Implementing a 21st Century Fare Collection System on a 20th Century Zone System

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ABSTRACT

The Port Authority Transit Corporation (PATCO) operates a 14-mile long rapid transit line with 13 stations from Philadelphia to New Jersey. Since its opening in 1969, fare collection has been fully automated. The fare structure consists of five zones. Under the original system, a separate magnetically-encoded ticket was sold for each zone. Tickets could be purchased from vending machines, sales clerks (rush hours only) or by mail. Only cash was accepted for purchases; vending machines only took coins.

In 2007-2008 the fare collection system was replaced. All vending machines and gates were replaced as part of this project. The new system included the first use of Smart Card ticket technology within the Philadelphia area. Individual tickets are still available for purchase at vending machines. Credit card transactions are now accepted for several different ticket options.

During the several-month installation of the new equipment, both the old and new fare collection methods had to be used concurrently in all stations. The changeover required careful sequencing of equipment conversion from old to new so that a passenger, regardless of origin and destination, could use either an old or new ticket.
This presentation describes PATCO’s original fare collection system, notes key elements of the new fare collection system, and its improved features and concludes with a discussion of the complexities associated with the equipment changeover.

HISTORY

The Port Authority Transit Corporation (PATCO) is a subsidiary of the Delaware River Port Authority (DRPA). The DRPA obtained approval from New Jersey and Pennsylvania in 1962 to build the current rapid transit line. Authority to operate it came three years later in the form of a carefully-worded act of Congress ensuring that the new line was not considered to be part of the “general steam railroad system.” The DRPA wanted to ensure operations would not be subject to the ICC rules and regulations the rapid transit line of the Port Authority of New York and New Jersey (PATH) was required to follow as a result of its Pennsylvania Railroad heritage.

PATCO itself was incorporated in late 1967 to operate and maintain the line, upon which construction was far along. Operations along a former railroad right-of-way began in New Jersey between Lindenwold and Camden on January 4, 1969. Between Camden and Philadelphia, PATCO ran over the route of a rapid transit line that crossed the Delaware River on the Ben Franklin Bridge (“the Bridge Line.”) Modifications to the Bridge Line’s subway facilities in Philadelphia delayed the opening of the entire 14.3-mile route until February 15, 1969. Figure 1 shows PATCO’s line; the colored circles at each station represent the color of tickets that were valid at that station under the original fare collection system. (See Table 1.)
In 2008, PATCO completed the installation of a new automated fare collection (AFC) system. The scope of the project included the replacement of all fare gates, ticket vending machines and transfer vendors in all 13 station, as well as parking gate entrance and exit facilities for parking lots at six stations in New Jersey. The new AFC system replaced the system that effectively dated to the 1969 opening of the line.

AHEAD OF ITS TIME IN 1969

Louis T. Klauder & Associates, the primary consultant responsible for creating PATCO, planned it to be an automated, efficient transit system. Only proven, state-of-the art equipment and concepts were chosen. DRPA’s financial vision that PATCO would cover its operating expenses entirely from fares was a major factor in the decision to operate the trains with a single Train operator, and to have unmanned stations. For several years in the early 1970s, revenues did exceed operating expenses, but, as the system aged, more personnel were required to maintain
equipment and facilities and energy costs increased. The recovery ratio began a slow decline to the present 54%, still considered excellent in the transit industry.

When it opened 1969, PATCO was the first rapid transit operation to use a fully-automated fare collection system and to have unmanned stations that were monitored and supervised by customer service agents (CSAs) using closed-circuit television. Passengers needing help could call the CSAs from Call for Aid phones installed at every station. The phones enabled passengers to ask questions, and deal with ticket problems.

PATCO’s fare structure was designed to be distance-based. This was similar to the system used by the statewide system of New Jersey Public Service Coordinated Transport buses. A passenger paid his/her fare upon entering the bus and told the driver their destination. The driver would then print a receipt for the proper fare paid, and hand it to the passenger to serve as proof of payment. The receipt was surrendered to the driver upon exiting.

Such a manually-intensive system would not work on a rapid transit line that was expected to carry tens of thousands of passengers per day in trains of up to six cars. With an eye towards slack travel times, however, such as late night and weekend service, 25 of the original 75 cars were configured as single cars with an additional door immediately behind the Train operator’s cab to enable the Train operator to collect fares. In practice, however, this capability was never used.
Fortuitously, in 1968, the Illinois Central Railroad had installed a state-of-the-art automatic fare collection system on its three commuter train lines in Chicago. The IC used a zone-fare system of a similar type envisioned for PATCO. The tickets were encoded based on the passenger’s origin and destination, and swiped through magnetic readers upon entry and exit from stations. After visiting Chicago to see the installation, PATCO’s managers and consultants decided to use the system, and wrote specifications for ticket vendors, change makers, and gates of the type observed in Chicago.

The fare structure implemented by PATCO included three distance-based zones and two superimposed geographically-based zones. These zones continue to the present day:

- Philadelphia-Broadway Station (Zone 7). This zone replicated the fare in existence for the existing Bridge Line route that PATCO was taking over.
- Philadelphia-Ferry Ave. (Zone 8). Ferry Ave. was the first new station on the line, and had a large park-and-ride lot.
- Philadelphia-Collingswood, Westmont and Haddonfield (Zone 9).
- Philadelphia-Ashland and Lindenwold (Zone 10).
- New Jersey-only (Zone 6). This fare applied between any two stations in New Jersey, regardless of distance traveled.

Table 1 summarizes the fares charged when PATCO opened and the fares in effect when the new AFC system was installed in 2008. The zone number coded on the back of the ticket, as well as the color of the associated zone, is also listed. A reduced-fare (senior citizen) fare was introduced

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in the mid-1970s; a 10-ride ticket good between any stations on the entire line cost $3.75, which was one-half of the-then $0.75 cent Zone 10 (Blue) fare.

<table>
<thead>
<tr>
<th>Zone (between Philadelphia and:)</th>
<th>1969 Fare</th>
<th>2008 Fare</th>
<th>Zone</th>
<th>Ticket Color</th>
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<tr>
<td>Camden, City Hall &amp; Broadway</td>
<td>$0.30</td>
<td>$1.15</td>
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<td>Ashland, Woodcrest* and Lindenwold (*opened 1980)</td>
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<tr>
<td>New Jersey Only</td>
<td>$0.40</td>
<td>$1.30</td>
<td>6</td>
<td>Brown</td>
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</table>

Table 1: PATCO Fares Through the Years

Advanced Data Systems of Los Angeles, CA, provided the original fare collection equipment consisting of 60 gates, 60 ticket vendors and one encoding machine. The PATCO tickets were plastic, credit-card sized—though thinner—with an iron-oxide layer on the rear upon which information was coded using a binary scheme. Figure 2 shows the rear and front of a Zone 10 (Blue) 1 ride ticket that had been in use for over 20 years.

Discrete data information could be read by repair personnel when the tickets were covered with iron filings. The data track, left side in Figure 2, included information about the last station at which the ticket was used, the zone of the ticket, rides remaining, whether the ticket was last used for entry or exit and some bits that were used for employee passes and reduced fare tickets. The other track was a timing (clock) track used for synchronizing the bit information contained in the data track.
The reusable tickets were captured by fare gates after the allotted number of rides had been taken. Staff collected the tickets, recoded them and then reloaded them into vendors for resale.

To provide convenient transfers between SEPTA services in Philadelphia and buses in New Jersey, PATCO purchased transfer vendors and ticket validators from the Cincinnati Time Recorder Company. The transfer vendors, like the ticket vendors, accepted only coins from the day they were installed in 1969 to the day they were unbolted and carted to the dumpster in 2008. The transfer vendors issued a light cardstock ticket, similar to parking garage tickets, that had two tabs—one for each leg of travel on connecting SEPTA service. Change machines were also provided for passengers arriving with only bills in their pocket.

**FOUR DECADES OF SERVICE**

The original equipment, by and large, operated well during nearly four decades of service. The one glaring exception was the four-door hydraulic fare gates; the original array of gates at Lindenwold station are to the right of Figure 3.
When a passenger inserted a ticket to enter or leave, the pair of doors immediately in front of the passenger would open. As the passenger walked through the gate, the second pair of doors would open, then the first set of doors would close, and when the gate detected the passenger was no longer in the gate, the second set of doors would close. This sequence was required to prevent tailgating—a second passenger following closely to the first so as to avoid paying a fare.

While the concept was successful, the mechanics of the gates proved a maintenance headache almost from opening day. As ridership increased, these problems required a solution. The Illinois Central had also reached the same conclusion with their gates, and had begun to replace them with a turnstile-based gate. PATCO again followed their lead, and awarded a contract in 1974 to Western Data Products for 76 gates.

Figure 3: Lindenwold Station, 1969, with the original four-door fare gates. Ticket vendors are at the left, and a SEPTA transfer vendor can be seen under the Call for Aid sign. Photo by Bill Coxey, used by Permission (1).
The turnstile-based gates were narrower than the four-door gates, so at certain stations extra gates could be installed in the array to speed passenger flow. Figure 4 shows the turnstiles at Lindenwold station in 1995; note the larger number of gates as compared to 1969. Additional gates were purchased for the soon-to-open Franklin Square station (to support Philadelphia’s Bicentennial celebrations), anticipated requirements at the planned Woodcrest station, as well as to provide some spares.

During their nearly 40 years of service, the ticket vendors underwent only one significant modification. Beginning in the mid-70s, a 10-year program was implemented to replace the original pull-handle used to vend a ticket with an automatic, solenoid-operated kicker. This modification proved to be exceptionally reliable. In 1981, the coin acceptors in the ticket venders were modified to accept the Susan B. Anthony dollar coins. Since by this time the one-way fare from Philadelphia to Lindenwold was $1.60, this provided a bit of relief for the coin-laden passengers. Change machines were modified/replaced through the years with machines that could accept bills up to $20.
The basic tickets went through a few changes; some visible, some not. Shortly after the line opened, it became clear that the ticket vendors could not reliably cope with the volume of sales. From the beginning of operation, at stations in New Jersey, 10-Ride tickets for frequent riders were sold at newsstands within stations, and then by contract personnel during rush hours when the newsstands closed. This combination of sales still overwhelmed the ticket vendors, and soon 2-Ride (round trip) tickets were introduced.

Not visible to the passenger was the digitally-coded, ride information on the rear of the tickets (Figure 2). The encoding scheme was modified slightly coincident with installation of the turnstiles, and shop forces designed and built an entirely new encoding machine.

The low coercivity coating used made the coding susceptible to damage in the proximity to magnets, such as found on purse clasps. As cell phone use increased among passengers, it was
discovered that magnets associated with the speaker/microphone or the vibrator motor could also erase the information on the ticket when they were in close proximity to each other.

FINDING A 21st CENTURY REPLACEMENT

By the year 2000, the fare collection equipment had far exceeded its useful life. Even so, the hefty electro-mechanical design of the machines, as well as the improvements made by the technicians and repairmen, contributed to a reliable, robust and cost-effective fare collection operation. Because of the lack of microprocessors and software anywhere in the system, only one “Y2K” problem was encountered—the date wheels on the SEPTA transfer machines and New Jersey bus validators did not have any year beyond 1999. The problem was elegantly solved by filing off the type on the year wheels, and for the next eight years nobody missed the year on the affected documents.

Parts availability was becoming difficult. “Lifetime” quantities of some critical parts had been purchased when suppliers went out of business. PATCO had begun to make certain parts; indeed, the encoding machine that had been replaced in the mid-1970s was kept operational for over three decades only because of the resourcefulness of shop personnel.

Passengers were increasingly frustrated by the coin-only system that required many to perform the “PATCO Two-Step:” First get change, then purchase a ticket. The cell phone-induced problems with the tickets sometimes made even the use of a just-purchased ticket a hit-or-miss proposition.
In 2002, PATCO hired a program manager to supervise the procurement and installation of the new AFC system. Booz Allen Hamilton, a consultant with experience in supporting the design and installation of new fare collection systems, was also brought on board. During the specification writing process, several trips were taken to nearby transit agencies that had either recently upgraded their fare collection systems, or were considering upgrades, to learn what did and did not work with their systems.

Following a best-value procurement process, Cubic Transportation Systems—the present day incarnation of the company that had manufactured the 30-year old turnstiles—was awarded a contract in December 2004 to provide the new AFC system. The scope of the contract included a supply of contactless smart cards (CSCs), ticket vending machines, paddle-style fare gates (with an ADA gate at every gate array), entry and exit parking gates and a central network-based control system to allow for remote control and monitoring of all AFC system devices. The original schedule called for a pilot installation to be in place by early 2006.

Just as PATCO’s original fare collection equipment was based on an already extant installation, so, too, is PATCO’s new AFC system. Cubic Transportation Systems was in the process of installing AFC systems on Atlanta, GA’s MARTA rapid transit system and the London Underground. Photos of MARTA’s installation were used by PATCO to show the public what the new equipment would look like. The use of surplus paddle gates from the London Underground installation helped reduce costs.

**PROBLEMS AND SOLUTIONS**
The new AFC system was intended to eliminate problems and shortcomings with the existing equipment, and provide associated enhancements.

- **Fare Evasion**
  - **Problems**
    - The most athletic and brazen evaders simply jumped over the turnstiles, despite the presence of the closed circuit television system. Conversely, small children would sometimes be “coached” by their parents to duck under the turnstiles. (All passengers five years old and over are required to pay the same fare.)
    - When PATCO made five stations accessible to wheelchairs in the 1990s, accessible gates were designed and fabricated in-house. The wide door required to enable a wheelchair through also allowed an unlimited number of unscrupulous people to go through on one fare. For this reason, the ADA gates earned the moniker “family gate.”
    - “There’s something wrong with my ticket,” was a constant refrain of those who would collect tickets they found on the ground or in trash receptacles. Without an expiration date, and if the magnetic information was seriously damaged, there was no way to positively know if a person was telling the truth or not.
  - **AFC System Solutions**
    - The paddle gates are designed to prevent “jumping” and “crawling,” as well as the single-door ADA gate problems. In concept, the gates provide a greater level of impenetrability as the original four-door style of fare gate.
The new 1-Ride and 2-Ride/Round Trip magnetic tickets expire in three days, and have the expiration date written on the back along with the purchase station and destination, enabling station supervisors, CSAs and other employees in the field to easily check the validity of a ticket.

**Passenger Convenience**

- **Problems**
  - Coins Only. A coin-only ticket-purchasing experience may have been tolerable when no fares were over one dollar, but it had long-since outlived its usefulness. Frequent riders could use bills and TransitCheks to purchase tickets during rush hours from sales agents in the New Jersey stations, but otherwise, coins were still king. Additionally, quarters were the only coins accepted at the entrance gates of pay lots at stations.
  - Unreliable Tickets. The increasing problems with cell phones causing data losses was a vexing issue, and the source of considerable complaints. On the production side, the encoder was just one critical part away from going out of service. With no ticket encoder, there would be no tickets to sell.
  - Ticket Options. The old system was extremely limited in the type and cost of fare media. The mechanical DIP switches on the coin acceptors in the ticket vendors actually constrained the specific amounts that could be changed for tickets.

- **AFC System Solutions**
  - The new magnetic ticket media is not subject to damage by magnets on purses or in cell phones.
Credit/debit cards are accepted for CSC purchases and value loading for transactions of $20 and more. (The bank transaction fees for smaller values made the use of credit/debit cards infeasible for paper ticket and SEPTA ticket/transfer purchases.)

- **Obsolete Equipment**
  - The advantage of having engineered-out all of the “bugs” during the previous decades was rapidly being negated by the lack of parts support. Many of the equipment manufacturers no longer existed, and where vendors were still in business, they were no longer interested in providing part support. When Illinois Central Railroad-successor operator Metra retired its fare gates in 2003, PATCO purchased several pallets of parts.
  - The new TVMs replaced both the old ticket vendors and the SEPTA ticket/transfer vendors. New Jersey bus validators were simply removed from stations since they had not been used for decades.

- **Revenue and Passenger Reporting**
  - **Problems**
    - Money Counting. With essentially an all-cash system, the majority of PATCO’s $20 million annual revenue had to be counted by hand. Tedious written records were required whenever personnel opened a ticket vendor or SEPTA ticket/transfer vendor to ensure accountability for cash and tickets. This manual method was able to identify problems with equipment, but the information was very labor intensive to obtain.
- Passenger Counts. The turnstile gates had mechanical counters to record entry and exits. These were transcribed each night by PATCO/DRPA police. The only origin-destination information available was zone-to-zone based on ticket sales.

- **AFC System Solutions**
  - A large suite of back-office reporting capability is now available that enables personnel to analyze everything from the use of a particular ticket by a CSA to determine if a ticket was still valid as a passenger claimed, to the sales of different media by station, machine, type and day. The TVMs record anomalies in cash received, so that a passenger’s claim that “the machine ate my $5 bill” can be easily checked.
  - The use of “auto-loading” value on a CSC when the balance reached a pre-determined limit, along with the use of credit/debit cards for adding value to CSCs reduces the amount of cash required to be handled and counted.

**IN-SERVICE QUALIFICATION TEST (ISQT)**

The contract called for a minimum 60-day In-Service Qualification Test (ISQT) with equipment installed in at least two stations. In addition to TVMs and fare gates, at least one parking gate, the “central system” network monitoring and supervisory system and a Ticket Office Terminal (TOT) were to be installed. As planned, the ISQT was to have lasted 90 days, and include Woodcrest, 8th/Market and 9th/10th-Locust stations.
Woodcrest was chosen because it has the largest number of individual parking lots within the station parking facility. Since the new parking gates would only accept the CSC, limiting the access to one lot would have less impact on the rest of the passengers. The large station lobby allowed a full complement of TVMs to be installed while leaving all the old ticket vending machines in place. Space was also available for a temporary customer service area to be established for customer outreach facility and for creating CSCs for the nearly 6,000 riders enrolled in PATCO’s Reduced Fare Program (RFP).

8th/Market provides interchange opportunities with major SEPTA routes in Philadelphia, and is PATCO’s second-busiest station.

Jefferson University and Hospital is located adjacent to the 9th/10th-Locust station. Jefferson expressed an interest in being involved in the pilot program with the CSC. The configuration of the station enabled the full complement of TVMs and a complete array of gates to be installed and operated in parallel with the existing fare collection system.

The ISQT began in August 2006. Even though all of the equipment in the fare gates and vending machines had been used in previous installations, gremlins soon appeared in several areas. The devices used to read the CSCs had a high failure rate, and magnetic tickets frequently jammed in the Universal Ticket Transports (UTTs). Software and network issues also surfaced, including problems with bank connections to process credit/debit transactions as well as the internal monitoring software, HP Open View. There was an unacceptably high failure rate of the CSCs at
the TOT in Woodcrest. With the limited number of CSCs available at the start of the ISQT, this slowed the issuing of cards for the Reduced Fare Program participants.

During the ISQT period, work continued at stations to route conduit to provide power and network connections for the eventual complete installation of the AFC system. This proved fortuitous, because at the end of the 90-day ISQT period it was clear that the system was not yet ready for “prime time.” However, project leadership made the decision to expand the ISQT to every station on the line.

**EXPANDING THE ISQT**

Expanding the scope and duration of the ISQT provided a larger population from which to monitor the reliability of the equipment. Any equipment installed during the ISQT would save installation time once the full installation occurred. Coincidentally, while working out the planned sequence of final system installation, it had become clear that when beginning the full installation, all current plastic RFP ticket users would have to have the capability to travel between any two stations with the CSC. Consequently, one new fare gate had to be installed at every station. A further, perceived, benefit of this expansion was the ability of the public to become familiar with the new system.

The ISQT expansion began after Thanksgiving in 2006. A complete array was installed at the 12th Street entrance of the 12th/13th-Locust station, along with a full complement of TVMs. This station has two entrances so completely converting one entrance to the new system was feasible,
in much the same way as the parallel installation at 9th/10th-Locust. At other stations, generally one new fare gate and two TVMs were installed. By the end of February 2007 the installation of equipment for the ISQT expansion was complete.

The expanded ISQT then lasted for nearly all of 2007, in part due to a completely unrelated issue associated with political issues affecting the overall DRPA budget that constrained execution of certain contract matters. Equipment reliability was slow to improve, and a new problem emerged with the “disc on chips” (DOC) that formed the electronic brain of the fare gates. As new software was introduced, some of the DOCs wouldn’t accept the changes, or failed soon after. The temporary solution eventually involved replacing nearly all of the DOCs.

As the weather warmed up, wet tickets became a problem. If passengers placed their old, plastic tickets in their pocket on a hot, humid day, it didn’t affect the performance of the ticket. The new magnetic tickets, made of paper, would get soggy, and when placed in the UTTs, frequently ended up as a mass of wet pulp, jamming the device. The paper stock met the contract specification, but a better solution was needed. Eventually a ticket of the same thickness, but with a slight plastic content was introduced that solved all but the most soggy of ticket problems.

From a maintenance perspective, the expanded ISQT equipment installation was a major headache because the lone fare gate became a “single-point failure.” Any problem with the fare gate effectively put that station out-of-service for anybody using the new fare media. Consequently, the deployment of the on-line repair personnel had to be modified to minimize
possible delays in response to problems. Problems with TVMs were a bit less disruptive because most stations had multiple TVMs installed, thus avoiding the “single-point failure” problem.

Existing turnstiles and vending machines were also negatively impacted by the expanded ISQT. The installation of one new fare gate typically resulted in removing two turnstiles, thus increasing usage of remaining turnstiles. Most new TVMs had to be installed in locations where existing ticket vending machines were located. As a result, most sales of 2-Ride tickets were curtailed to provide adequate capacity for 1-Ride purchases. Revenue personnel were largely able to adjust to the variation in ticket sales rates and cash collection, but spot shortages of some 1-Ride tickets occurred as the use/collection/re-encode/reload cycles for these tickets became strained.

Despite copious signage, many passengers thought they could use the new tickets in the old turnstiles, or the old tickets could be used in the new fare gates. Fortunately the UTTs simply ejected the plastic tickets, but using a new magnetic ticket in an old turnstile typically ended up jamming its ticket transport. On Friday and Saturday nights it wasn’t uncommon for 80% of the turnstiles to become jammed with new tickets at Lindenwold, requiring in midnight call-ins of maintenance personnel.

FULL INSTALLATION BEGINS

By the fall of 2007, DRPA budget issues had been resolved with respect to the AFC system installation. Enough CSCs were available to satisfy the estimated initial demand associated with

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a full installation. The AFC system’s network had been hardened sufficiently to permit credit and debit cards. Software permitting the use of bank cards was still being developed, but that wasn’t an obstacle to completing installation. The performance of the fare gates and TVMs was acceptable. Finally, a contract to administer a Customer Service/Call Center office at the Broadway station to help passengers with the new AFC was signed, and four agents were hired.

As mentioned earlier, PATCO’s overlapping zone system required a complex coordination of station equipment changeout and ticket sales conversions because a passenger had to be able to travel between any origin and destination with the tickets available at the origin station. Already having at least one new AFC system fare gate and TVM at every station was essential to making this feasible.

Table 2 contains an overview of the conversion process. At stations with multiple entrances, each entrance is listed separately. The colored rows show which plastic tickets were accepted at each station. The next-to-last row is the month/day in 2007/2008 when conversion of that particular entrance/station began. The last row shows the numerical sequence of the conversions. Clearly, the conversion was not a simple matter of beginning at one end of the line and moving to the other.

A week before the conversion began, signs were placed on all vendors of the Red and Brown tickets, announcing that sales would end on November 29. This gave passengers plenty of time to become familiar with the workings of the new TVMs. Additionally, signs were placed at every
station listing the tickets that were being accepted at all other stations throughout the conversion. As stations were converted, the signs were updated to reflect the current situation.

The first station to be converted was Broadway/Walter Rand Transportation Center in Camden which is located in Zone 6 (Brown Ticket) and Zone 7 (Red Ticket). For a week before the conversion began, PATCO personnel were on hand in the station for several hours each day to sign people up for the CSC. This was necessary because the TVMs by themselves did not have sufficient capacity to support thousands of individual CSC purchases.

The Broadway station has two separate entrances, and the east entrance was completely closed beginning on November 26. During the afternoon of November 28, the vending machine stacks throughout the line selling Red and Brown tickets were deactivated. On the morning of November 29, the east entrance of Broadway station opened with only new AFC system equipment in operation. The west entrance was then closed, and three days later it reopened with new AFC system equipment.

Table 2: PATCO Stations and Entrances with Accepted Tickets, and Sequence of Conversion.

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<tr>
<th>STATION</th>
<th>10th/March</th>
<th>Tenth/Market</th>
<th>12th/Market</th>
<th>City Hall</th>
<th>Haddonfield</th>
<th>Collingswood</th>
<th>Westmont</th>
<th>Haddonfield</th>
<th>WOODCROS</th>
<th>Ashland</th>
<th>Lindenwold</th>
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</table>

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City Hall station was the next to be converted. Because it has only one entrance, it had to remain open during the conversion. The phasing of equipment changes involved removing one old turnstile and installing on new fare gate on the first night. During the day, the new fare gate was tested and placed in service. The second night, the remaining two turnstiles were removed, additional station site preparation work done, and one fare gate installed. On the third day the newly-installed fare gate was placed in service. On the fourth night, the last fare gate was installed, a second TVM was installed and other connections to the network were made. During the following day, everything was tested and placed in service.

**CHANGE COMES TO PHILADELPHIA**

The next two stations converted were individual entrances at 8<sup>th</sup>/Market and 15/16<sup>th</sup>-Locust in Philadelphia. The North entrance of 8<sup>th</sup>/Market was closed to passengers on December 10. Signage was placed throughout the station providing directions to the South entrance, and during rush hours personnel were stationed at the South entrance to assist with the flow of passengers.

The conversion was completed on time, within five days. But, passenger confusion continued until the conversion of the South entrance, two months later, because passengers with tickets for the old system would still attempt to leave the station via the North entrance despite signage directing them to the South entrance.

The array at the 16<sup>th</sup> Street (East) entrance of 15<sup>th</sup>/16<sup>th</sup>-Locust was next conversion. Again, signage and personnel were on hand to help guide people to the right stairway from the platform.
to the mezzanine for leaving the station With the completion of the 16th Street (East) entrance conversion, every station in Philadelphia was now equipped with a complete array of new fare gates and TVMs. This set the stage for complete conversion of the seven remaining New Jersey stations.

**COMPLETING THE CONVERSIONS**

A week before each New Jersey station conversion, PATCO personnel were on hand in the station for several hours each day to sign people up for the CSC. Signs were posted at appropriate vending machines in advance of terminating of plastic ticket sales. Sales of Orange (Zone 8) tickets ended on January 3, 2008, just prior to completing the Ferry Avenue station conversion. Work began at Ferry Avenue just before Christmas, and during the planned holiday-interrupted changeover, old turnstiles and vending machines were available alongside a few new fare gates.

The Zone 9 (Green ticket) stations of Westmont, Collingswood and Haddonfield stations were next to be converted, in that order. All of these conversions followed a sequence of gate changes similar to that which occurred at City Hall station. Green tickets sales ended on January 8, 2008, the day the Westmont station conversion began. Refer to Table 2 for the dates the other station conversions began.
With only Zone 10 stations left to convert in New Jersey, it was again time to head back to Philadelphia to convert the 15th Street entrance of 15/16th-Locust. The changeover of the 15th Street entrance was accomplished during the week of January 21.

On January 24, 2008 the sale of Blue (Zone 10) ticket sales from the old vending machines was terminated. This marked the complete end of plastic ticket sales. By this time, most passengers were purchasing 1-Ride and 2-Ride magnetic tickets from the TVMs, so the impact was minimal. Ashland was the first of the Zone 10 stations to be converted, followed by Woodcrest and finally Lindenwold. On February 6, 2008, the era of plastic tickets ended with the decommissioning of the remaining turnstiles at Lindenwold.

With the completion of New Jersey station AFC system station equipment installation, the remaining station entrances in Philadelphia that still had turnstiles were changed. The South entrance at 8th/Market was closed on February 12, and three days later it reopened. The 16th-West entrance of 15/16th-Locust was converted the following week.

The last gate array to be changed was the Juniper Street entrance of 12th/13th-Locust. This entrance had never had one of the new fare gates installed because the other station entrance, 12th Street, had a complete array of new fare gates.

Many passengers still had “left over” plastic tickets. PATCO initially offered to redeem them for a CSC with an equivalent dollar value loaded on it, but eventually cash refunds were also given. Refunds of the plastic tickets lasted until September 2008.

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The full installation took just over three months, and finished approximately a week early.

**PARKING, WARRANTY PERIOD and CONCLUSION**

Following the completion of the station equipment installation, Cubic turned its attention to converting the parking gates at the six New Jersey stations with park-and-ride lots. A detailed discussion of this portion of the work is beyond the scope of this paper. The parking gate installation was completed however, in the allotted three months.

Acceptance by the public has been positive, and in most respects, the new AFC system has achieved its goals. Within a month of the conversion, “ridership” rose by several percent. Other agencies had also reported similar spikes in revenue and passenger count. Most of the increase was attributed to reduced fare evasion.

After a year, use of CSCs has reached the hoped-for level of at least 75%. There are over 55,000 CSCs in circulation, and PATCO’s weekday ridership is approximately 40,000 (February 2009). The personnel handling the stocking of TVMs with cash and tickets have been able to perform their tasks within normal workday hours. During the transition, weekend overtime was the norm, and due to the changing nature of station/ticket combinations.

Trouble calls to CSAs using the “Call for Aid” phones in the stations dropped to levels much lower than those experienced in the last years of the old system.
On the contract side, the warranty period lasted for 12 months following the completion of the station fare gates and TVMs. Reliability of some components remains the topic of on-going discussions between PATCO and Cubic. Nevertheless, the new AFC is a major improvement for both the riding public and PATCO.

REFERENCES
Vigrass, William J., “The Lindenwold Hi-Speed Line—The First Twenty Years of the Port Authority Transit Corporation,” ©1990.

FIGURES
Figure 1: The PATCO Route and Connections
Figure 2: PATCO Tickets. (Zone 10—Blue Shown)
Figure 3: Lindenwold Station, 1969. Photo by Bill Coxey, used by Permission (1).
Figure 4: Lindenwold Station, 1995. Photo by the Author.

TABLES
Table 1: PATCO Fares Through the Years
Table 2: PATCO Stations and Entrances with Accepted Tickets, and Sequence of Conversion.