Pittsburgh's Light Rail Vehicles

How Well Are They Performing?

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The Port Authority of Allegheny County operates 55 double-ended light rail vehicles (LRVs) on a 10.5-mi segment of its 22.5-mi system in metropolitan Pittsburgh. The rest of the system relies on 45 President's Conference Committee (PCC) cars. Political and financial considerations dictated this mixed fleet. Introducing LRVs to a system served by PCC cars was not difficult because many of the operating techniques are the same. Port Authority Transit's experience with its LRVs began with a subway shuttle operation launched in 1985—nearly two years before the final segment of the light rail system opened to the public. In that time the authority and its car builder have tackled problems with the LRV braking system, doors, air conditioning, corrosion, and automatic trip stop system. Given the satisfactory solutions found for most of the problems, the authority is pleased with the performance of the LRVs.

THE DREAM OF A CENTURY came true on May 22, 1987, when the final segment of the Port Authority Transit's (PAT's) light rail transit (LRT) line opened to the public in Pittsburgh. The $542-million LRT improvement project, including the downtown subway, became the largest public works project ever undertaken in western Pennsylvania (Figure 1).

Because sufficient governmental funding was not available to rebuild the entire 22.5-mi rail system, PAT opted to build the downtown subway and to rebuild the Mt. Lebanon line, converting it from a turn-of-the-century trolley line to a state-of-the-art LRT line. The line to South Hills Village was also

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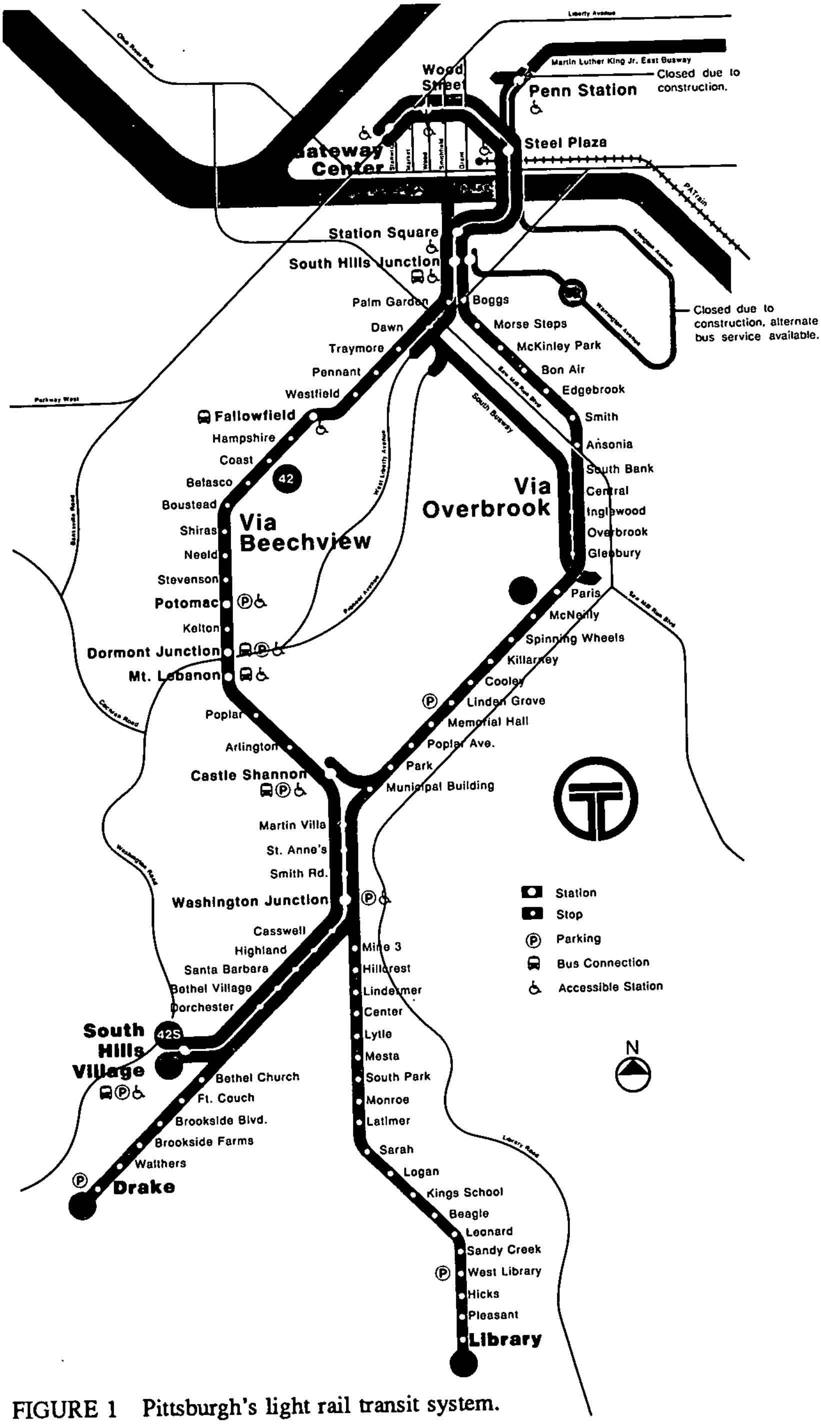

FIGURE 1 Pittsburgh's light rail transit system.

new construction—the first trolley line built in Pittsburgh in more than 50 years.

To maintain as much rail service as possible during the construction work, the lines were built, or rebuilt, incrementally. Construction on the downtown subway was accomplished with minimal interference while trolleys continued to operate on the streets. Reconstruction of the line outbound from Castle Shannon was performed simultaneously with construction of the new line to South Hills Village and construction of the 62-acre yard, shop building, and operations control center at the village. Once these contracts were completed, the base of operations was moved from the 1906 South Hills Junction Car House to the new facility. Work then progressed on rebuilding of the Mt. Lebanon line.

The downtown subway was put into operation on July 7, 1985, taking rail vehicles from downtown streets for the first time in 126 years. President's Conference Committee (PCC) cars had provided all the revenue service until November 1985, when the new articulated light rail vehicles (LRVs) were placed into shuttle service between the three downtown stations and Station Square.

Eventually, three LRVs were required to handle a rapidly developing lunch-time rush hour that grew as downtown workers and shoppers discovered how easy it was to hop the subway to cross the river to Station Square, a collection of trendy shops and restaurants in a renovated railroad station. Although this shuttle operation gave PAT a chance to gain some experience with the cars and the new system, the acid test really did not begin until May 1987. So, when PAT attempts to determine how well the LRVs are performing, it has a vast amount of experience from limited operation and a limited amount of experience from full operation to draw on.

GENERAL DESCRIPTION

At present, the LRVs operate over a 10.5-mi right-of-way (the downtown subway, the Mt. Lebanon line, and the South Hills Village line, with PCC cars handling the remainder of the routes. The LRV route, or the 42S, includes several miles of street running, a number of grade crossings protected by crossing flashers, grades as steep as 9 percent, three tunnels, and approximately 1.3 mi of joint running with buses on the South Busway. The entire line is double tracked. Signaling is accomplished through automatic track circuits, augmented by remotely controlled signals, all providing double block protection supported by automatic trip stop equipment.

Automatic route selection through the 17 interlockings along the line is accomplished with train-to-wayside (TTW) equipment that not only routes the vehicles but also provides a record of their progress to the movement directors at the operations control center (OCC).

The system combines state-of-the-art vehicles with PCC cars built in 1949. Because both types of cars share parts of the trackage, various LRV components had to be retrofitted to the PCC cars, including the TTW encoders, trip stop devices, and pantographs. The decision to operate a mixed fleet (45 PCC cars and 55 LRVs) was a result of both political and financial considerations. The rehabilitation of the entire rail system would have been astronomical in cost; therefore, it was tackled in two stages. Stage 1 is now complete, and Stage 2 planning is about to begin. One very evident result of this multistage reconstruction is the design of the LRVs, notably the single street-level door on each side of the vehicle. This door is used to load and unload at a number of lightly used stops and, of course, does increase dwell and running times. But the public wanted the convenience of "traditional" stops rather than high speed.

THE VEHICLE

The competitive bidding process resulted in the choice of Siemens Duewag to construct the 55 double-ended LRVs. The cars are 84 ft (25.81 m) long; 8 ft 9 in. (2.68 m) wide; 12 ft 5 in. (3.66 m) high; and weigh 43 tons (39 008.74 kg). Each vehicle seats 62 but can accommodate 263 passengers in crush load conditions. The vehicle is powered by two 100 hp motors fed by the 650 volt dc overhead. Acceleration and speed control are via a chopper system, and braking is controlled through a modulated computer system. The vehicles have three distinct, but integrated, braking systems. The dynamic force produced by the motors slows the vehicle to less than 5 mph. Friction brakes then bring the vehicle to the final stop. Magnet rail brakes are used for holding and to assist in emergency stopping. Up to three vehicles can be operated as a train. Most functions, except for traction power and lower platform door control, are trainlined.

TRAINING

The introduction of LRVs into a system served by PCC cars was not as difficult as one might think. Although the vehicles are as different as 50 years of technology could make them, many of the operating techniques are the same. Training began early for the instructors and road operations personnel. Operators also received extensive qualification time on the vehicles and on the new line segments as they became operable. A special task force was created from personnel in the operations, training, and safety divisions and charged with the responsibility of writing operating procedures for all employees connected with the system.

Formal technical training began for car house and other maintenance personnel at a much later time, although virtually all of the PAT personnel worked with the vehicle manufacturer's representatives and gained much knowledge through this contact. Although road operations personnel received some training in troubleshooting, it was subsequently decided that the cars were complex enough that roving vehicle technicians were required to minimize road delays. These technicians, who have radio-equipped trucks, can respond to the location of a vehicle, locate the trouble, and, it is hoped, have the vehicle on its way before serious delays occur.

OPERATING EXPERIENCE

As mentioned earlier, PAT's first revenue experiences came from operation of the subway local shuttles. Three cars were scheduled for this service but were rotated out on a weekly basis. Because the intended use line, the 42 line, was not yet completed and because of load restrictions on the PCC route, these vehicles were moved weekly over the PCC line after regular service hours. This procedure usually took place late Sunday of each week. Three fresh cars left the rail center at South Hills Village and the three service cars from the past week were taken back. A temporary vehicle pit was set up outside the Penn Park side of the system to accommodate daily maintenance and troubleshooting.

BRAKING SYSTEM

The pit got a workout as operators started reporting a braking problem. As the vehicle slows for a typical service stop, it decelerates to approximately 3 to 5 mph through dynamic braking. As the car reaches this speed, the dynamic braking becomes ineffective and the friction or disc brakes take over. This slows the car to a stop but, just before the final stop, a computerized control releases, then reapplies, the disc brake to alleviate the jerking typically felt when a large vehicle comes to a stop. Instead of experiencing this smooth stop, some of our operators reported a release of the disc brake and no reapplication. The car drifted through stops until the final brake—the magnetic rail brake—was applied. This rail brake application caused considerable jerking and an uncomfortable stop. This was happening at the final stages of deceleration and consequently the cars were merely creeping. To make matters worse, it was an intermittent problem, making it hard to fully understand.

Although the failures were not deemed to be of a safety-critical nature, the cars were removed from service until the situation was fully understood. Intensive testing and investigation pointed to some components of the computerized braking system, specifically the EPROMs (erasable, programmable, read-only memories). The problem was further traced to the vehicle's reverser switch. It was found that if the reverser was turned to neutral during the final disc brake release, but prior to its reapplication, the EPROMs were set for failure. With this information, the brake manufacturer was able to reprogram its system to prevent this from happening again.

DOORS

Although the new line still lacked some of the finishing touches, PAT was given an unexpected opportunity to operate it in March 1987 when a landslide, caused by an undetected water line leak, forced the closing of the Overbrook Line. Cars operated via the new alignment for three days, providing passengers with a preview of coming attractions.

Prior to the May opening, PAT had three months for operator training and general debugging of the line and cars. PAT operators did have limited operating experience, but these training exercises helped to uncover additional problems. One such problem was the doors.

Each LRV has a total of eight doors, three high-platform type and one low-platform type on each side. The high-platform doors are controlled from the operator's cab or can be set on "release" to allow passenger operation by buttons located at each door. When not in the "release" mode, these inside buttons act as stop requests. The operator not only can elect for patron door operation, but also can select to open all doors or just the front high-platform door. Whichever mode the operator decides to use, the side of operation must be chosen. The system has two center-platform stations that require the operator to select the left-side doors rather than right-side doors. In the case of the low-platform door, it has one capability only and that is to be open or closed on the end of operation. All doors close with a warning "beep" followed by a 3-sec delay and have exterior open indication lights and sensitive edges.

The sensitive edges led to one of the first door problems. They were too sensitive. This was a bothersome problem, as the edge would continually cycle the affected door and prohibit further operation of the vehicle until the problem door was cut out of service. This cut-out is accomplished by opening the circuit breakers associated with that door. This problem was easily fixed by adjustments to the sensitive edging and door hang. In the case where the problem arose in the central business district (CBD), a maintainer handled it at the temporary pit. If it happened during the exercising of the system, it was noted and adjusted at the South Hills Village Rail Center.

In addition to the one just mentioned, another door problem developed. As cold weather operating hours began to build up, so did slush. It was discovered that slush would accumulate on the thresholds of the doorways and freeze. When the door was closed, the sensitive edge would hit this hardened lump and the door would recycle and continue to recycle until the obstruction was cleared. This problem exists today. Operators are instructed how to clear the problem, but this can cause service disruptions if the procedure is lengthy. The permanent solution is to install the threshold heaters that were omitted from the final design.

As mentioned in the line description, the low-platform door has a large impact on the overall system speed because of its contribution to lengthy dwell times. To explain this a little further, out of 50 stops along the right-of-way, there are 40 low-platform stops. The impact of these low-volume, low-platform stations is two-fold. First they can be served by only one narrow door and second, the entrance steps are higher than people are accustomed to. Put this all together and longer-than-desired dwell times result. A solution would have been to have folding steps at the high-platform doors, similar to those used in Buffalo and Portland, to serve the longer platforms better. Another would be to eliminate the low-platform stops. But, during the planning stages of the system and during the public hearings, the people who use the system testified that they wanted the low-platform service. Although faster running is desirable from a transit person's point of view, the passengers seem quite content with what they asked for.

AIR CONDITIONING

Each vehicle is equipped with two roof-mounted Sutrak air conditioning units, one on each car section. The condenser coils are part of the roof-mounted system, with the compressors on the undercarriage. Because the compressor and condenser are separated vertically by more than 12 ft, problems with liquid migration and "slugging," small frozen blocks of freon, have caused premature compressor failures on a number of the cars. Not only have compressor problems arisen, but condensation discharge was experienced, too. During hot, humid days, condensation from the roof coils languished in the drip pans and "rained" on the passengers and lighting. Better sealing of the pans and drip path easily solved this problem.

Although air conditioning continues to be an ongoing problem, thanks to the willingness of the manufacturer of the air conditioning units to work with us, the passengers have been reasonably cool and therefore happy.

CORROSION

Corrosion is currently a problem on the undercarriage of the vehicle. Signs of early corrosion are appearing on critical piping, valves, and the understructure itself. The car builder is working with PAT to solve this problem and, as with most of our vehicle debugging, we anticipate a timely professional solution.

COMMUNICATION

Communications within the vehicle are threefold. A public address (PA) system is used within the car, an intercom system allows communications between coupled cars, and a third system allows communications between the vehicle and the OCC.

All of these functions are handled through the mobile data unit (MDU), located to the front and the left of the operator. There are two MDUs per vehicle—one in each cab, with one radio transmitter/receiver centrally located. Communication between the vehicle and the OCC is accomplished in one of three ways. When the car is within the confines of the rail storage yard, the operator selects the yard channel using the radio control panel to the left rear. Once the car leaves this designated area, the operator selects one of two modes. The OCC determines which will be used. As the vehicle leaves the yard, the OCC instructs the operator to switch to either the operations channel or the support channel.

The support channel is a contention-type system with all vehicles tuned in. That is to say, if the OCC wants to call car 4102, the movement director calls the car number over the air and all vehicles receive the transmission. However, only 4102 should respond. If the operator needs to talk to the OCC, the reverse occurs.

Should the OCC request that the operations channel be selected, all communications are controlled through the computer-aided dispatch (CAD) system. Through CAD, if the OCC wants to talk to car 4102, the movement director enters the car number into the computer with a keyboard and pushes the "call train" button. A data message is sent to the specific car being called and "beeps" the MDU. This signals the operator to pick up the handset and talk. Should the operator need to call the OCC, a "request to talk" button is pushed and basically the reverse happens. The movement director gets "beeped," the car number appears on the screen and, when the call is acknowledged, the operator and the director talk. At no time do the other cars receive messages as they do on the support channel.

Other CAD functions are mechanical alarms, emergency highlighting, silent alarms, canned messages, and PA announcing to one or more cars from the OCC. At this writing, this IAL/Comstock system is not on line because of numerous technical problems. The system failed a 50-day validation test and discussions are currently under way with the system's manufacturer and subcontractor.

AUTOMATIC TRIP STOP

Rear-end protection is accomplished through an automatic trip stop (ATS) system. This frequency-controlled system detects signals from wayside equipment located at each signal. If the operator violates a red or dark aspect, the car is automatically tripped and brought to a full service stop. The operator must reset the car according to established procedures and continue the run. Each time the car is tripped, a counter on the control panel advances one increment. Should a problem arise on the wayside equipment in that a signal is holding red, the vehicle can "key by" the signal by pressing the key-by button on the control panel. The vehicle then has 20 sec to advance past the fault. This function is also monitored through the use of a counter.

There have been some problems with the system in that stray signals in certain areas are causing false trips. This, coupled with the lack of experience in resetting the equipment, has lead to some lengthy delays. With the continued cooperation of the signal equipment manufacturer, and as PAT operators gather experience, this two-block, rear-end protection should prove to be a beneficial public safety device.

TRAIN TO WAYSIDE

Our rail network is somewhat complex, with a number of interlockings and switches. To maneuver vehicles through these areas safely, a computerized routing system was installed. This system reads signals from the vehicle through wayside detector loops and safely routes the car, locking out any conflicting moves. This equipment is known as TTW (train to wayside).

The car-borne control panel is located to the right of the ATS panel and consists of a three-digit dial encoder. All routes on our system can be described by using a three-digit number. Once this number has been entered, the wayside computers do the rest.

Wayside equipment is located on the track just prior to an interlocking and is connected to the routing computer at that interlocking. These computers are housed in heated signal rooms at the interlockings and can be manually taken over either at the control panel in the signal room or from the OCC. By and large, the car-borne equipment is functioning well. Some field debugging is still under way. PAT is confident that this system will function up to its potential.

PERFORMANCE

PAT's "T" system is definitely an asset to the city of Pittsburgh and Allegheny County. In its short existence, the LRV fleet has given the passengers a quiet, comfortable, and safe ride. The operators have also overcome the natural tendency to reject anything new or different and have grown to appreciate the vehicle.

The public at large also has accepted the system with open arms. Ridership as of March 1988 averaged 28,000 per day, considerably ahead of the consultant's projections. Although there are more than 2,000 spaces at the free park-and-ride lots, these are generally filled before 8 a.m. each day. The public's excitement with a subway and rail system that took nearly 80 years to build was evidenced during the July 4, 1985, grand opening of the subway. It wasn't—and still isn't—unusual to see entire families riding mass transit for the first time. PAT is looking forward to a bright future and has begun taking the initial steps toward extending the line to both the North Side and East End.

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