A + R) ^ 2 - R ^ 2) / R)) * 180 / PI
200 IF LE < RE GOTO 180
210 IF LE = RE GOTO 300
```

**Figure C-2 Microsoft Quick Basic Program Listing (1 of 2)**





```
220 REM
300 DEG = (180 * T) / (R * PI)
400 PRINT
405 PRINT "Observation Distance  "; CSNG(T)
410 PRINT "Viewpoint Distance From Observer  "; CSNG(A)
415 PRINT "Platform Curvature Radius  "; CSNG(R)
420 PRINT
901 REM
902 Q = (R + A) ^ 2 - (MS + R) ^ 2
903 IF Q < 0 THEN GOTO 30
904 B = ATN((SQR(Q) / (MS + R)))
960 OF = ((MS + R) / COS((DEG * PI / 180) - B)) - R
1002 PRINT "Distance Along Platform", "Obtruction Offset Distance"
2020 F = ATN(R * TAN(DEG * PI / 180) / OF) * 180 / PI
2100 ES = 0
2101 SDEG = (DEG / 10 * ES)
2102 BD = B * 180 / PI
2104 IF SDEG > BD GOTO 6000
2105 E = DEG - SDEG
2106 IF E = 0 THEN GOTO 4000
2121 L = TAN((90 - F) * PI / 180)
2122 M = TAN((90 - E) * PI / 180)
2123 N = SIN(E * PI / 180)
2124 S = (((OF + R) / (L + M)) / N) - R
2126 DT = SDEG * PI * R / 180
2130 PRINT CSNG(DT), , CSNG(S)
2140 ES = ES + 1
2150 IF ES = 11 THEN GOTO 7000
2160 GOTO 2101
3000 CLOSE
3001 END
4000 S = OF
4001 GOTO 2130
5000 A = A + 2
5001 S = MS
5010 ES = 0
5020 SDEG = DEG / 10 * ES
5030 E = DEG - SDEG
5035 IF SDEG = 0 THEN GOTO 5060
5037 REM
5038 DT = SDEG * PI * R / 180
5040 PRINT CSNG(DT), , CSNG(S)
5060 ES = ES + 1
5070 IF ES = 11 GOTO 7000
5080 GOTO 5020
6000 S = MS
6001 GOTO 5030
7000 A = A + 2
7001 GOTO 30
```

**Figure C-2 Microsoft Quick Basic Program Listing (2 of 2)**

# APPENDIX D

## CAMERA POSITIONING AND FIELD-OF-VISION CALCULATIONS



### THEORETICAL BASIS

For a CCTV-based observation aid, camera quantities, lens horizontal field of vision values and camera orientation is determined by the coverage requirements. It is possible to calculate these parameters based on the characteristics of the vehicles and the methodology used to image the rail car/platform interface. In addition, the program accounts for the type of video display to be used including adjustment of the field of vision requirement to compensate for the use of a screen splitter. For the case of a straight platform edge, these calculations can be readily made using the program included in this appendix. Where the platform edge is curved, the camera position requirements are best determined using the viewpoint setback calculation methodology defined in **Appendix B** as the starting point.

### CALCULATION BASIS

**Figure D-1** is a graphical representation of scenario addressed by the calculations. The variables in the figure are defined as follows:

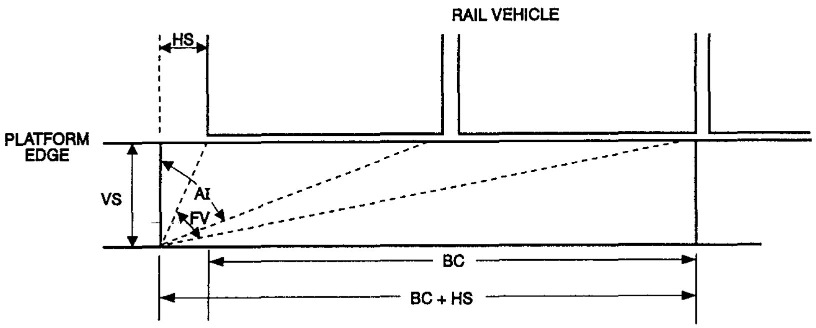


**Figure D-1 Video Camera Selection/Installation Design Requirements**

AI - The angle of incidence of the camera lens relative to a line perpendicular to the platform edge. This angle is defined from the perpendicular to the center of the camera lens.

FV - The horizontal field of vision of the camera lens required to image the desired field of vision.

HS - The horizontal setback of the camera field of vision relative to the plane of the front of the rail vehicle.



VS - The vertical setback of the camera field of vision relative to the edge of the platform.

BC - The length of the rail car pair (Sequential Imaging Pattern) or one-half of the consist length (Crossing Imaging Pattern). **Figure 33** in the report illustrates these two (2) imaging schemes.

Where the sequential imaging pattern is used, the program assumes that each video camera will image a maximum of two rail cars. Where the consist has an odd number of cars/vehicles, this value is prorated down accordingly. The program operates by assuming values of HS and VS and calculating the corresponding values of the angle of incidence and field of vision. These values have upper limits of 5 for the horizontal setback and 10 for the vertical setback. These limits can be expanded my modifying the limit values in lines 600 (VS) and 700 (HS) of the program. In the case where screen splitter use is specified, the reported field of vision value is doubled to account for the fact that a screen splitter uses only one-half of the image from the cameras connected to its inputs.

### PROGRAM EXECUTION

**Figure D-2** is a listing of a Microsoft Quick Basic program which will perform the calculations described above. This program will run on any MS-DOS operating system (version 5.0 or greater) based computer. This program uses standard Basic language constructs and may be readily adapted to other computers and versions of the basic language.

When running the program, the user will be prompted to enter the following information:

- Car/Vehicle Length in Feet
- Consist Length in Cars/Vehicles
- Planned Platform/Vehicle Imaging Pattern
- Split Screen Display Use

This information is used to develop accurate values for the Horizontal and **D-2**

Vertical Setback (HS and VS respectively), Horizontal Field of Vision (FV) and Angle of Incidence (AI) as shown in **Figure D-1. Figure D-3** is a sample program output. As provided in **Figure D-2,** the program outputs results to the screen of the computer. In the event a hard copy printout of the results is desired, the Basic keyword "PRINT" should be changed to "LPRINT" from line 93 to the end of the program.

### OUTPUT ANALYSIS

As output, the program will provide a listing of corresponding sets of values of HS, VS, FV and AI. When selecting the appropriate set of values to use, the Field of Vision (FV) value will take precedence. **Table 5** in the report lists horizontal field of vision values for various combinations of video camera sensor formats (1/2 and 1/3 inch formats) and camera lenses. The value output by the program nearest to a value listed in the table is the appropriate combination for the application. The program has limits (lines 550 and 560) which will restrict the value of the field of vision for the lens to common hardware configurations as listed in table 5 of the report. It should be noted that there may be multiple combinations which are appropriate based on the use of different camera sensor formats.

It is important to consider that this program provides only general guidance in selecting camera hardware and designing camera installations. Factors such as contrast differences due to varying lighting conditions and platform obstructions must be considered in the final design of video camera installations for a specific application.

```
                  'Program to estimate camera quantity requirements,
                  'Lens Field of Vision and Camera Angle of Incidence
                  '
                  'Date: 13 February 1995
                  'For Hardcopy Printout Change PRINT to LPRINT on
                  'all lines starting with 93.
1 CLS
2 DEFSNG P
10 INPUT "CAR/VEHICLE LENGTH IN FEET: ", CL
15 INPUT "CONSIST LENGTH IN CARS/VEHICLES: ", MC
20 LN = (CL * MC) + ((MC - 1) * 3)              'Consist Length = Cars + Gaps
23 PRINT
25 PRINT "Planned Platform/Vehicle Imaging Pattern"
30 PRINT "Enter 1 For Crossing Pattern or 2 For Sequential Pattern"
35 INPUT "Enter Selection (1 or 2): ", CC
40 IF CC = 1 OR CC = 2 GOTO 52
45 CLS
50 GOTO 25
52 PRINT
55 PRINT "Will Split Screen Displays Be Used"
60 PRINT "Enter 1 IF YES or 2 IF NN"
65 INPUT "Enter Selection (1 or 2): ", SS
70 IF SS = 1 OR SS = 2 GOTO 85
75 CLS
80 GOTO 55
85 NC = 2                                   ' Assume 2 Camera in Crossing Pattern
90 IF CC = 2 THEN NC = INT(LN / (NC * CL))
91 REM For hard copy printout change all following Print to LPRINT
92 CLS
93 PRINT "Rail Car/Vehicle Length ="; CL
94 PRINT "Consist Length in Cars/Vehicles ="; MC
95 PRINT "Estimated Total Consist Length ="; LN
97 PRINT
100 PRINT "Number of Video Cameras"; NC
110 PRINT
120 IF SS = 1 THEN PRINT "Split Screen Display"
125 IF SS = 2 THEN PRINT "Full Screen Displays"
130 PRINT
140 IF CC = 1 THEN PRINT "Crossing Platform/Vehicle Imaging Pattern"
145 IF CC = 2 THEN PRINT "Sequential Platform/Vehicle Imaging Pattern"
150 PRINT
170 PRINT "HS", "VS", "FV", "AI"
190 BC = LN / NC
300 HS = 0
310 HS = HS + 1
320 VS = 0
330 VS = VS + 1
340 P = 3.14159
420 GM = ATN(HS / VS) * (180 / P)
510 BT = ATN(VS / (BC + HS)) * (180 / P)
520 FV = 90 - (GM + BT)
525 IF SS = 1 THEN FV = FV * 2        'Double Lens FV for Split Screen
530 IF SS = 1 THEN AI = GM + (FV / 4) 'Center Image in usable FV
535 IF SS = 2 THEN AI = GM + (FV / 2)
550 IF FV < 40 GOTO 600               'Bound Field of Vision to Common Lenses
560 IF FV > 84.6 GOTO 600             'See table 4 in report
599 PRINT HS, VS, FV, AI              'Output Calculated Data
600 IF VS = 10 THEN GOTO 700          'Vertical Setback Limit is 10 Feet
610 GOTO 330
700 IF HS = 5 THEN GOTO 799           'Horizontal Setback Limit is 5 Feet
710 GOTO 310
799 PRINT
800 PRINT "VS is Setback of Camera on Line Perpendicular to Platform Edge"
805 PRINT
810 PRINT "HS is Setback of Camera along Platform Edge (i.e. ahead of train)"
820 PRINT
```

**Figure D-2 Microsoft Quick Basic Program Listing (1 of 2)**





```
825 PRINT "FV is Required Camera Lens Field of Vision"
830 PRINT
835 PRINT "AI is Angle of Incidednce of Center of Camera Lens"
840 PRINT "to line perpendicular to platform edge"
845 PRINT
1010 PRINT "See Report Table 5 for Camera Angular Field of Vision Values"
1015 PRINT
1020 PRINT "Select Lens with Field of Vision Closest to or"
1025 PRINT "Greater than Value of FV"
1030 END
2000 END
```

**Figure D-2 Microsoft Quick Basic Program Listing (2 of 2)**

```
Rail Car/Vehicle Length = 55
Consist Length in Cars/Vehicles = 6
Estimated Total Consist Length = 345

Number of Video Cameras 2

Split Screen Display

Crossing Platform/Vehicle Imaging Pattern

HS            VS            FV            AI
 2             1             52.47332      76.55333
 3             2             66.07421      72.82853
 4             2             51.83156      76.39289
 4             3             71.79216      71.07819
 5             2             42.31159      78.77654
 5             3             59.99084      74.034
 5             4             74.73763      70.02464

VS is Setback of Camera on Line Perpendicular to Platform Edge

HS is Setback of Camera along Platform Edge (i.e. ahead of train)

FV is Required Camera Lens Field of Vision

AI is Angle of Incidednce of Center of Camera Lens
to line perpendicular to platform edge

See Report Table 5 for Camera Angular Field of Vision Values

Select Lens with Field of Vision Closest to or
Greater than Value of FV
```

**Figure D-3 Sample Program Output**

# APPENDIX E

## CCTV/MIRROR DEMONSTRATION NOTES



### GENERAL

The following information summarizes the CCTV/mirror demonstration test performed at PATH's Journal Square station. These notes include information regarding the general procedures employed in conducting the tests, the configuration of the equipment used, and comments solicited from the PATH train conductors relative to their impressions of the benefits provided by the demonstrated observation aids.

**Demonstration Period**

This demonstration was performed between the dates of 19 and 21 October 1994. On 19 October, the equipment was temporarily installed, and performance tests were performed. As part of these tests, the positioning of the mirror and video cameras was fine-tuned to provide the optimal field-of-vision to the train crew. Testing was initiated in the early afternoon of 20 October and continued into the morning of 21 October. This test period was selected to provide the greatest possible exposure to different train crews in order to obtain feedback in significant quantities. In addition, the testing period spanned complete morning and evening rush hour periods as well as off-peak periods. This allowed the demonstration observation aids to be exercised during periods of peak loading and to allow the aids to be assessed when the platforms were the most crowded.

Prior to the demonstration, a site survey was conducted to collect baseline information to be used in designing the installation of the demonstration system. This survey was performed on 26 September 1994 and addressed demonstration aspects such as camera installation locations, mirror locations, the monitor location, lighting levels, and station structures.

**Demonstration Personnel**

Both the principal and associate investigators for the project participated in the demonstration. Generally, the principal investigator addressed the installation of the equipment and reconfiguration during testing, while the associate investigator was responsible for fine-tuning equipment positions and collecting feedback from operations personnel. Various PATH personnel supported the demonstration. This support included assistance during equipment installation, particularly during the stringing of power and cables. In addition, a PATH operations examiner worked with the associate investigator in soliciting feedback from the train crews. This was particularly useful in overcoming resistance of the crews to provide information on the



effectiveness of the observation aids.

### DEMONSTRATION EQUIPMENT CONFIGURATIONS

As was introduced above, both CCTV- and mirror-based observation aids were demonstrated. Equipment for both types of aids were co-located with the existing observation aid to allow comparisons to be made and contrasts to be developed. Figures 1 and 2 show the locations of equipment for both aids relative to the conductor's position for a properly berthed eight (8) car train as is most commonly operated by PATH. Figure 2 shows the monitor as being four (4) feet from the conductor's location. This distance was varied to test the guidelines for monitor positioning as presented in Part I of this report.

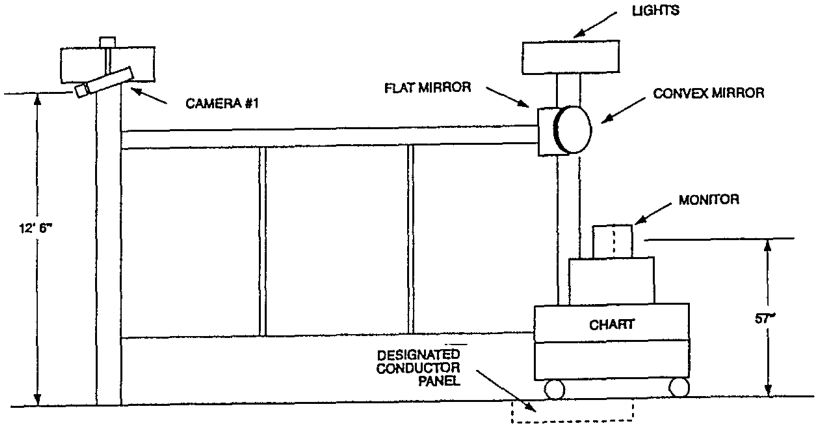


*Figure 1. Demonstration equipment installation. (1 of 2)*

**CCTV Equipment Configuration**

Multiple configurations of a CCTV-based observation aid were demonstrated. These included a system with a platform-mounted color video monitor as well as a system with a video monitor carried on the vehicle. The later tests were conducted briefly and were designed only to verify that clear video images could be received on the train. This was because platform monitors are the most widely used in the industry and existing PATH operating procedures were better served by the platform monitor.

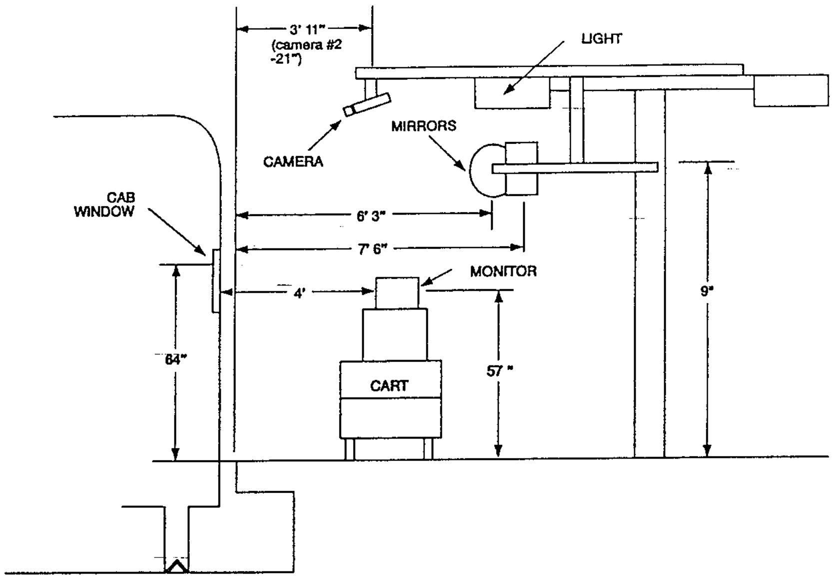


*Figure 2. Demonstration equipment installation. (2 of 2)*

All equipment used in the implementation of the demonstration system provided color images with the exception of the monochrome monitor used for the carborne tests described below.

As shown in Figure 3, two (2) video cameras were installed along the platform employing a crossing similar to that used at the Haddonfield station on the PATCO system (see Part II for additional details of PATCO's use of CCTV as an observation aid). This pattern provides the most complete coverage of the edge of a platform and the rail car doors for curved platforms. Before performing the demonstration, the required camera fields-of-vision were calculated on the basis of station characteristics, equipment consist lengths, and train stop locations. The cameras were temporarily installed to allow the camera angles to be varied slightly to aid in the validation of the camera installation guidelines. A ball/swivel-head camera mount was used to allow installation angle variance. The cameras were attached to existing light stanchions in the station using clamping brackets fabricated from Vari-Strut system components. No existing structures were modified in any way and foam padding was used to ensure that no cosmetic damage was made to any existing structure. Because of the temporary nature of the camera installations, some compromises were made in these locations. This is due to the fact that it was necessary to use existing station structures for camera mountings. It was possible



to compensate for the bulk of this compromise by varying the vertical and horizontal adjustment of the camera. As a result, it was possible to image over 98% of the required field-of-vision. It should also be noted that the demonstration CCTV observation aid installation was designed to supplement the conductor's field-of-vision rather than become the sole means of observation. This decision was made to simplify the installation system design and to provide conformance to existing PATH operational procedures.

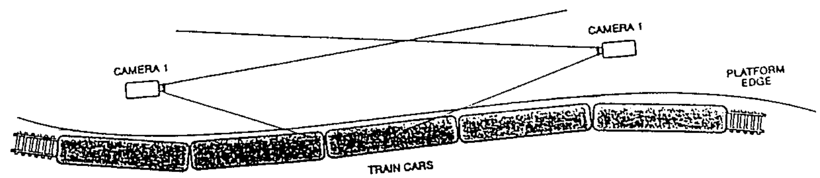


*Figure 3. Demonstration CCTV camera installation scheme.*

Figure 4 is a block diagram showing the configuration of the video demonstration system. This figure reflects the use of a platform monitor as well as the use of an RF transmitter for the carborne video monitor. The RF transmitter was connected to the looping output of the video monitor to allow both system configurations to be operated simultaneously. As shown in the figure, the two video cameras had their images combined into a single display using a split-screen image combiner. During the basic design of the camera installations, the fact that the screen-splitter uses only half of the image captured by the camera was taken into account. The location compromises necessitated by the use of existing station structures for camera installation also accounted for this fact. Common synchronization for the two (2) video cameras will be provided through the use of a distribution amplifier. Power for all equipment located on the platform was derived from a 115 VAC source. This power was provided by existing NEMA outlets on the platform. As required, extension cords were strung between the outlets and the equipment locations.

On the basis of established industry guidelines, a 9-inch-diagonal monitor was used in the demonstration system. The monitor selection was determined using the formula:

Monitor Viewing Distance + 4 = Diagonal monitor size (inches)

The monitor size has a tolerance of ±25%. For the nominal monitor viewing distance of four (4) feet, the required monitor size was in the range of 6.4 to 10 inches. The monitor was located on a cart to allow it to be moved to account for variations in the train berthing location.

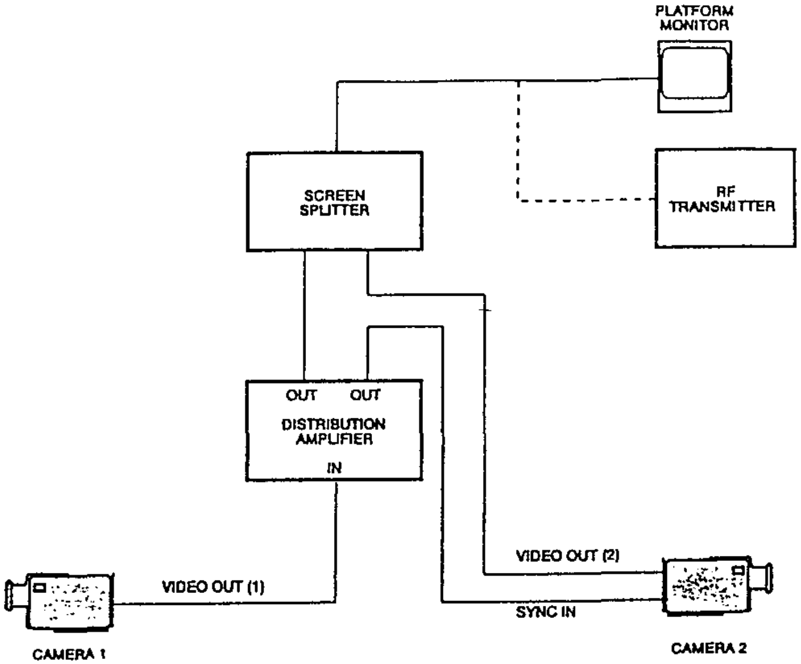


*Figure 4. CCTV demonstration system configuration.*

For the vehicle-borne monitor system demonstration, the transmitter antenna was located at the leading edge of the platform (with respect to the normal direction of train travel). A receiver was carried on board the train with the antenna located behind the window of the door at the front face of the train. The output of the receiver was connected to a handheld video monitor. This monitor was monochrome and had a screen size of 2.6 inches. In actual transit practice, such a system would use a larger video monitor. The purpose of this test was more to evaluate the technical feasibility of vehicle-borne monitors rather than to evaluate the overall effectiveness of a CCTV-based observation aid. For this reason, the demonstration keyed on the transmission of images. The received images were viewed and assessed to determine image clarity, video transmission reception range, and the degree of interference from train propulsion systems, power distribution, signaling equipment, and other train subsystems. Part of this latter test involved having the receiver on the platform next to a train and viewing the images as the train entered the station, stopped, and then exited the station. During these observations, the receiver was located as close as possible to propulsion system components, such as traction motors and power converters.



**MIRROR CONFIGURATION**

PATH's Journal Square station currently has convex mirrors located at the seven (7) and eight (8) car stopping positions on track 4. On the basis of operational surveys, these mirrors were determined to be effective in aiding the conductor in surveillance of train doors. Because these mirrors are convex, they are subject to image size compression, which is an inherent characteristic of this type of mirror. For these reasons, it was decided to co-locate a square, flat plane mirror with the convex mirror to allow the differences to be contrasted. Because most trains operated by PATH on track 4 are eight (8) cars in length, the flat mirror was installed only at the conductor's location for an eight-car train. The flat mirror was aligned to provide a supplementary view of the portions of the third and fourth cars of the train, which are obscured from unaided observation. Generally, the conductors were queried to assess the benefits of the image size differences between the two mirrors. To aid the operators in the comparison, the existing convex mirror was cleaned to avoid having mirror cleanliness affect the comparison.

**Demonstration Site Environment**

As indicated in Part I of this report, the most challenging scenario for rail car side-door observation is posed in stations with S-curve-shaped platforms. Because the platform adjoining track 4 in the Journal Square station exhibits this characteristic, it was determined to be an ideal location for the demonstration.

Because of the arrangement of facility structures and the platform edge configuration, PATH conductors cannot readily observe the middle cars of an eight (8) car consist without observation aids. As was indicated previously, two (2) mirrors are currently installed to assist the conductor in observing the entire train. Regardless of these existing aids, it is difficult to observe the rearmost car in an eight car consist because of the curvature of the platform and structural obstructions.

Another notable facet of the Journal Square station is the variation in lighting levels across the platform. The Journal Square station is located at grade level; however, the presence of structures over the station dictate the use of artificial lighting at all times. During daylight hours, there is some bleed of light into the station; this was determined to have a significant impact on the lighting level in the platform areas used during normal operations. During the location survey preceding the demonstration, it was determined that there were significant variations in the lighting level across the platform (i.e., from leading edge to trailing edge with respect to the direction of train travel). As an example, the lighting level at the planned monitor location was determined to be 5 foot-candles (50 lux). Near the center of the station, under the fare collection concourse, the lighting level was found to be 40 foot-candles (400 lux). This was primarily because of the low ceiling in this portion of the station as well as the fact that there are more lighting fixtures in this area. It was also interesting to note that the light level at this location jumped to 50 foot-candles (500 lux) when a train was in the station. This jump was attributed primarily to reflections of light off the polished bare metal sides of the rail cars and contributions of vehicle interior lighting. This significant difference in lighting levels results in image contrast differences that can make portions of a video image unusable and can have similar effects on mirror images.

## DEMONSTRATION PROCEDURES

### Standard PATH Observation Procedures

During the demonstration period, the researchers reviewed the existing PATH observation procedures in use on track 4 at the Journal Square station. For reference purposes, trains using this track are generally traveling from the World Trade Center in New York City to Pennsylvania Station in Newark, New Jersey.

As the train approaches the berthing location and is coming to a complete stop, the conductor extends his/her head through the opened side window at the rear of the train's lead car and observes the platform. After the train has come to a complete stop and the conductor has determined that it is properly aligned (via platform markings and the convex observation mirror), the doors are opened and passenger ingress/egress commences.

During the passenger boarding process, the conductor observes the platform along the side of the train by direct unaided observation and through the use of the convex mirror located approximately seven (7) feet from his/her location. After the conductor has determined that passenger boarding is complete and the doors are clear of obstructions, the conductor will first look forward and activate the closure control for that zone of the doors. During this process, the operator uses the red door indicator lights on the outside of the train to ensure that the doors have closed. Following these actions, the conductor makes another observation of the rear doors to ensure that they are clear of obstructions. The convex mirror is used as part of this process because it provides a view of the third, fourth, and fifth cars of the train not available to the unaided eye. Upon determination that the rear doors are clear, the operator activates the rear door zone closure control. Again the door indicator lights on the exterior of the train are used for verification. After the operator observes that the rear doors are closed and that no objects or persons are lodged between the panels, the conductor retracts his/her head into the car to observe the interlock control display to ensure that the doors have properly closed. If the green interlock indicator is illuminated, the conductor will remove the control panel key, which will transfer control of the train to the motor operator. The conductor will then extend his/her head through the window opening to observe as the train leaves the station as a preventive measure against dragging incidents. After the train clears the platform, the conductor pulls his/her head back into the car to prevent injury.



### CCTV/Mirror Demonstration Procedures

Because the demonstration mirror and CCTV monitor were co-located, the researchers were able to obtain comments on both simultaneously. In addition, it was possible to obtain comments contrasting the relative merits of each in a common scenario. As a precursor to the demonstration, a notice was prepared and distributed to train conductors on the day prior to the demonstration. A copy of the notice is provided as attachment A to this document. During the demonstration, a five (5) step process was used to obtain the comments of the conductors. Generally, these steps included the following:

1) A brief explanation of the purpose of the demonstration was provided.

2) An explanation of equipment used during the demonstration was provided.

3) A description of the images on the CCTV monitor, relating them to station structures and the train itself, was provided.

4) Questions soliciting the views of the operator regarding the relative benefits of each observation method as opposed to present techniques were posed to the conductor.

5) As warranted, clarification of the conductor's views was requested or questions posed by the train crews were answered.

To avoid significant increases in station dwell time, these discussions were kept as brief as possible. In addition, there were numerous cases where specific train crews passed through the demonstration site more than once. In these cases, the basic procedure was modified to account for ideas and comments the conductors may have had on the basis of further reflection on the demonstrated observation aids. Details of the basic data collection activities are as follows:

Step 1

After the train was stopped and the conductor opened the doors, the researchers approached the conductor and briefly explained the demonstration being performed. It was highlighted that the research was TCRP (federally) funded and that it was designed for the benefit of the transit industry at large. As the demonstration progressed, it became important to explain that what was occurring was a demonstration and that PATH was not contemplating the installation of similar equipment on a permanent basis. As train crews passed through the demonstration site multiple times, this general explanation of the demonstration goals became less important. Generally, this step took a few seconds.

Step 2

It was indicated to the conductors that, as a part of the demonstration, CCTV equipment and mirrors were being employed. Because the demonstration mirror was located adjacent to the existing convex mirror and the monitor was located adjacent to the conductor's position for a properly berthed train, this was generally obvious. As the demonstration progressed and crews made multiple passes through the Journal Square station, this explanation became unnecessary.

Step 3

The functional characteristics of the demonstration aids were described to the conductors. As part of this, arrangement of the image on the video monitor was explained. It should be noted that a sign explaining the images was affixed to the monitor to aid the conductors in interpreting the images. This practice is similar to that employed by MTA-NYCT at various locations. Figure 34, in the body of the final report, illustrates this scheme.

Included in the explanation of the demonstration CCTV observation aid was a description of the camera locations, relating them to the station's physical features, and the train's berthing location. Because the camera providing the fight portion of the image was located near the conductor's position, it was often pointed out to the conductor. To clarify the field-of-vision provided by the left camera, the last set of doors on the train was pointed out in the video image. Following this explanation, the conductor was asked if he/she understood the provided field-of-vision. In the event that there was uncertainty, additional explanation was provided. As the demonstration progressed, the researchers were able to develop an understanding of the sensitivities and particular viewpoint of the conductors. This had the effect of making this description progressively easier.

Similar activities were performed for the mirror observation aid. Generally, this description contrasted the differences between the fields- of-vision provided by the convex and flat mirrors. In addition, the relative size of the images in each of the mirrors was accentuated.

Step 4

Following the discussions of step 3 above, the conductors were asked their opinions of the images provided by the mirror and CCTV monitor. While this data collection process was generally scripted, it evolved and became more streamlined over the course of the demonstration as the conductors became more familiar with the equipment. The questions asked were placed within the specific context of PATH's operating procedures and the specific characteristics of the Journal Square station. An aspect of this process that was accentuated



was to solicit the recommendations of the conductors as to how the observation aids could be improved.

Step 5

After receiving the initial comments of the conductors, further discussions of the relative benefits of the aids and areas of improvement were held. Depending on the operators' responses, follow-on questions were directed to the specific areas addressed by their comments. In the event that the comments were negative, the conductor's attention was directed to specific portions or aspects of the images to contrast them to existing observation methods. Following this, the conductor was asked why there was no discernible advantage provided by the demonstration aids over the existing methods.

## DEMONSTRATION OBSERVATIONS

### General Observations

In general, the observation aids were well received by the PATH conductors. Feedback was readily provided by the train crews and was sufficiently detailed to allow lessons to be learned and observation aid usage guidelines to be reviewed and refined. The PATH operations examiner working with the researchers was particularly helpful in this regard because he personally knew all of the train crews and this familiarity made the conductors comfortable enough to feel free to provide uncensored commentary. A total of twenty-eight (28) different conductors were interviewed over the course of the demonstrations. These conductors accounted for seventy-eight (78) interviews as trains passed through the demonstration site. In most cases, the observations made by the train crews were consistent as they passed through the station on a repeat basis. Generally, where there were negative comments on the first pass through the station, positive comments were obtained on later passes as the conductors became more familiar with the aids.

Nearly all of the feedback on the CCTV observation aid was favorable. Most notable among the favorable comments was the fact that the color images helped the train operators to see the red door lights on portions of the train and that the contrast between the yellow platform edge stripe and the rail car aided observation. On the negative side, a number of the conductors indicated that the video monitor screen size was too small. As a result of this feedback, the researchers revisited the monitor sizing standard previously mentioned and developed a revised usage guideline, which is included in Part I of this report. In the early stages of the demonstration, a few conductors indicated that they did not trust the image provided by the monitor. The researchers attributed this to unfamiliarity with the observation aid and the lack of formal training rather than a deficiency in the observation aid itself.

Most of the comments on the flat plane mirror were unfavorable. The majority of these unfavorable comments were due to the mirror itself rather than its application as an observation aid. From the onset of the demonstration, it was agreed between the researchers and PATH that the mirror used in the demonstration would be left in place at the conclusion of the test. For this reason, the most durable mirror available was selected for use. This mirror was constructed from chrome-plated stainless steel. Unfortunately, the surface of the mirror had a small bend to the left of center, which distorted the image. Another problem with the mirror was that the chrome plating on the surface was uneven giving the image a textured appearance. Based on these experiences, the mirror application guidelines indicated in Part I of this report do not recommend the use of this type of mirror. In addition, negative comments were made regarding the narrower field-of-vision provided by the flat mirror as opposed to the convex mirror. Because this is an inherent difference between the two types of mirrors, this comment was not unexpected by the researchers. On the positive side, some conductors indicated that the size of the image provided by the flat mirror as opposed to the convex mirror was superior. They indicated that the larger image size makes it easier to pick out details, such as the door locations and persons, particularly as opposed to the edges of the convex mirror where the image compression is most severe.

**<u>Specific Conductor Comments</u>**

Multiple visits were made to the demonstration site by most conductors during the two days of testing. The round trip between the terminus points (World Trade Center and Newark Penn stations) of the line passing through the Journal Square station was observed by the researchers to take approximately one (1) hour. As a result, most conductors passed by the demonstration location on an hourly basis. While the initial conductor impressions of the observation aids were of primary interest to the researchers, conductors passing through the demonstration site on a repeat basis were again asked for their impressions or any additional suggestions they might have. Generally, their impressions were consistent. In most cases, the conductors with unfavorable impressions of the CCTV on their first pass had more positive views the second time through.

The table that follows provides a chronology of station activity during the demonstration, including the time of train arrival, the car numbers of the leading and trailing cars of the consist, whether the visit was the conductor's initial or a repeat, and the conductor's comments. It should be noted that, at each end of the line, the train reverses direction. As a result, the leading car on one pass will be the trailing car on the next pass, and the motor operator and conductor switch from one end of the consist to the other. By tracking the consist car numbers, the researchers were able to determine if the conductor's visit was the initial or a repeat. Also where the table does not indicate comments for a repeat visit, there was no change in the conductor's opinion. In addition, the language used for the




comments most nearly represents what the conductor said and for this reason is presented in colloquial rather than technical terms.

**Demonstration Test Chronology**
**Date: 10/21/94**

| Time | Lead/ Trail Car | Init./ Rep. Obs. | Comments |
|---|---|---|---|
| 12:54PM | 892/703 | I | CCTV is good - Like it a lot. |
| 1:05PM | 672/? | I | Helpful - Good - Needs a larger screen (Note: Used CCTV monitor to observe arrival of train on track 3 with arriving 33rd street passengers transferring to a Newark bound train. A large number of these passengers were at the rear of the train due to the nature of the 33rd street station layout. CCTV helped conductor manage large load.) |
| 1:17PM | 757/742 | I | Likes video - Flat mirror is not necessarily an improvement - distortion in mirror surface is distracting - flat mirror enlarges image. |
| 1:23PM | 654/879 | I | Likes video - make monitor larger - reopened doors to allow a passenger standing at the rear of the train board - passenger only seen through CCTV system. |
| 1:35PM | 667/634 | I | Likes - glad to be able to see rear door of last car. |
| 1:45PM | 660/641 | I | Prefers mirror - Doesn't trust video images - on further explanation reconsidered and indicated that it might be okay. |
| 1:54PM | 703/892 | R | Still liked. |

**Demonstration Test Chronology (contd)**
**Date: 10/21/94**

| Time | Lead/ Trail Car | Init./ Rep. Obs. | Comments |
|---|---|---|---|
| 2:04PM | 691/627 | I | Liked CCTV - Helpful to see rear of train. |
| 2:17PM | 742/757 | R | Liked CCTV and appreciated cleaned convex mirror. |
| 2:23PM | 879/654 | R | Liked CCTV. |
| 2:34PM | 634/667 | R | - |
| 2:44PM | 641/660 | I | CCTV is excellent - View of end of train is particularly helpful. |
| 2:54PM | 892/703 | I | Good - Liked CCTV. |
| 3:04PM | 627/691 | I | CCTV much better than mirrors, liked CCTV. |
| 3:14PM | 757/742 | R | - |
| 3:24PM | 654/879 | R | - |
| 3:35PM | 667/634 | R | - |
| 3:45PM | 660/641 | I | Generally liked CCTV |
| 3:53PM | 847/823 | R | CCTV is good - used as sole means of observation |
| 4:03PM | 892/703 | R | Larger monitor would make door lights more visible. |
| 4:14PM | 691/627 | R | - |
| 4:20PM | 742/757 | R | Suggested placing monitor at track light location for entering into B yard. |



**Demonstration Test Chronology (contd)**
**Date: 10/21/94**

| Time | Lead/ Trail Car | Init./ Rep. Obs. | Comments |
|---|---|---|---|
| 4:27PM | 879/654 | R | Used CCTV and mirrors together. |
| 4:34PM | 634/667 | R | CCTV is good. |
| 4:38PM | 714/727 | R | - |
| 4:46PM | 767/683 | R | Likes CCTV. |
| 4:49PM | 750/769 | I | Liked CCTV - Big improvement over mirrors. |
| 4:52PM | 835/629 | R | - |
| 4:56PM | 670/? | I | Likes CCTV - Can see passengers much better than as dark spots in the mirror. |
| 5:02PM | 823/847 | R | - |
| 5:08PM | 892/847 | R | - |
| 5:12PM | 610/628 | I | "Waste of money - give motormen money" (see later comment). |
| 5:16PM | 627/691 | R | - |
| 5:18PM | 757/742 | R | - |
| 5:20PM | 885/692 | I | CCTV is excellent. |
| 5:26PM | 654/879 | R | - |
| 5:31PM | 667/634 | R | - |
| 5:33PM | 756/603 | II | CCTV looks good - is an improvement over the mirror - need to gain trust before can rely on CCTV. |

**Demonstration Test Chronology (contd)**
**Date: 10/21/94**

| Time | Lead/ Trail Car | Init./ Rep. Obs. | Comments |
|---|---|---|---|
| 5:36PM | 727/714 | R | |
| 5:42PM | 743/669 | I | Good - improvement over mirrors which can fog in bad weather. |
| 5:45PM | 660/641 | R | CCTV is intriguing. |
| 5:47PM | 683/767 | R | - |
| 5:51PM | 769/750 | R | - |
| 5:55PM | 629/835 | R | - |
| 5:59PM | 751/670 | R | - |
| 6:01PM | 847/823 | R | Very Good. |
| 6:07PM | 703/892 | R | - |
| 6:10PM | 628/610 | R | Previous waste of money comment - explained that it was a research demo and not PATH funded - subsequent comment was that the CCTV was good. |
| 6:14PM | 7 Car Train | I | CCTV is good - Likes view. (Note: Last stop for consist - returned to World Trade Center - prior to departure, passengers standing next to platform edge made direct observation difficult - CCTV was helpful.) |
| 6:19PM | 691/627 | R | Stuck door on closing in mid consist prevented interlock signal - couldn't observe light on monitor but was able to verify that the door was clear. |





**Demonstration Test Chronology (contd)**
**Date: 10/21/94**

| Time | Lead/ Trail Car | Init./ Rep. Obs. | Comments |
|---|---|---|---|
| 6:23PM | 692/885 | R | - |
| 6:25PM | 879/654 | R | - |
| 6:29PM | 603/756 | R | - |
| 6:32PM | 634/166 | R | - |
| 6:39PM | 714/727 | R | - |
| 6:43PM | 767/683 | R | - |
| 6:47PM | 750/769 | R | - |

At this point, the PATH operations examiner aiding the researchers indicated that all conductors on the PM rush has observed the CCTV and mirrors more than once. As a result, no new comments were forthcoming and it was decided to end the test for the day. At this time, passenger load levels had dropped to the point where they could be classified as medium to light.

The demonstration was resumed on the morning of the following day. As a result, the demonstration observation aids would be exposed to a new group of conductors and fresh comments could be obtained. In addition, this demonstration would span the morning rush hour providing further stress testing of the capabilities of the observation aids. A chronology of the second days testing is provided in the following table.

**Demonstration Test Chronology**
**Date: 10/22/94**

| Time | Lead/ Trail Car | Init./ Rep. Obs. | Comments |
|---|---|---|---|
| 8:02AM | 610/628 | I | Can see just as well with mirrors - liked flat mirror. |
| 8:07AM | 847/823 | I | Can see rear cars without CCTV. |

**Demonstration Test Chronology (contd)**
**Date: 10/22/94**

| Time | Lead/ Trail Car | Init./ Rep. Obs. | Comments |
|---|---|---|---|
| 8:13AM | 727/714 | I | Good - Helpful. |
| 8:21AM | 746/? | I | Liked - Okay. |
| 8:27AM | 885/692 | I | Liked - Can see rear of the train. |
| 8:34AM | 660/641 | I | Liked. |
| 8:40AM | 756/603 | I | Okay. |
| 8:59AM | 743/669 | I | 100% improvement over mirrors. |
| 9:04AM | 628/610 | R | Liked mirror better. |
| 9:08AM | 627/691 | I | CCTV better - can see people at rear better. |
| 9:15AM | 892/716 | I | CCTV much better. |
| 9:22AM | 769/750 | R | (Repeat conductor on different train). |
| 9:29AM | 692/885 | R | - |
| 9:33AM | 641/660 | R | - |
| 9:37AM | 603/756 | R | - |
| 9:57AM | 654/XXX | R | - |

At this point, the PATH operations examiner aiding the researchers indicated that all conductors on the AM rush has observed the CCTV and mirrors more than once. As a result, no new comments were forthcoming and it was decided to end the test. At this time, passenger load levels had dropped to the point where they could be classified as medium to light.

## ATTACHMENT A

**<u>Notice</u>**

**Platform Observation Aid Testing**

**at**

**Journal Square Station**

**on**

**20,21 October 1994**

On 20,21 October 1994, at PATH's Journal Square Station, researchers from the Telephonics Corporation will be performing a one or two day test of advanced aids for rail car side door observation. These tests are being performed as a part of a federally funded, Transit Cooperative Research Program (TCRP) study. The Transit Cooperative Research Program (TCRP), was established under Federal Transportation Administration (FTA) sponsorship in July 1992. The purpose of the Transit Cooperative Research Program is to identify and explore areas which can help to enhance the level of service provided in transit operations. Examples of areas addressed by the program include equipment, structures, operations and safety.

The purpose of the study being performed by Telephonics is to identify means which can be used by transit systems to help enhance the safety of passengers as they enter and exit trains at stations. This study includes observation aids which are intended to help extend the field of vision of train conductors as well as compensate for platform curvature and other obstructions. As a result, the conductors will be better able to insure that train doors are clear before they are closed. This should result in improved passenger safety and greater utilization of mass transit services.

During these tests, conductors on trains passing through the Journal Square Station will be afforded the use of both closed circuit television and enhanced mirror-based observation aids. Train crews are encouraged to view these aids and provide opinions to the researchers as to their effectiveness. Any additional ideas or comments that train crews have regarding rail car side door observation will also be welcome.

Thank you in advance for your cooperation in this matter. As you, and your fellow conductors throughout the nation, are the professionals who will be the ultimate users of these aids, your opinions on this matter are needed and will be highly regarded.

**THE TRANSPORTATION RESEARCH BOARD** is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering. It evolved in 1974 from the Highway Research Board which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Bruce M. Alberts is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research and recognizes the superior achievements of engineers. Dr. Harold Liebowitz is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purpose of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce M. Alberts and Dr. Harold Liebowitz are chairman and vice chairman, respectively, of the National Research Council.