

METRO TRANSIT METRO BLUE/GREEN LINE LIGHT RAIL VEHICLE (LRV) AUTOMATED PASSENGER COUNTER

PROGRAM EVALUATION AND AUDIT



December 10, 2014

INTRODUCTION

Background

Metro Transit is required by Federal Transit Administration (FTA) regulations to input annual ridership and other data into the National Transit Database (NTD). As stated in A Guidebook for Using Automatic Passenger Counter Data for National Transit Database (NTD) Reporting, prepared by the National Center for Transit Research, “to be eligible for the Urbanized Area Formula Grant Program (i.e., Section 5307), transit agencies must report annual data on unlinked passenger trips (UPT) and passenger miles traveled (PMT) to NTD for each mode and service type.” Unlinked passenger trips are the number of passengers boarding transit vehicles while in revenue service. Passengers are counted each time they board a revenue vehicle, regardless of how many vehicles are used to travel from origin to destination. Passenger miles traveled refers to the total distance traveled by all passengers of transit vehicles while in revenue service.

The FTA requires a 100% count for UPT and PMT if it is available and reliable. If a reliable 100% count is not available, it must be estimated through random sampling meeting a 10% precision and a 95% confidence level. Additional requirements (benchmarking and maintenance plans) apply to using Automatic Passenger Counter (APC) data for FTA reporting, even if they are employed on 100% of vehicles. The benchmarking plan must contain procedures for conducting a benchmarking study during the first year for which an agency wants to use APC data for NTD reporting. The maintenance plan must include procedures for calibrating APCs every year thereafter. Both plans must be submitted to the FTA before APC data can be placed in the NTD database.

Metro Transit personnel currently conduct on-board manual ride checks to collect the necessary boarding and alighting data for each station. APCs, using electronic infrared beams and associated software to count passengers as they board and alight transit vehicles, offer a convenient method of sampling for statistically accurate ridership data. It can be difficult to manually collect data for night, weekend and early morning train trips due to staff availability; however, APC technology allows light rail agencies to gather ridership data 24 hours a day. Metro Transit has installed APCs in 778 of its buses, and 29 of its 59 Siemens light rail vehicles (LRV). None of the 27 Bombardier LRVs are currently equipped with APCs. The APTA 2013 Public Transportation Fact Book reports that, as of January 2011, 29 transit agencies entering data into the NTD operated either light rail (22) or streetcar (7) systems in which APCs were installed on 21.3% of the vehicles.

Houston METRORail conducted testing in 2004 to measure the accuracy of their new APC system. Ridership data was examined for weekday and special events. APC units counted 2.61% fewer passengers on average compared to manual counters. The largest variances occurred in special event counts where the APC’s counted between 4.54% and 8.5% fewer riders.

The Center for Urban Studies at Portland State University examined the TriMet APC system in 2005. The research found that APC units undercounted boardings by 5.4%.

The Transportation Research Board of the National Academies conducted a study in 2008. The respondents stated that “data processing and reporting software is the most important part of APC implementation.” TriMet was also included in this study operating 81 APC equipped LRVs over four lines. The primary benefits that TriMet reported were a large amount of statistically valid ridership data, greater confidence in the accuracy of the data, and no need for ride checkers. However, the agency noted that it took about a year to work out all issues involved in integrating APC/AVL databases.

The aforementioned studies were conducted on APC units developed prior to the current multi-dimensional infra-red technology incorporated in the units purchased by Metro Transit. Such technology is more precise in identifying and counting individual passengers as they board the light rail vehicle.

In addition to using manual ride counts for annual NTD reporting, Metro Transit uses the data to report ridership for internal uses including service analysis, route improvement studies and safety analyses, and for reporting to external stakeholders including funding partners such as the Minnesota State Legislature, the Counties Transit Improvement Board, county boards within the 13 county metropolitan area, local governmental entities and community organizations.

Assurances

This audit was conducted in accordance with the Institute of Internal Auditors’ International Standards for the Professional Practice of Internal Auditing and the U. S. Government Accountability Office’s Government Auditing Standards.

Scope

This review was limited to an evaluation of the accuracy of ridership data as recorded by APCs used on METRO Blue and Green Lines LRVs during normally scheduled and populated trips. Audit did not test for special events or for NTD reporting.

Methodology

To gain an understanding of the APC equipment and software used to collect ridership data and assess the accuracy of that data, the following methods of inquiry were used:

- *Council personnel were interviewed.*
- *A physical count of boardings and alightings from random and judgmental samples of trips on LRVs equipped with APCs was taken.*
- *Sample data and APC data were compared and analyzed.*
- *Research was conducted regarding peer transit agency use and reliability of APCs.*
- *Metro Transit policies, procedures and work instructions were reviewed.*
- *FTA regulations, guidance and best practices were reviewed.*

OBSERVATIONS

Initial Sampling Results Required Follow-up Sampling to Confirm Accuracy of APCs

Audit staff conducted two phases of sampling to ensure that the APCs installed on Siemens LRVs met the manufacturer's guaranteed accuracy rates. In its marketing literature, the APC manufacturer INIT states that it "guarantees accuracy rates at > 95%." The APC "system requires a sample of 500 passenger counts and is then accurate to 4% for passenger (net) error" and "8% for unbalanced boarding and alighting (absolute) errors." The first sampling phase was a random sample of APC-equipped LRV doors. Later a second phase of sampling was required due to issues discovered with the APC onboard computers. This second phase required a judgmental sample.

Phase 1 Passenger Counts

A random sample of APC-equipped doors was selected for manual counts during a four-week time period in February and March, 2014. These counts were compared to APC counts provided by Metro Transit Revenue and Ridership (R&R) personnel.

Clusters of APC-equipped doors were sampled during peak and non-peak times. Weekend train trips were included within the non-peak clusters. The observation unit was one door event, meaning a door opens. The sample size needed, using a 95% confidence level, 5% sample error and 3% expected error, 44 door events during peak times and 45 during non-peak times.

Audit sampled 54 trips and compared its counts to the APC data. Of the 54 trips, 25 (46%) were not reported by the APCs.

Of the remaining 29 trips, Audit counted 399 passenger boardings across five LRVs, resulting in an absolute variance of 61 boardings (15%). INIT's guaranteed absolute variance is 8%. The individual LRV absolute variances ranged from 3% to 24%. One LRV APC unit (each LRV is equipped with 8 APCs) incurred 19 of the 34 variances of that LRV. After adjusting for that failure, the overall absolute variance was 11%.

Both the high variance and the loss of APC data required further sampling of the APCs by Audit and Metro Transit.

Passenger Counts by APCs are Within Manufacturer Specifications

Phase 2 Passenger Counts

As a result of information learned in Phase 1, it was decided that sample counts were required of every APC equipped LRV. To achieve INIT's required 500 boardings for the guaranteed 8% absolute and 4% net variances, Audit and R&R staff conducted simultaneous testing from May through July, 2014, with Audit staff later focusing on LRVs with high pre-May 20, 2014 counts. Audit staff had been informed that onboard computers required rewiring due to installation errors. The rewiring was to have occurred by May 20, but in November, Audit staff learned that installation errors had not occurred and rewiring had had not been necessary, although that had been one of hypotheses for the loss of data considered by Metro Transit staff.

Audit judgmentally sampled LRVs with high pre-May 20 counts to provide assurance that the prior counts were accurate and not impacted by the supposed rewiring of onboard computers. Audit staff sampled 11 LRVs from June 26 to July 15. Eight did not exceed 4% net variance; however, none of the LRVs reached the 500-count threshold.

Due to time constraints, the decision was made to combine audit counts with those of R&R to attain the 500-count threshold. Ten of the 11 sampled LRVs had net variances less than 4% with eight LRVs exceeding 500 boardings and all 11 exceeding 400. The variances for all sampled LRVs were either within or trending to be within the manufacturer's specifications for accuracy. However, during Phase 2 APC data was periodically lost. The total net variance for all LRVs tested showed that the APCs were underreporting ridership, similar to the studies mentioned in the Background section, by less than one percent.

Intermittent Loss of APC Data Resolved by Installation of Software Patch

During Audit's analysis of its February and March passenger counts, it was discovered that four LRVs had not reported APC data for four to five weeks by mid-March. This loss of data was due to both an automatic shutdown feature on the LRVs that disrupted storage of APC data onboard, as well as only partial installation of access points that collect APC data at rail operations and maintenance facilities.

In July it was discovered that, although two LRVs had begun reporting APC data, six others had been silent for at least three weeks. Metro Transit sent hard drives from the copilot computers of four of those LRVs to Siemens in Germany for analysis. That analysis failed to identify problems with the hard drives. However, when reinstalled in August, those copilots began to transmit data. At the end of August, however, Metro Transit discovered other LRVs had discontinued transmitting data.

In September, INIT diagnosed the issue to be caused by a software upgrade. In early October a software patch was applied which appeared to work, as all scheduled LRVs were transmitting data without interruption as of October 14th. However, on October 23rd, one LRV stopped reporting data and as of November 17th, had not yet resumed.

APC Warranty

Section XIII. Warranty Requirements, of the contract between Metro Transit and the LRV manufacturer Siemens states the warranty period will be "at least two (2) years from and after the date that each Vehicle is conditionally accepted, with a minimum of one (1) year from the date the Vehicle is placed into revenue service. The warranty shall apply regardless whether the equipment, materials or labor were furnished or performed by the Contractor or by any of its subcontractors or suppliers of any tier. If any Unit is repaired, rebuilt or replaced by the Contractor or by the Council's personnel pursuant to this contract, the Unit shall have the unexpired warranty period of the original Unit, or a minimum of one year after the repair is accepted by the Council; whichever is greater."

Siemens personnel began installing APCs on Siemens LRV vehicles in December 2013 and will continue doing so until all 59 Siemens LRVs are equipped. An agreement was made between Siemens and the APC provider INIT (with Metro Transit acknowledgement) to begin the two-year warranty period on May 31, 2014, for APCs attached to LRVs 201 through 229, regardless of the date they began correctly reporting data. A beginning warranty data has yet to be determined for the remaining 30 LRVs.

The last instances of APCs reporting data after having not done so for an extended period appeared to have occurred on October 11th and 14th, when the APCs on five LRVs began reporting (see Exhibit I for additional details). As of November 17, 2014, the APCs on 27 of the 29 LRVs were reporting uninterrupted data; one LRV was out of service for non-APC related repair and the other had not been reporting since October 23rd. The reason was not known as of November 17th as to why the one LRV was not reporting.

Rail management personnel have stated that Siemens is in the process of establishing a software source code escrow agreement for all LRV systems, including APCs. A separate software maintenance agreement does not exist and Metro Transit personnel will be conducting APC maintenance in the future; however, Metro Transit has purchased a software license that covers normal upgrades.

Ridership Count Procedures

Metro Transit is currently relying on a half page of written guidance that was developed for METRO Blue Line manual ridership counting. This guidance is neither a controlled, signed nor dated policy, procedure or work instruction. It is supplemented by verbal guidance developed to meet specific situations. Metro Transit personnel are currently determining how to best use the data reported herein as they set operational goals for the coming years.

Ridership Reporting

Prior to equipping LRVs with APCs, Metro Transit conducted manual passenger counts as a sole method of determining ridership. This is still the method used to calculate ridership on the Blue Line that primarily runs the older Bombardier light rail vehicles. This will change when APC equipped LRVs begin running on the Blue Line, which is estimated to occur in January 2015.

Only APC equipped LRVs that have passed acceptance testing have been used to determine ridership (except for manually counted special events) on the Green Line since its opening in June 2014.

CONCLUSIONS

The APCs' passenger counts are accurate to within the manufacturer's specifications, however, MetroTransit Revenue and Ridership will need to continue monitoring APC data to identify any interruptions in APC data transmission.

Manual counts were conducted by Metro Transit and Audit confirmed that the APCs were accurate to within four percent of the balanced load for a complete full-length trip. The loss of APC data for some LRVs during 2014 led to concerns about the reliability of the completeness of the data. The manufacturer diagnosed the cause as a result of software updates. A software patch was installed to the Met Council's APC system in early October. While the software patch appears to have resolved the issue for most APCs, continued monitoring of the completeness of APC data transmitted from the LRVs is advised, since one LRV has not reported data since October 23rd.

Metro Transit has been reporting ridership throughout the period of this audit using manual counts for the Blue Line and APC counts for the Green Line. In no instance was LRV APC data used for ridership reporting until Metro Transit personnel verified the accuracy of the data based upon the manufacturer's testing specifications.

The two-year APC warranty period for APCs on LRVs 201 through 229 took effect before there was evidence that all APC units were functioning according to manufacturer specifications.

The APC warranty was negotiated between Siemens and the manufacturer, with verbal agreement from Metro Transit, to begin on May 31, 2014, even though data losses continued to occur through mid-November 2014, effectively limiting the warranty period for those units that were most problematic by almost four months.

The procedures used by Metro Transit for determining passenger rides on the Green Line had not been updated since their use on the Blue Line, nor were they formalized, dated, or approved.

Metro Transit does not have formal policies/procedures/work instructions for counting ridership on the Green Line. The current use of a half page informal procedure used on the Blue Line does not account for the use of APCs, nor is it sufficient in scope or detail to inform a novice that may have to conduct such passenger counts.

RECOMMENDATIONS

Program Evaluation and Audit recommendations are categorized according to the level of risk they pose for the Council. The categories are:

- **Essential** – Steps must be taken to avoid the emergence of critical risks to the Council or to add great value to the Council and its programs. Essential recommendations are tracked through the Audit Database and status is reported twice annually to the Council's Audit Committee.
- **Significant** – Adds value to programs or initiatives of the Council, but is not necessary to avoid major control risks or other critical risk exposures. Significant recommendations are also tracked with status reports to the Council's Audit Committee.
- **Considerations** – Recommendation would be beneficial, but may be subject to being set aside in favor of higher priority activities for the Council, or may require collaboration with another program area or division. Considerations are not tracked or reported. Their implementation is solely at the hands of management.
- **Verbal Recommendation** – An issue was found that bears mentioning, but is not sufficient to constitute a control risk or other repercussions to warrant inclusion in the written report. Verbal recommendations are documented in the file, but are not tracked or reported regularly.

1. (Significant) Metro Transit should continue to conduct manual ridership counts on all LRVs newly fitted with APCs to ensure that system software and hardware functions according to manufacturer specifications and guarantees.

During the course of the review and specifically on May 15, 2014, hardware problems become known resulting in the need to rewire the APCs on each LRV. In addition, software problems resulted in LRV ridership data not being recorded on numerous individual occasions beginning on February 12, 2014, and continuing through November 17, 2014.

Ridership data recorded by APCs must be sufficiently tested over an error free time period to demonstrate that Metro Transit can have confidence in using the data for management purposes, limit the amount of future manual counting effort and position the system to be used for NTD reporting, if desired.

Management Response: *Metro Transit management agrees with this recommendation. Before finance uses an APC equipped car for ride calculations 500 boardings by door are manually counted and compared to the APC reported boardings. If the net boarding error is less than or equal to 4% that APC cars data is used for the calculation of rides beginning the month after this testing is complete. As of 11/30/2014 27 APC equipped cars met the 500 ride test requirement and are being used in monthly ride calculations. New rail cars are being equipped with APCs though 2015. None of these cars will be used in ride calculations until the 500 ride test comparing manual to APC counts is completed and validated. Records of this testing and the vehicles approved for use in ride calculations are maintained by the Revenue and Ride department.*

Staff Responsible: *Revenue and Ridership Department personnel*

Timetable: *The 500 ride test is in current use and will stay in place for the use of all future APC equipped cars. By 12/31/14 formal documentation of a process for ongoing regular testing of all approved LRV cars will be created and adopted.*

2. (Significant) Metro Transit should develop formal, written and controlled policies/procedures/work instructions to guide the process of accumulating and recording manual and electronic (APC) ridership data.

Metro Transit's current uncontrolled procedure for obtaining LRV ridership data was developed prior to the installation of APCs and does not address current operating practices. In order to properly control the process of collecting and reporting LRV ridership data using manual and APC methods, Metro Transit needs to develop current, formal and controlled policies/procedures/work instructions.

Management Response: *Metro Transit management agrees with this recommendation.*

Staff Responsible: *Revenue and Ridership Department personnel*

Timetable: *By 12/31/14 formal documentation of the process for the accumulation of ridership data and calculation of monthly rides using APCs will be created and adopted into formal and controlled procedures and work instructions.*

3. (Significant) Metro Transit should accept and commission APCs placed onboard LRVs for future light rail projects only upon obtaining assurance from Revenue & Ridership personnel that the APCs are reporting data accurately and in accordance with manufacturer guarantees.

The APCs installed on LRVs 201 through 229 incurred off and on mechanical and data reporting malfunctions from February 2014 through mid November, with a beginning warranty date of May 31, 2014 determined between Siemens and the APC manufacturer and agreed to by Metro Transit. In addition, as of June 8, 2014, Metro Transit had accepted all the APCs. Although the problems that arose after acceptance and the beginning of the warranty period were fixed within the two year warranty time frame, there remains concern that problems may still arise once the warranty period expires.

Management Response: *In regards to verifying accurate data counts before the start of the warranty period; Metro Transit will work with Contracts and Procurement to write that into future vehicle procurement specifications with the intent that the 500 count verification will be performed by Metro Transit within three months of the APC commissioning date. This will assure the manufacturer that the warranty start date will occur within a reasonable time period.*

Staff Responsible: *Asst. Director Rail Vehicle Maintenance LRT and Supervisor of Revenue and Ridership.*

Timetable: *The wording for future rail vehicle procurements for verifying accurate data counts will be drafted and will be ready for inclusion in future contracts by 12/31/2014.*

**Metropolitan Council
Program Evaluation & Audit
LRV APC Review**

Exhibit I: APC 2014 Warranty Timeline

- 05-14-14: 4 LRVs (206, 210, 214 & 215) have defective hardware and even after repaired, continue not reporting data through August.
- 05-31-14: 2-year warranty period begins for APCs in LRVs 201 thru 229
- 07-16-14: 7 LRVs (205, 210, 213, 214, 218, 223 & 226) were not reporting data for periods ranging from 18 to 36 days.
- 09-23-14: A software correction is identified in work INIT is conducting in Houston. It is being tested on 4 LRVs (213, 217, 219 & 226).
- 09-29-14: 2 LRVs (214 & 217) are now reporting data.
- 09-29-14: 6 LRVs (211, 218, 220, 227, 228 & 229) have not reported in the last 3 weeks.
- 10-11-14: 3 LRVs (218, 227 & 229) began reporting after not reporting data for lengthy periods.
- 10-14-14: 2 LRVs (220 & 228) began reporting after they were not reporting data for lengthy periods
- 10-23-14: ALL APCs affixed to LRVs 201 through 229 have been successfully reporting data since 10-14-14, except for LRV 209. LRV 211 is also not reporting; however, it is out of service for repair.
- 11-17-14: LRV 209 has not been reporting data since 10-23-14.



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