TRANSMIT EVALUATION

TRANSIT APPLICATION BASELINE DATA REPORT

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16. Abstract

As part of the FY99 earmarked ITS Integration Program, the TRANSMIT program received funds to expand the use of the E-ZPass toll tag readers to other transportation applications in New Jersey. Operated by Transcom for agencies in NY, NJ, and CT, TRANSMIT monitors the flow of vehicles equipped with toll-tags, thereby providing information for transportation management purposes. This report presents the results of baseline data collection for an evaluation of the use of TRANSMIT for managing the bus operations of NJ Transit at the Port Authority Bus Terminal (PABT) in Manhattan. The TRANSMIT application consists of NJ Transit staff using handheld computers equipped with wireless communications to locate specific buses as they pass the E-ZPass readers. Five central objectives for the evaluation of the transit application were identified: to increase the number of on-time bus departures; to enable faster access to bus-status information; to improve communication among NJ Transit staff; to make record storage and retrieval easier; and to provide more accurate and efficient decision-making on reassigning buses.

Progress toward these objectives will be assessed by measuring conditions prior to the use of TRANMSIT and comparing the same measurements taken after the system begins operation. This report identifies the specific measures, methods of data collection, and presents the results of the baseline or "before" conditions. Daily log data on buses kept by "chutemen and starters" were collected and tabulated to measure the schedule adherence of buses on eleven bus lines chosen for the evaluation that departed the PABT in the PM rush hours of May and October of 2000. Overall, the log data indicate that bus lateness increases as the rush hours wear on and is more pronounced on Fridays and in May.

Surveys and an interview with NJ Transit staff were used to investigate current work patterns and identify potential deficiencies that TRANSMIT might address. Among the 17 starters and chutemen who were surveyed, the results show that staff members would like to have more information on the whereabouts of buses than is currently available, and they could also benefit from improvements that would enable them to communicate with greater ease. The interview with a scheduler in the bus planning group indicated that the automated storage of the bus log data made should facilitate the retrieval and use of information for the NJ Transit planning staff.

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EXECUTIVE SUMMARY

As part of the FY99 earmarked ITS Integration Program, the TRANSMIT program received funds to expand the use of the E-ZPass toll tag readers to other transportation applications in New Jersey. Operated by Transcom for agencies in New York, New Jersey, and Connecticut, TRANSMIT monitors the flow of vehicles equipped with toll-tags, thereby providing information for transportation management purposes. TRANSMIT was selected by USDOT for an evaluation of benefits of ITS deployments. This report presents the results of baseline data collection for an evaluation of the use of TRANSMIT for managing the bus operations of NJ Transit at the Port Authority Bus Terminal (PABT) in Manhattan. A major difficulty at PABT is the handling of hundreds of bus arrivals and departures in a confined space and the timely positioning of buses during the PM rush hours. The TRANSMIT application consists of NJ Transit staff using handheld computers equipped with wireless communications to locate specific buses as they pass the E-ZPass readers. Working in conjunction with NJ Transit and Transcom, the evaluation team consisting of Battelle (prime contractor), Castle Rock Consultants, and URS/BRW identified five central objectives for the transit application that could be assessed in the evaluation:

- To increase the number of on-time bus departures
- To enable faster access to bus-status information
- To improve communication among NJ Transit staff
- To make record storage and retrieval easier
- To provide more accurate and efficient decision-making on reassigning buses.

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Surveys and an interview with NJ Transit staff were used to investigate current work patterns and identify potential deficiencies that TRANSMIT might address. Among the 17 starters and chutemen who were surveyed, the results show that staff members would like to have more information on the whereabouts of buses than is currently available, and they could also benefit from improvements that would enable them to communicate with greater ease. The interview with a scheduler in the bus planning group indicated that the automated storage of the bus log data should facilitate the retrieval and use of information for the NJ Transit planning staff.

The post-deployment data collection and analysis will be performed in 2002, with a final report available by January 2003.

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1 Introduction

1.1 Background

As part of the FY99 earmarked ITS Integration Program, the U.S. Department of Transportation (USDOT) is sponsoring an independent evaluation of enhancements to TRANSMIT, TRANSCOM's System for Managing Incidents and Traffic. Battelle Memorial Institute, together with Castle Rock Consultants, Inc. and URS/BRW, Inc., were selected by USDOT to conduct this independent evaluation. In accordance with Federal evaluation standards, the consultant team has performed baseline data collection and analyses as the first step to assess the efficacy of TRANSMIT for improving the transportation system in New Jersey. Once TRANSMIT has been fully deployed, the consultant team will document the changes attributable to the technology and any lessons offered by the project so that other locations seeking similar deployments can learn from the experience.

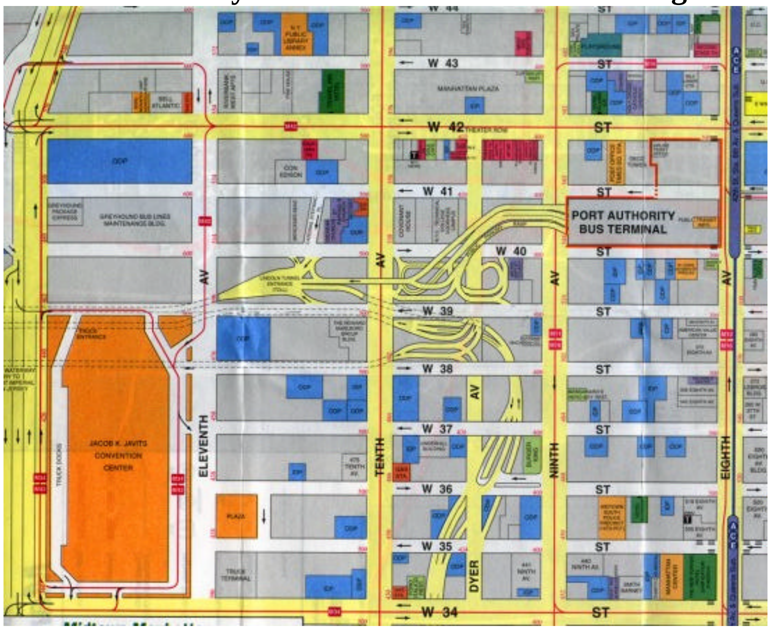
1.2 Overview of NJ Transit Application

TRANSMIT enhancements covered in the present study are comprised of the NJ Transit application. Although TRANSMIT is being used in a variety of applications in the region, this document focuses solely on the NJ Transit portion of TRANSMIT, and includes the detailed test plan for that application along with an analysis of baseline data.

The Port Authority Bus Terminal (PABT) is located in downtown Manhattan, New York City. The PABT occupies almost two city blocks, and manages the ingress and egress of transit vehicles on one of the most heavily traveled transit routes in the world[1]. Figure 1-1 illustrates the location of the terminal relative to downtown Manhattan.

[1] *The New York, New Jersey, Connecticut Metropolitan Area TRANSMIT Operational Test Case Study*, April 2000.

Figure 1-1. Port Authority Bus Terminal and Surroundings in Manhattan



The PABT consists of five levels. The bus terminals occupy the two top levels above floors devoted to retail and other functions. Figure 1-2 illustrates the imposing size of the PABT as it appears from the street. In the photograph, a multitude of buses can be seen traversing the upper floors of the facility.

Figure 1-2. Street View of Port Authority Bus Terminal

At street level, patrons enter the retail center. Pedestrian access to the bus terminal is not available directly from the street. Pedestrians access bus platforms via escalators and stairways located throughout the retail center. Bus routes and platforms are well marked with overhead signs. Figure 1-3 illustrates the retail aspect of the PABT.

Figure 1-3 Retail Center at PABT

Figure 1-4 illustrates the extensive signage to show patrons the bus platform locations throughout the PABT facility.

Figure 1-4. Transition from Retail Corridor to PABT Bus Gates

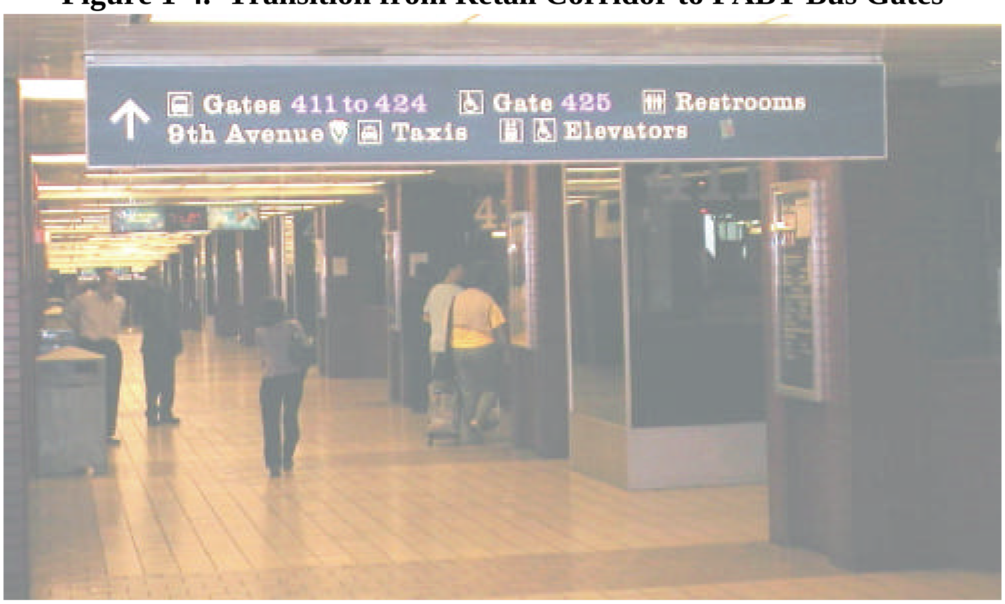
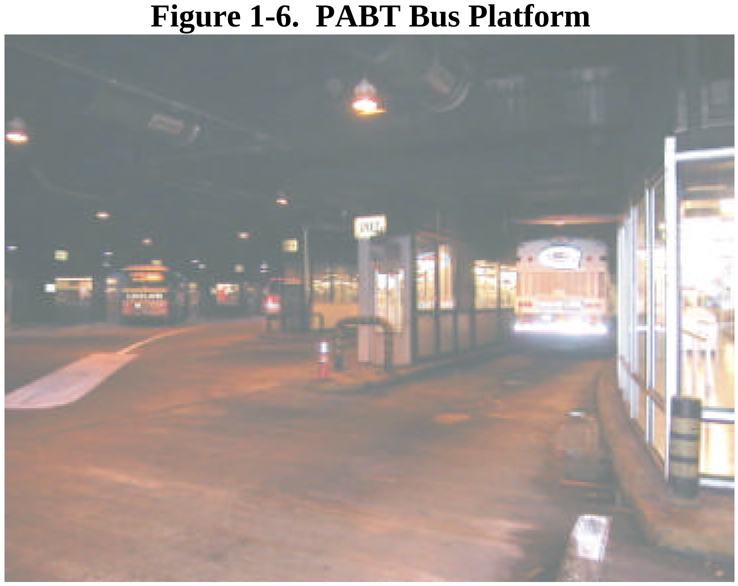


Figure 1-5 illustrates a typical example of a PABT loading area used by New Jersey Transit, where pedestrians await bus arrivals. One of the many dispatcher or "starter" stations is depicted in the left side of the photo. From these stations starters have direct contact with bus patrons and offer assistance when needed. Similar stations are located in platforms throughout the PABT.

Figure 1-5. PABT Patron Platform

Figure 1-6 illustrates examples of lower level bus platforms within the terminal.

Figure 1-6. PABT Bus Platform



Figures 1-7 and 1-8 provide illustrations of both the upper and lower level bus platforms in the PABT. Each level consists of an unloading platform, where inbound buses drop off arriving passengers. The New Jersey Transit staff working in this section of the terminal are known as "chutemen." Buses are routed through the building and are either directed by the chuteman to their destined platforms, where they will pick up the next load of riders, or they are directed to substitute for another bus at a platform as needed. Depending on the time of day, chutemen can cover either a platform "zone" or an entire floor. As the day progresses to late evening and the number of bus departures decreases, all buses are directed to the lower level platforms.

Figure 1-7. Illustration of PABT Upper Level Bus Platforms

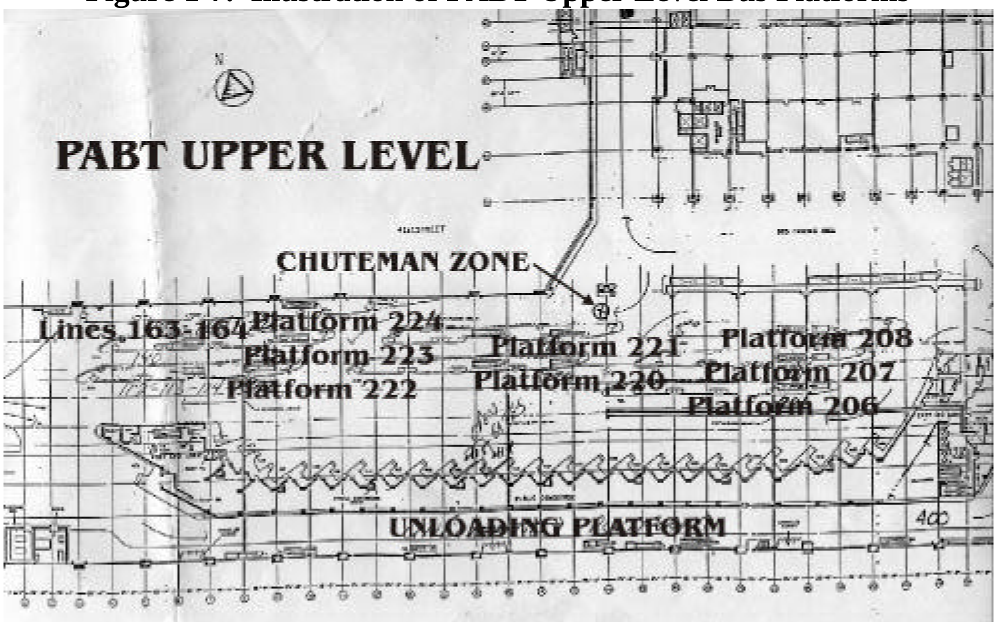
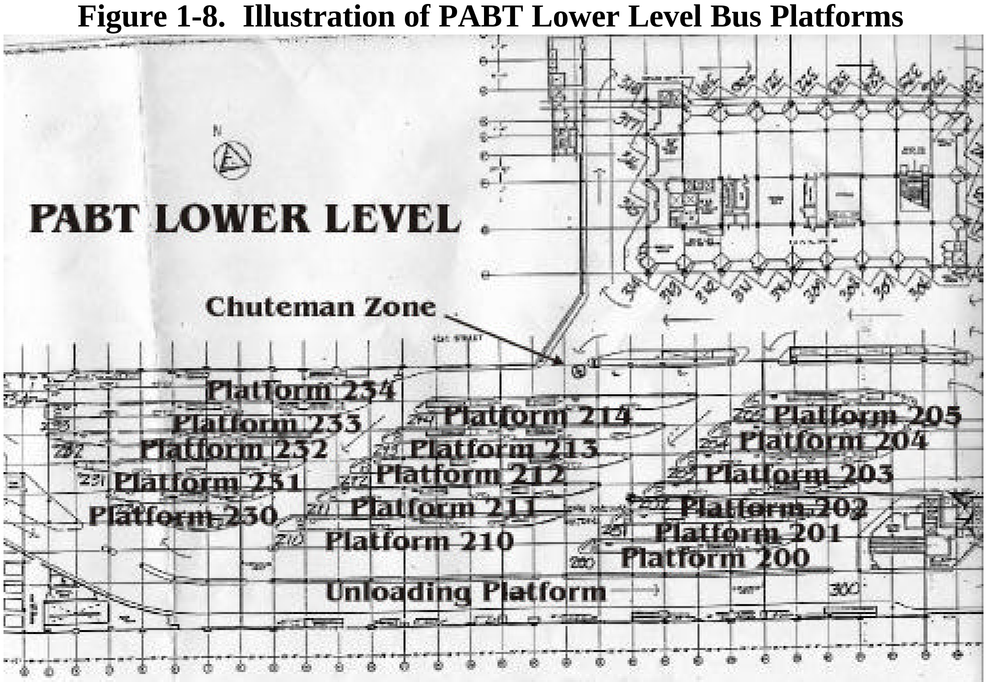


Figure 1-8. Illustration of PABT Lower Level Bus Platforms



1.2.1 Overview of Baseline Report Contents

Section 2 of this plan summarizes the approach to the evaluation of the NJ Transit application. Sections 3-7 present more specific details for implementing the approach. Records of NJ Transit bus operations at the PABT building in New York City have been collected, reviewed and analyzed. These records serve as baseline data, along with interviews and surveys of NJ Transit staff. Following the implementation of TRANSMIT in the fall of 2001, data will be collected once more in 2002 and compared with the baseline data in order to measure operational improvements. Section 8 presents the results of the baseline data analysis. Section 9 discusses resources required to complete the evaluation, Section 10 presents the suggested format of the final report, and an assessment of risks to completion are presented in Section 11.

1.2.2 Problem Statement

The issues associated with NJ Transit bus operations focus on the difficulty that *chutemen* and *starters (dispatchers)*[2] experience in their determination or prediction of bus arrival times into the PABT building. Currently, no system exists either for notifying chutemen and starters about the locations of buses as they approach the PABT, or for notification of when a bus is scheduled to arrive. Unless a bus shows up late, PABT personnel assume that all buses will be arriving on time. As conveyed to the evaluation team by PABT personnel, a chuteman's only verification of bus arrival is his own visual confirmation of a particular bus approaching the terminal facility, and he most often does not see the bus until well after it has entered the building[3]. If a chutemen or starter is overly concerned about late arrival of a particular bus, he must use his judgment and possibly make a switch to ensure on-time departure. The lack of any knowledge as to the bus' position causes the chuteman to make an assignment "switch" based on his experience.

1.2.3 Objective/Hypothesis

The evaluation focuses on five central objectives that NJ Transit seeks to achieve with the TRANSMIT technology:

- to increase the number of on-time bus departures;
- to enable faster access to bus-status information;
- to improve communication among NJ Transit staff;
- to make record storage and retrieval easier; and,
- to provide more accurate and efficient decision-making on reassigning buses.

The key hypothesis to be evaluated in this test is that NJ Transit departure times will improve as a result of provision of TRANSMIT bus location data. Specifically, NJ Turnpike staff will receive advanced information with regard to approaching bus whereabouts, will be able to communicate and make better decisions about which buses to dispatch on which route, and improvements in schedule adherence will result.

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[2] *Chutemen* and s*tarters* are terms employed by NJ Transit to identify staff who are responsible for monitoring and directing bus arrivals and departures at each floor of the NJ PABT building.
[3] Refer to Section 9 for a detailed summary of interviews with PABT personnel.

Through the course of developing the evaluation objectives, a couple of the objectives were developed but subsequently eliminated. These included:

- To improve riders' overall perception of the service provided by NJ Transit; and,
- To reduce non-productive time.

Measurement of riders' perception was eliminated early on because it was determined that the extensive rider surveys that would be needed in order to gather sufficient data could not be conducted under the budgetary constraints of the evaluation. With regard to reduction of non-productive time, this objective would have been difficult to measure as the Port Authority was not supportive in allowing the evaluation team an opportunity to examine driver records. The Port Authority felt it was necessary to restrict access to this information in order to protect the privacy of their drivers.

1.2.4 Technical Approach

The evaluation objectives will be addressed through the application of TRANSMIT toll technology to provide NJ Transit personnel with real-time status information on their buses. To provide information on buses as they approach the PABT building, TRANSMIT tag readers (antennas) are being installed on:

- I-495 at the entrance to the Lincoln Tunnel (NJ side);
- I-495 at the exit to the Lincoln Tunnel (NY side); and
- Pleasant Avenue
- Kennedy Boulevard
- Weehawken parking lot
- The ramps leading to the PABT building.

The NJ Turnpike will be installing TRANSMIT readers along the NJ Turnpike, which will increase the availability of bus arrival data to the PABT. This is expected to provide additional benefit to NJ Transit although it is not the subject of this evaluation. Section 1.2.5 discusses the TRANSMIT concept of operation in more detail.

1.2.5 Concept of Operation

As all NJ Transit buses are equipped with E-ZPass toll transponders, TRANSMIT will utilize existing transponder technology to identify the location of each bus as it travels its route. Under TRANSMIT, the presence of each NJ Transit bus equipped with an E-ZPass toll tag will be detected and identified as it passes beneath roadside tag readers deployed specifically for this effort. The first detection of each inbound bus (typically at the entrance to the Lincoln Tunnel) will generate an expected time of arrival (ETA) at the PABT building. Subsequent reads will update this ETA information in order to take into account the real-time status of the inbound bus. This ETA information will be conveyed via hand-held devices (HHDs) to chutemen who work on the terminal floor. Figure 1-9 below illustrates HHDs provided to chutemen and starters. This portable device measures approximately 10" x 8" and is about ¾" thick.

Figure 1-9. Hand Held Device

Chutemen and starters have a responsibility for maintaining schedule adherence and for maintaining vehicle flow through the terminal. Chutemen must identify when delays to inbound buses will prevent them from meeting their next scheduled departure time and take immediate and appropriate action to recover the time lost. If an inbound bus is delayed, the chuteman can reassign another bus to cover the delayed bus' next scheduled trip by performing a switch[4], depending on immediate resources available. In this way, the chutemen minimize the number of delayed departures.

The same ETA information is also conveyed via HHDs used by the starters, who are responsible for ensuring the safe loading and timely departure of buses at platforms. It is anticipated that starters will use ETA information derived from HHDs to advise riders of bus delay status. Figure 1-10 below illustrates a high-level overview of the system architecture concept for the transit application. The architecture for the transit application is focused on two sites (the PABT and Bus Operations). The Bus Operations site in Maplewood, New Jersey, is the location of the TDS-3500 external system. The PABT is the location of the PABT server application as well as the hand held devices (HHDs) that the server communicates with. Both sites have a workstation, although in practice workstation in Maplewood is the one that is typically referred to as having proper the workstation (terminal supervisor) functionality. Regarding the architecture, it is also important to note that:

- The workstation with the PABT application has the regional architecture (RA/TRANSMIT) software on it
- The PABT server software is currently slated to run on a TRANSMIT application server. A TRANSMIT server consists of 2 machines: 1 is a TRANSMIT application server (with

[4] A switch is defined as occurring when one bus is substituted for a second bus, or, when a bus is taken out of service.

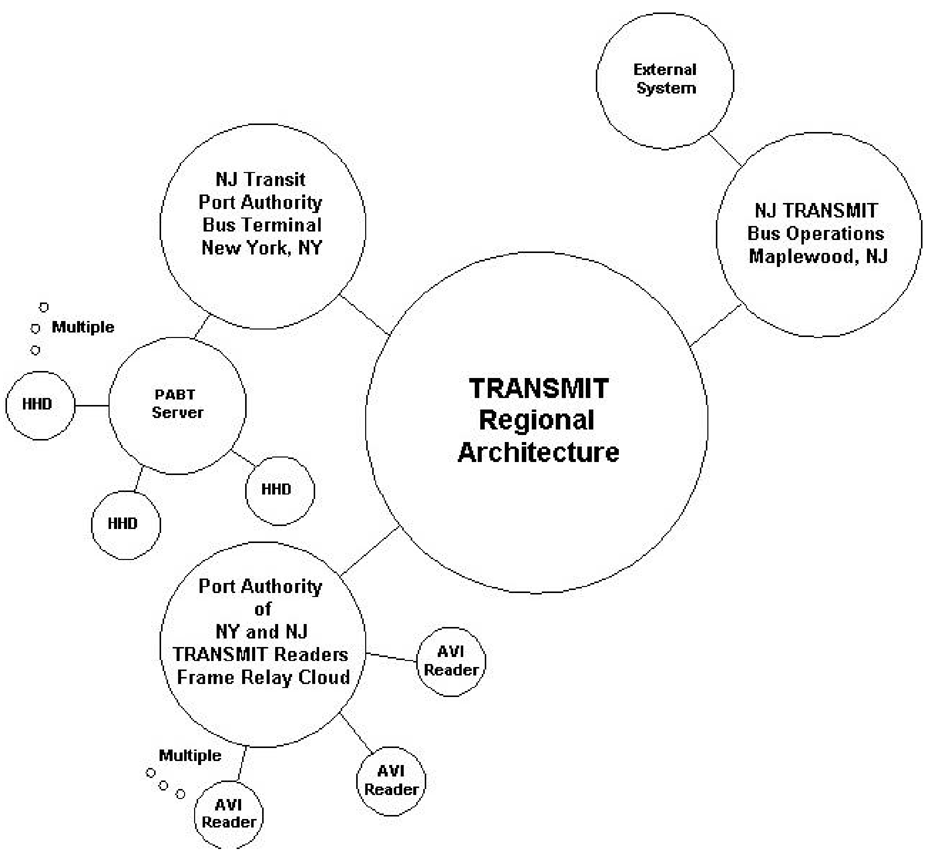
TRANSMIT applications), the other is a TRANSMIT framework server, which facilitates RA/TRANSMIT messages throughout the Regional Architecture network.

The communications supporting the application consist of two parts: handheld to Internet service provider (ISP) and server to ISP.

- For the link between handheld and ISP, the transmission will use wireless connections based on the CDPD protocol of a local cellular provider, such as Verizon.
- The PABT server will communicate with the ISP over a dedicated line to be installed by WorldCom from the PABT to the ISP location.

Data from the TDS-3500 system, which includes daily schedules and driver sign-ons, come to the PABT over the private frame-relay network. The schedule itself does not show the bus number assigned to a particular route, but it contains a "train ID" that is used to tie together all trips that a particular bus will service for that day's schedule. When the TDS-3500 receives a driver sign-on, the association between train ID and bus is made and the actual bus is scheduled to service the trip. All these data flows use IP communication through the private frame relay network.

Figure 1-10. TRANSMIT Transit Application System Architecture Diagram



2 Overall Evaluation Approach

2.1 Introduction

The primary goal of the NJ Transit application of TRANSMIT is to improve mobility. The implementation of TRANSMIT is expected to produce measurable changes in NJ Transit at the PABT operations, manifested by improvements in on-time performance and improvements in information dissemination among operational personnel. Determining the extent to which TRANSMIT has assisted NJ Transit in meeting this goal will be based on the consultant team's assessment of:

- how NJ Transit operational personnel use information on the status of each bus;
- the impact that this information has on the way NJ Transit operational personnel carry out their respective responsibilities; and
- impacts on terminal operations.

2.2 Summary of Expected Impacts

The provision of ETA information is expected to impact Terminal operations at a number of levels. For example, the ETA information will be conveyed to the chutemen via the HHDs. The expectation is that by providing the chutemen with advance notice of the ETA of inbound buses, earlier action can be taken to reassign other buses to cover any delays. In this way, chutemen can attempt to ensure that there will always be a bus available to depart on each scheduled trip. This is expected to be a significant improvement over the current sequence of events, where a chuteman's first indication of delays to an inbound bus is when it does not pass him in the PABT building as expected. The HHDs should provide the chutemen more time to prepare for expected delays and therefore, take appropriate action. Additionally, by providing quantification of the actual delay a bus is experiencing the HHDs may help prevent unnecessary changes to the allocation of other buses.

This ETA information is expected to have impacts on dispatchers, known as "starters". Typically, the starter represents the "client-facing" side of the NJ Transit operation; in this case, the clients are riders. In this role, starters are often a rider's primary source of information on the status of a bus. Starters will be equipped with HHDs and will have access to the same information as the chutemen. Namely, a starter will have access to up-to-date information on the status of bus arrivals, including information on switches or substitutions performed by chutemen. As starters would be within close proximity to bus patrons waiting on platforms for incoming buses, each starter can provide a direct verbal response to rider queries as the latest information on bus status arrives on the HHD.

Improving on-time performance is also expected to have a positive impact on riders' perceptions of the service provided by NJ Transit. Riders are expected to see a difference in the regularity with which their buses depart on time. As discussed previously, riders should also expect to see improvements in the timeliness and accuracy of information provided to them by starters.

Beyond improvements in on-time performance, the use of the TRANSMIT data is expected to have a number of other impacts including:

- Reducing the amount of time buses spend in the PABT building between arrival in and departure to their next trip. Chutemen will be able to better coordinate the use of buses and drivers, especially when there are delays to inbound buses; and

- The flow of information between chutemen and starters should be improved through the use of HHDs.

2.3 Measuring the Impacts

Early in the evaluation, it was determined that it will not be possible to measure all of the impacts discussed above within the practical and budgetary constraints of the evaluation. However, a series of evaluation objectives or measurable expected impacts were defined that focus on the benefits to the operations of the transit agency. The benefits fall within two evaluation goal areas: efficiency and mobility. TRANSMIT is expected to help NJ Transit staff make better decisions more quickly. That will lead to better on-time performance of the buses resulting in enhanced mobility for transit riders. Once the evaluation is complete, these impacts will provide stakeholders with a very good indication of the extent to which TRANSMIT has assisted NJ Transit in improving on-time performance. These evaluation objectives, together with the hypotheses supporting them and the proposed measures, are listed in Table 2-1 below.

Table 2-1. Overview of How Expected Impacts will be Measured

Goal Area	Objective/Expected Impacts	Hypothesis	Few Good Measures	Measures/Surrogate Measures
Mobility	To increase the number of on-time departures	Chutemen have advance knowledge of delays to inbound buses and can therefore plan switches earlier	On-time departures Chutemens' awareness of inbound bus status	Improvements in number of on-time departures Time in advance of arrival chutemen are aware of actual bus status
Efficiency	To enable faster access to bus-status information	Starters and chutemen have access to information on status of all inbound buses. Starters have access to the details of all switches	Chutemens' and starters' accessibility to information	Perception of changes in accessibility to information
Efficiency	To improve communication among NJ Transit staff.	All starters have access to real-time information on bus status and chutemen's decisions	Increased/better communication	Reported benefits of HHD Perception of changes in accessibility to information
Efficiency	To provide more accurate and efficient decision-making	More accurate and timely information on bus status will lead to better decisions on switching of buses.	Chutemen's awareness of inbound bus status. Availability of historical bus data.	Reported benefit of HHD Perception of changes in how decisions are made

Both quantitative and qualitative approaches to data collection will be used to measure the impacts of TRANSMIT, and three types of test plans are required for each measurement approach. As shown in Table 2-2 the mobility goal will use tests plans based on extracting data from logs used by NJ Transit staff and data extracted from the HHDs of the TRANSMIT system. Assessment of efficiency will be done through interviews with key informants at NJ Transit and through use of system data from the HHDs.

Table 2-2. Data Collection Methods or Tests

Evaluation Goal Area	Test		
	Log Data	TRANSMIT System Data	Key Informant Interviews
Mobility	√	√	
Efficiency		√	√

2.4 "Before" and "after" data collection

The techniques used to measure the impacts of TRANSMIT are described further in Sections 4 and 5. These techniques are based on the collection of:

- "before" data - baseline data which serves as the basis of on-time performance and is indicative of overall bus lateness; and
- "after" data - collected once the TRANSMIT transit application has been installed and is in full operation.

The "after" data will be compared to the "before" data in order to determine the extent of any changes which arise through the deployment of the TRANSMIT transit application.

2.4.1 "Before" data

"Before" data has been collected through an analysis of operation logs, referred to as "chuteman logs" and "starter sheets", provided by NJ Transit personnel. Chutemen and starters, as part of their day-to-day duties, complete these logs, forming a record of specific aspects of the operations at the PABT building. Summary sheets, which summarize the contents of these logs, are also completed. This evaluation specifically takes advantage of the information recorded on both the chutemens' and starters' logs.

2.4.2 "After" data

"After" data will be collected using analysis of "system data" (i.e., data derived from the use of HHDs) and using interviews with NJ Transit staff regarding their assessment of the impact TRANSMIT system on operations. The system data are essentially comprised of two types:

- data related to the use of the system (e.g., the number of times that data were entered into a HHD); and,
- data collected by the system which are directly analogous to data currently collected using operational logs (e.g., bus departure times as entered into the HHD).

3 Test Schedule

3.1 Introduction

This section describes the schedule for undertaking the evaluation of the NJ Transit application.

3.2 "Before" Data Collection

Originally planned for spring of 2001, beta testing of the HHDs took place in the late fall of 2001. In order to ensure that "before" data were representative of baseline conditions at the PABT building (prior to TRANSMIT implementation), operations logs were selected in consultation with NJ Transit staff for the months of May and October 2000, and the rationale for those months is discussed in Section 4.3.

3.3 "After" Data Collection

"After" data will be collected once the TRANSMIT transit application is in full operation and once the starters and chutemen have had an opportunity to be trained on and fully familiarize themselves with the technology. As the implementation schedule for the HHDs has been changed since the start of the evaluation activities, the final implementation period of HHDs will determine the time frames for collecting "after" data. Whereas it was originally expected that May and October of 2001 would be the months in which "after" data would be collected, postponement to May and October of 2002 will be necessary for comparability to the baseline data.

The interviews with NJ Transit staff will be scheduled for the spring of 2002. Dates will be selected based on availability of NJ Transit staff.

3.4 Data Collection and Analysis Schedule Overview

The schedule for collecting data and performing analyses is illustrated in Figure 3-1. The schedule is based upon assumptions of the "after" data collection described in Section 3.3.

Figure 3-1. Schedule for Evaluation of NJ Transit Application

	2000				2001												2002												03
	S	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**
Evaluation Plan	X	X	X																										
Detailed Test Plans				X	X																								
Baseline Data Collection					X	X																							
Analysis/Report Baseline Data							X	X	X	X	X	X	X	X	X	X	X												
Updated Evaluation Plan																	X	X											
Updated Test Plans																		X	X										
Post-deployment Data Collection																				X	X	X	X	X	X	X	X		
Data Analysis/Draft Evaluation Report																						X	X	X	X	X	X	X	
Final Evaluation Report																													X
Archived Data																						X	X	X	X	X	X	X	X

4 Generic Pre-Test Activities

4.1 Introduction

This section describes the generic activities that were performed in advance of the baseline data collection phase of the evaluation.

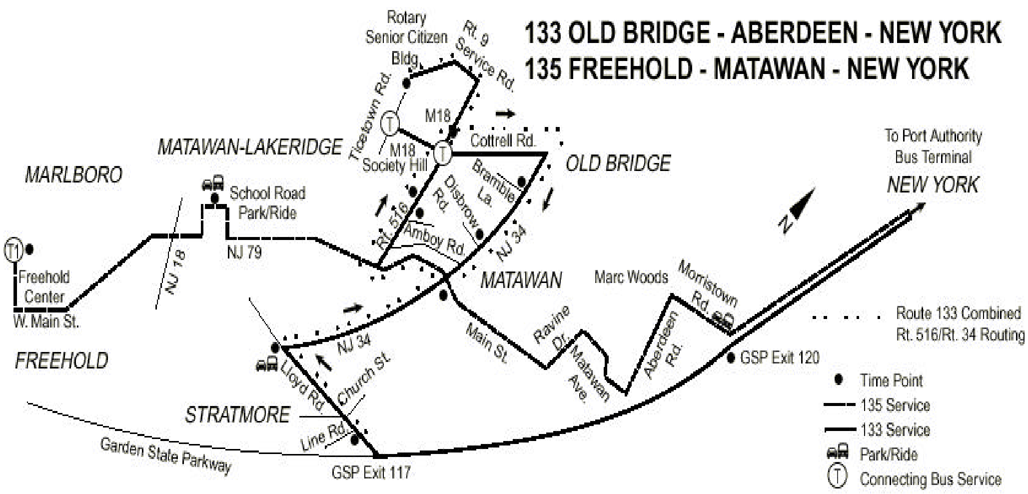
4.2 Selection of Bus Lines for Evaluation

Given the scale of NJ Transit's operations at the PABT building, it was determined that the time and budget constraints of the TRANSMIT evaluation would prevent taking measurements and making observations for all of its lines and buses over the entire course of the year. Through coordination with NJ Transit, the Evaluation Team identified eleven (11) bus lines and two (2) sample months of archived bus departure data that, once cleaned, would serve as baseline data. The selected bus lines include:

- #133, #135, #138 – Monmouth County,
- #144, #162, #163, #164 – Bergen County, and,
- #191, #192, #194, #195 – Passaic County.

These bus routes represent a variety of headways, equipment and service areas. The 133, 135, and 138 routes serve Central New Jersey. These routes serve long distance commuters, and have a typical end-to-end trip time of 60 to 85 minutes. These buses are subject to variable delays due to congestion, incidents and equipment failures. The routes 144, 162, 163, and 164 serve short distance routes in Bergen County. These routes are generally on local streets, with some express and skip-stop service during the peak hour. The routes 191, 192, 194 and 195 service a middle distance market from Passaic County. These routes use a mix of local roads and interstates. Figures 4-1 to 4-3 illustrate each of the routes.

Figure 4-1. Monmouth County Bus Routes



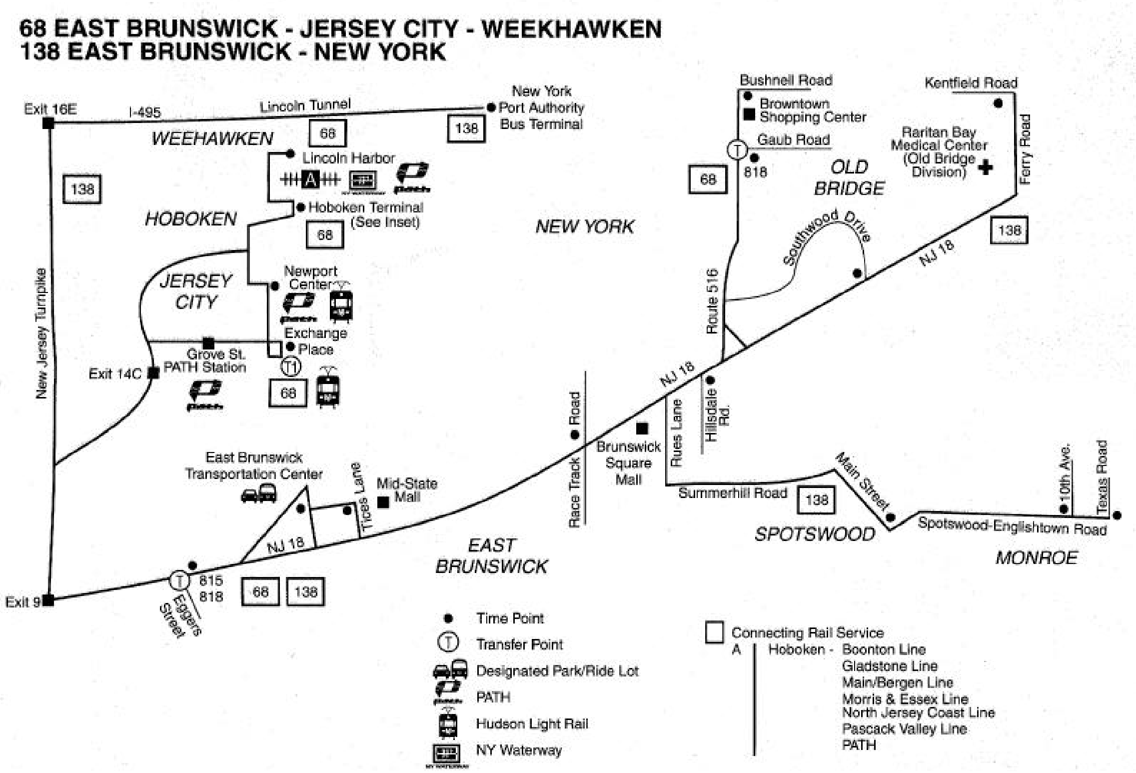
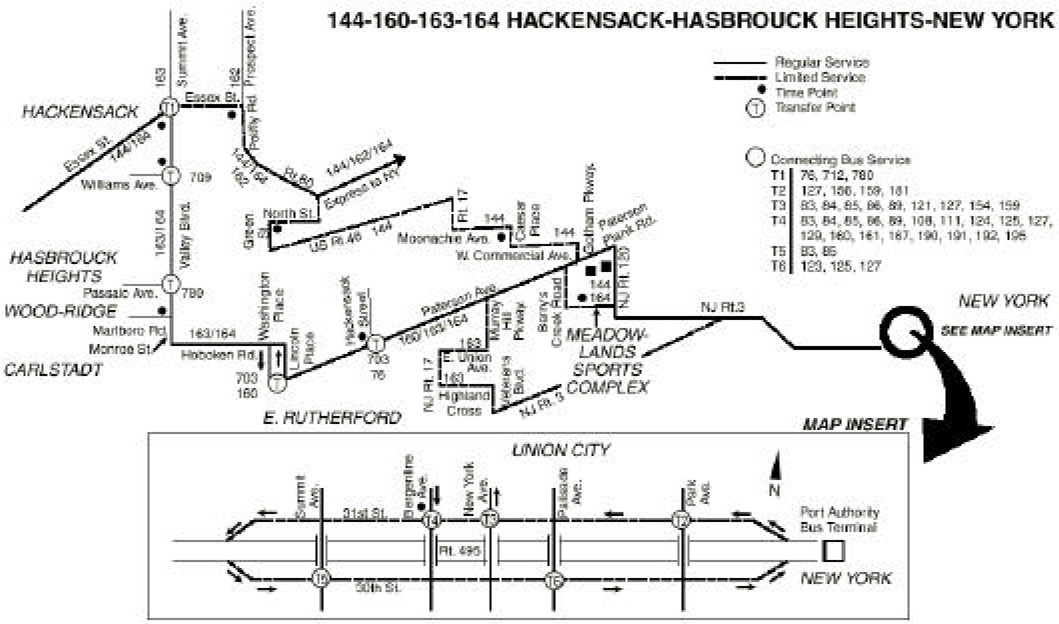


Figure 4-2. Bergen County Bus Routes



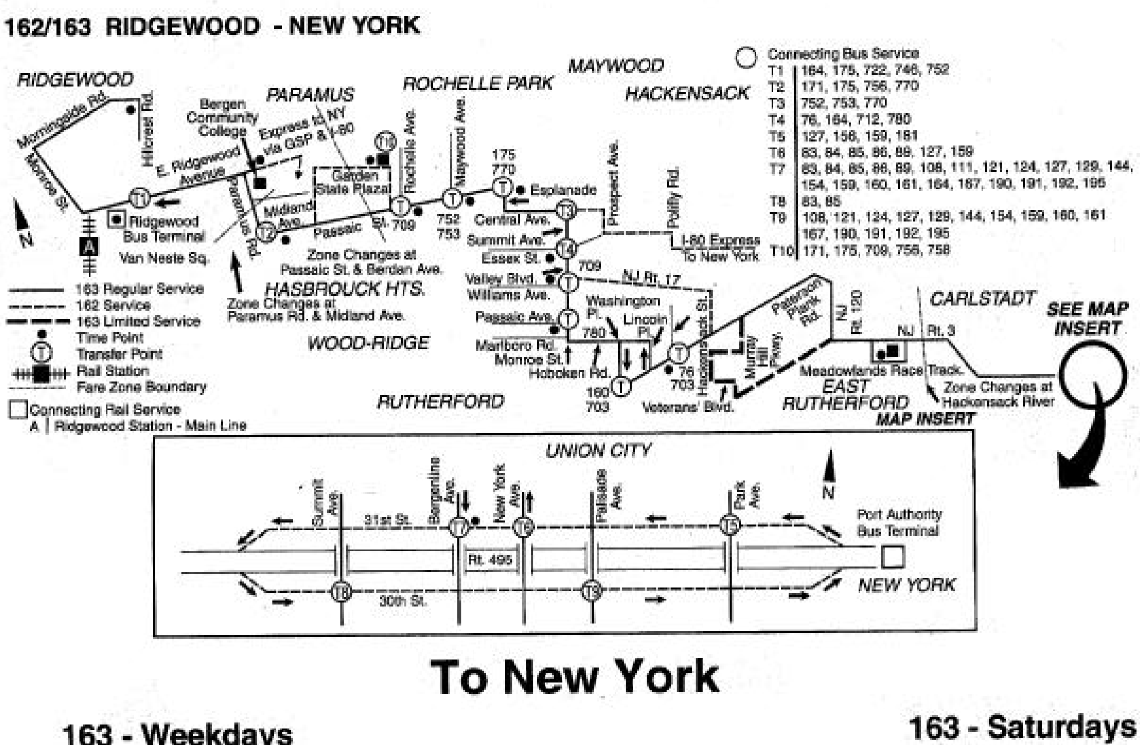
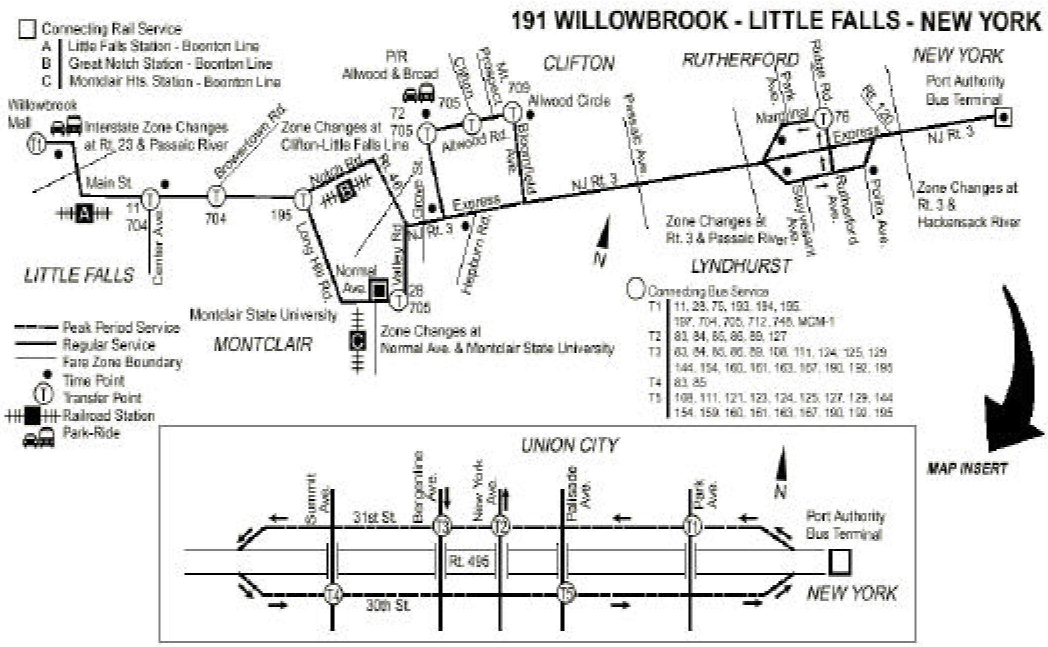
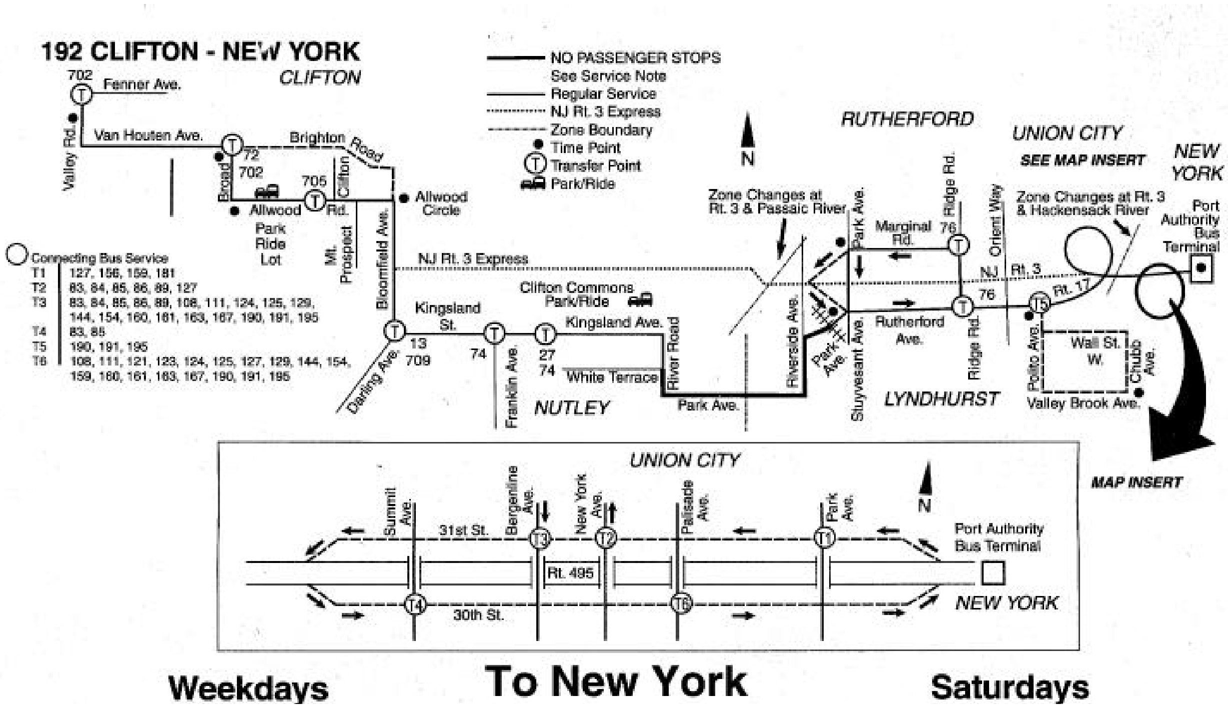


Figure 4-3. Passaic County Bus Routes





These bus lines were selected to ensure that each route included travel on the New Jersey Turnpike, the Garden State Parkway, and a variety of other major and minor roadways in New Jersey. The PM peak period was used because it happens to be the busiest departure time at the PABT. During this period, inbound bus traffic (i.e., those returning from garages) are most likely to be influenced by congestion, causing problems with queuing and internal bus circulation at the terminal. The uncertainty of these inbound delays contributes to the bus switches and other departure delays that have been measured for this evaluation. In terms of sample months, May and October of 2000 were selected based on the availability of the largest sample of "typical day" travel conditions over the course of the year.

4.3 Definition of "typical" days

A key part of the data analysis ensures that only data from comparable days are actually used. A pair of "comparable" days are those where, as far as is possible, no external factors have unduly influenced the data collected. External influences such as inclement weather or other seasonal variations, summer vacations, traffic accidents and parades, just to name a few, can have a significant skewing effect on the number of riders choosing to use NJ Transit's buses. Comparing data collected on days such as these with what might be termed as "normal' days could unfairly bias the evaluation results.

Therefore, criteria, which dictate "typical" days (and therefore, days from which data can be used in the analysis), were defined. These are days that do not fall on:

- nationally-observed holidays;
- the day prior to or immediately after nationally-observed holidays;
- days where adverse weather can be construed as a contributing factor to delay; and,
- days where planned major events (such as football games) are scheduled.

Thus, the months of May and October were considered to be the best candidates for collecting the NJ Transit log data.

5 Test Plan for Operations Logs

5.1 Introduction

This section details the pre-test and test activities that were undertaken specifically for the collection of data using the operations logs. Additionally, post-test activities are discussed which were necessary for the comparison of pre-test and post-test data.

5.2 Pre-test activities

Pre-test activities included:

- retrieval of operations logs from NJ Transit's record keeping system; and
- design and construction of a database/spreadsheet to record data for the purpose of the evaluation.

5.3 Test activities

5.3.1 "Before" data collection

The evaluation utilized data recorded on logs by NJ Transit operational personnel as part of their day-to-day responsibilities. Each log entry included the number of the bus, thus enabling log entries to be related to the bus schedule and to equivalent "after" data. Appendix A includes an example of logs of a chuteman and starter.

Data collected

Operations logs provided a summary of bus activity over the course of each month. For May and October of 2000, evening departures were examined for each of the eleven (11) selected bus lines for departures Monday through Friday. Table 5-1 below summarizes lines and observation periods for each bus line derived from the logs.

Table 5-1. Observed Bus Lines and Times

Bus Line #	Period of Observation (May and October data)
133	3:30PM – 7PM
135	4:50PM – 6:20PM
138	5PM – 7PM
144	4:45PM – 6:18PM
162	4:35PM – 7PM
163	3:30PM – 6:50PM
164	3:50PM – 7PM
191	4:15PM – 6:40PM
192	4PM – 7PM
194	4:10PM – 6:40PM
195	4:10PM – 6:30PM

For each bus line, the following classifications of data were extracted:

- Route Number;
- Bus Number;
- Destination;
- Routing;
- Date and Day;
- Scheduled Departure Time;
- Actual Departure Time; and,
- Number of Passengers.

Data quality check
All data derived from the logs were reviewed to ensure that they conformed to the typical day criteria defined in Section 4. Any data not conforming to these criteria were removed from the analysis.

Data pre-processing
The analysis of the TRANSMIT data on the eleven (11) bus lines focuses on an assessment of minutes late. Therefore, for each bus, the number of minutes late or early has been added to the data set. The data were cleaned to remove outliers and, thus, the potential for skewed results. The following measures have been conducted in the cleaning process:

- Switches between late buses and early buses were accounted for by interchanging actual departure times;
- Bus entries with incomplete "schedule departure" or "actual departure" times were removed;
- Bus entries where buses broke down or where buses were over 60 minutes late were removed;
- Where buses depart before scheduled departure times, departures over 5 minutes early were removed from the database; and
- Buses leaving 5 minutes early or less were edited to be shown as leaving on time. NJ Transit's policy is that buses leaving within five minutes of scheduled time are considered on time.

All cleaned data passing the "typical day" test were entered into the evaluation database in preparation for detailed analysis. Pre-processing of these logs took place between January and February of 2001.

5.3.2 "After" data collection

As the post-implementation evaluation activities will focus on performance generated from the use of HHDs, operations logs will not be used as part of the after data collection effort. Instead, data will be extracted from the TRANSMIT server containing the NJ Transit application as described in Section 6.

5.4 Post-test activities

Data from the May and October 2000 periods were organized into individual spreadsheets for each bus line. Each spreadsheet summarizes late performance of buses throughout the observation period for both months. Data were presented in each of the following four analysis categories:

Average minutes late by scheduled departure time
For each scheduled departure time, the average number of minutes late was recorded and graphed. In addition, a summary chart was developed that represents the average minutes late of all buses (for each month studied) leaving between 4 – 4:59PM, 5 – 5:59PM, and 6 – 7:00PM.

Average minutes late by weekday
For each weekday, the average number of minutes late was recorded and graphed. A summary chart was included that represents the average minutes late of all buses (for each month studied) that leave on each weekday.

Percentage of Late Buses
For each bus line and each month, all bus departures were separated into the percentage of buses departing on time, those that depart late within 5 minutes of scheduled departure, and buses that depart more than 5 minutes late. A chart was developed to compare the percentage of buses departing over 5 minutes late (for each month studied).

Average Minutes Late
For each bus line, the average minutes late of all buses (for each month studied) was documented. A chart was developed that compares average minutes late for buses.

5.4.1 Data analysis

Analysis of the data was performed to compute the average and variance of minutes late according to the categories described in Section 5.4. Results are documented in summary charts of baseline data in Section 8.

6 Test Plan for TRANSMIT System Data

6.1 Introduction

This section presents the pre-test, test and post-test activities that will need to be undertaken specifically for the collection of data on use of the hand held devices (HHDs) as part of the TRANSMIT system.

6.2 Pre-test activities

Pre-test activities will include:

- Examination of the beta test HHDs to ensure that the entries made on the operations logs can be mapped to the data recorded using the HHDs;
- Examination of the server holding data used by the HHDs with a view to ensuring that data can be retrieved for subsequent data analysis; and
- Design and construction of a database/spreadsheet to record data for the purpose of the evaluation.

6.3 Test activities

6.3.1 "Before" data collection

System data are not used as part of the "before" data collection effort, as reported in Section 5.

6.3.2 "After" data collection

<u>Data to be collected</u>
"After" data derived through the use of the HHDs will mimic "before" data collected using operations logs. Therefore, in addition to basic information regarding the line and bus, the following system data will be derived:

Measurement	Measurement method
Scheduled bus departure time	System data
Delay to departure (if any)	System data
Time, location and bus number where any switches or substitutions are performed	System data

<u>Data quality check</u>
All data collected will be reviewed to ensure that they conform to the "typical-day" criteria defined in Section 4. Any data not conforming to these criteria will be removed from the analysis.

Data pre-processing

All data passing the "typical-day" test will be entered into the evaluation database in preparation for detailed analysis. The format of the database to be used in the evaluation should follow that which is used in the analysis of baseline data.

6.4 Post-test activities

The system data will be analyzed using statistical techniques to capture the trends and main effects in the data. The primary goal of analysis is to determine the extent to which TRANSMIT handheld devices affect on on-time bus departure performance. However, because performance varies with bus line, time of day, day of week, and month, these factors must be taken into account in determining the effect of handheld devices. Techniques such as ANOVA and logistic regression models will be used to characterize and determine the statistical significance of the difference in on-time performance before and after the implementation of the handheld devices. Other types of transformations may be necessary to fit the best model to the data.

7 Test Plan for Key Informant Surveys and Interviews

7.1 Introduction

Information was collected using surveys and one-on-one interviews with NJ Transit personnel, specifically chutemen, starters, and managerial staff in order to establish a baseline condition which will be compared against future terminal operations once the HHDs are implemented. The purpose of the post-deployment interviews will be to develop an in-depth understanding of any benefits derived through the use of the TRANSMIT transit application --in particular --the HHDs—and the archiving of data from the TRANSMIT system. As terminal staff have been using the same paper-based data logging method for many years, they have developed a keen awareness of activities within the terminal, despite the fact that they could benefit from having more information. This is not to say that having advanced knowledge of bus status will not prove to be useful information. It means that despite having no knowledge of the whereabouts of incoming buses, somehow buses are still able to get switched and depart. Nevertheless, on-time departures and other aspects of operations might improve significantly with the advent of new information from TRANSMIT.

Developing and conducting interviews and surveys with NJ Transit staff prior to the deployment of HHDs helped to establish this baseline condition which defines how information is currently processed, how and what information is being shared among terminal staff, as well as how information is being stored, retrieved, and used to improve operations.

Surveys were conducted with chutemen and starters. The evaluation team developed a set of survey questions and distributed them among terminal staff. In addition, a personal interview was conducted with PABT's head scheduler located in the NJ Transit headquarters in Newark..

7.2 Pre-test Activities for Baseline Data Collection

To learn what activities are currently conducted, what information is presently known about bus arrivals and status, how information is exchanged among terminal personnel, and how departure data are stored, retrieved and utilized for planning purposes, NJ Transit staff were queried.

The baseline condition would be based on the terminal staff's perception of current operations and processes, prior to the deployment of HHDs. In the post deployment phase of the evaluation, this information would serve as a basis for comparison when evaluating PABT operations and processes.

A list of interview and survey questions were developed and submitted to terminal and scheduling staff. Table 7-1 illustrates the pre-deployment interview questions that were submitted to the chutemen and starters. The supervisory staff at the PABT agreed to distribute the survey form to the chutemen and starters at the PABT in early August, 2001. To collect information about the use of stored data, NJ Transit identified the appropriate staff person to contact so that an interview could be arranged with the evaluation team.

Table 7-1. Summary of Chuteman and Starter Interview Questions

	Interview Question	Chuteman	Starter
1	Do you have enough information on the location of buses *inside* the PABT to do your job effectively?	√	√
2	Do you have enough information on the location of buses *outside* the PABT to do your job effectively?	√	√
3	Would knowing the exact location of buses *before* they enter the terminal change the way that you do your job?	√	
4	Do you use data on historical patterns of late arrivals to assist you in doing your job?	√	√
5	If no, would having this information be useful to you?	√	√
6	Is communication with chuteman/starter an important part of your job?	√	√
7	Please indicate the number of times during the peak period that you communicate on average.*	√	√
8	Would having a better idea of the actual (instead of scheduled) arrival times help you to assist bus riders?		√
9	How many minutes past a bus' scheduled and/or arrival time do you wait, on average, before deciding to switch the bus?**	√	
10	Does the time it takes to record start time and ridership take away from your other responsibilities?		√
11	Is the daily information for the lines that you handle always accurate and delivered at the beginning of your shift?	√	
12	Is managing the paperwork necessary for every shift a difficult part of your job?		√

*Selections were: 0 times, 1 – 2 times, 3 – 4 times, 5 – 6 times, or over 6 times.
**Selections included: 0 – 1 minute, 2 – 5 minutes, 6 – 10 minutes, 11 – 15 minutes, or over 15 minutes.

7.3 Pre-Test Activities for Post-Deployment Data Collection

In order to guide the conduct of surveys and interviews, a semi-structured protocol will be developed. Key informants to be interviewed and surveyed will be those who will be directly involved in bus operations or storage of bus log data. This approach will enable the evaluation team to focus on those individuals who have knowledge about issues of central importance to the purpose of the evaluation. The sample of chutemen and starters for the survey will be drawn primarily from those who are responsible for the eleven bus lines for which log and system data are being collected. Managerial staff will include supervisors at the Port Authority Bus Terminal and the headquarters staff responsible for archiving and using log data.

A survey and interview guide will be constructed for both sets of respondents. Question areas to be used in the interview and survey forms will include those presented in Table 7-2, and others will be determined after early experiences with the HHDs are identified by the evaluation team and stakeholders. In addition to chutemen and starters, their supervisors will be interviewed in the post-deployment phase.

Table 7-2. Post Deployment Information to be Derived from Surveys and Interviews

Stakeholders	Post Deployment information to be obtained from surveys and interviews
Chutemen and starters	Perception of ease of use of the HHD as compared to a manual logging
	Perception of the timeliness of receipt of information
	Perception of the completeness and accuracy of information
	Perception of contribution of HHD to job performance
	Perception of improvement in decision-making on reassigning buses
Supervisors	Perception of contribution of HHD and TRANSMIT data to bus operations
	Perception of HHD in terms of training needs and acceptance by chutemen and starters
	Perception of whether or not storage and retrieval of information is easier and faster
	Perception of flexibility to report on historical data
	Perception of improved decision making on reassignment of buses

The instrument will be pre-tested to enable the evaluation team to consider additional "probing questions" to elicit greater detail from the interviews. Pretesting will also help to ensure that the question wording and length of the interview are appropriate.

The interview protocol will contain a cover sheet to identify the name of the respondent, title or role at NJ Transit, date and starting time/ending time of the interview. Also, the cover sheet will list information to discuss with the respondent before asking specific questions related to their use of ITS technologies.

7.4 Baseline Test Activities

7.4.1 "Before" data collection

The questionnaires were printed and sent to the NJ Transit Manager of Terminal Operations at the PABT, who distributed them to terminal staff. Responses were received from 14 starters and 3 chutemen.

Data quality check and pre-processing

Completed interviews were checked for thoroughness, legibility, and consistency. The completed questionnaires from the survey of chutemen and starters were transferred to a database. The entries were filled in by an individual respondent and contained either coded or narrative responses as appropriate for each question.

7.4.2 "Before" Data Analysis

Tabulations of the survey data were performed. These are presented in Section 9. Results from the interview with the NJ Transit scheduler are also discussed in Section 9.

7.4.3 "After" data collection

Data to be collected

The post-deployment interview guide will be constructed with similar questions and in a similar format as those used in the baseline data collection, such that both closed and open-ended questions will be asked. For example, the respondent may be asked multiple choice, yes/no, or similar types of questions that have a limited number of responses that can be coded into numeric data. Open-ended questions and follow-up probes to closed-end questions will enable the respondent to provide narrative responses than are recorded verbatim by the interviewer.

Data quality check

Completed interviews will be checked for thoroughness, legibility, and consistency. When interviews are conducted, training of interviewers will reduce inter-interviewer differences, and minimizing the number of interviewers will reduce errors of consistency.

Data pre-processing

The completed questionnaires will be transferred to a database. The entries will be by individual respondent and contain coded or narrative responses as appropriate for each question.

7.5 Post-test Activities

Results of the interviews will be tabulated and analyzed in order to identify patterns of responses relating to "before" and "after" performance for each of the questions. Tables and graphs of the results will be prepared where appropriate.

8 Analysis of Data: Operation Logs

8.1 Introduction

This section provides an overview of the analysis methodology applied to operation logs.

8.2 Analysis Approach

Table 8-1 below presents an overview of how the operation logs collected as part of the TRANSMIT test have been analyzed. The baseline data described in this report relate to the goal of mobility, in that the HHD is expected to improve the on-time performance of bus departures and thereby reduce delay for bus riders.

The baseline data describe conditions prior to the HHDs being deployed. The goal of efficiency will be assessed through interviews with NJ Transit staff after the deployment of the HHDs and, therefore, no data on efficiency are presented in the baseline report.

Table 8-1. Overview of Analysis of Operations Logs

Mobility Goal	Measurements	Analysis
To improve on-time departure (Bus departure time)	• Expected departure time determined from schedule • Before bus departure time determined from starters log • After bus departure time from starters records in HHD	Before/after changes in bus departure time compared to schedule

8.3 Baseline Analysis of Bus Performance

The results of the analysis are presented in graphical form and are accompanied by explanatory commentary. Comparisons of "before" and "after" data, once they are collected, will reveal the impact of the TRANSMIT system on both the individual bus line and on general operations at the terminal. For ease of exposition in this report, the baseline data have been pooled in various ways. During the post-deployment analysis, statistical techniques will be used to isolate the impact of the HHDs from the various other effects on schedule adherence. For example, time of day, day of week, month, and bus line will be examined to isolate statistically significant effects.

The graphical depiction used with the baseline data is a "whisker" chart. Such a chart offers the advantage that it can highlight the spread of data points around the median, but it can also depict the full range of data points in the form of a whisker. Thus, in the accompanying charts the lower whisker shows the first 25% of the data points. (The absence of a lower whisker in some charts indicates the presence of many zero values and, thus, no lower whisker is created.) The charts also show a thicker highlighted area encompassing the 25^{th}-75^{th} percentiles of data points, and the upper whisker depicts the top 25% of the range.

8.4 Summary of Statistical Analysis of Baseline Data for Bus Lines Combined

Figure 8-1 displays the box-plots of late minute distribution for May combined for all bus lines by their scheduled departure time. It is observed for all bus lines that bus lateness increases with the scheduled departure time. Especially after 5:00 PM (17:00), the general profile of late minute distribution starts changing with one or more buses at least 50 minutes late a common occurrence. Indeed, 25% of all buses operating for all bus lines with the departure time scheduled after 6:00PM are late more than 10 minutes.

Figure 8-1 All the Lines, Minutes Late By Time of Departure, May 2000 (25th to 75th Percentile Highlighted)

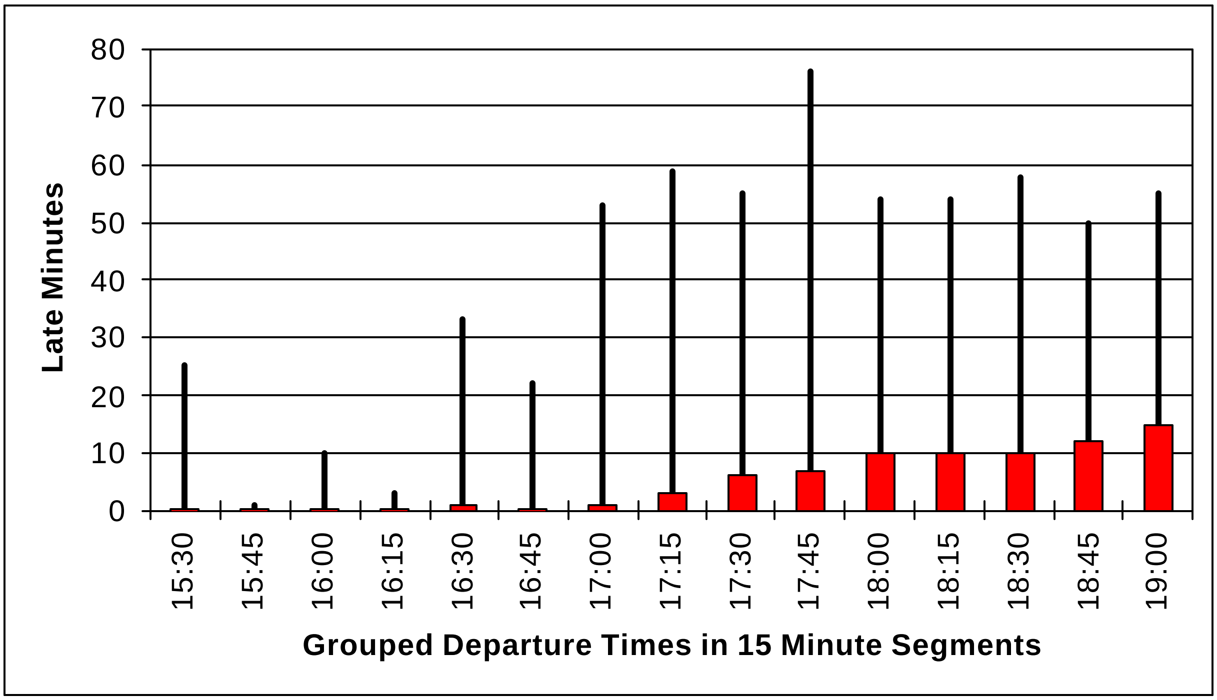


Figure 8-2 displays the box-plots of late minute distribution for October combined for all bus lines by their scheduled departure time. The box plots in Figure 8-2 have a similar characteristic with Figure 8-1, except the profile of late minute distribution starts changing at 5:30pm. (There is also a questionable or missing data located at 7:15PM.)

Figure 8-2 All the Lines, Minutes Late By Time of Departure, October 2000 (25th to 75th Percentile Highlighted)

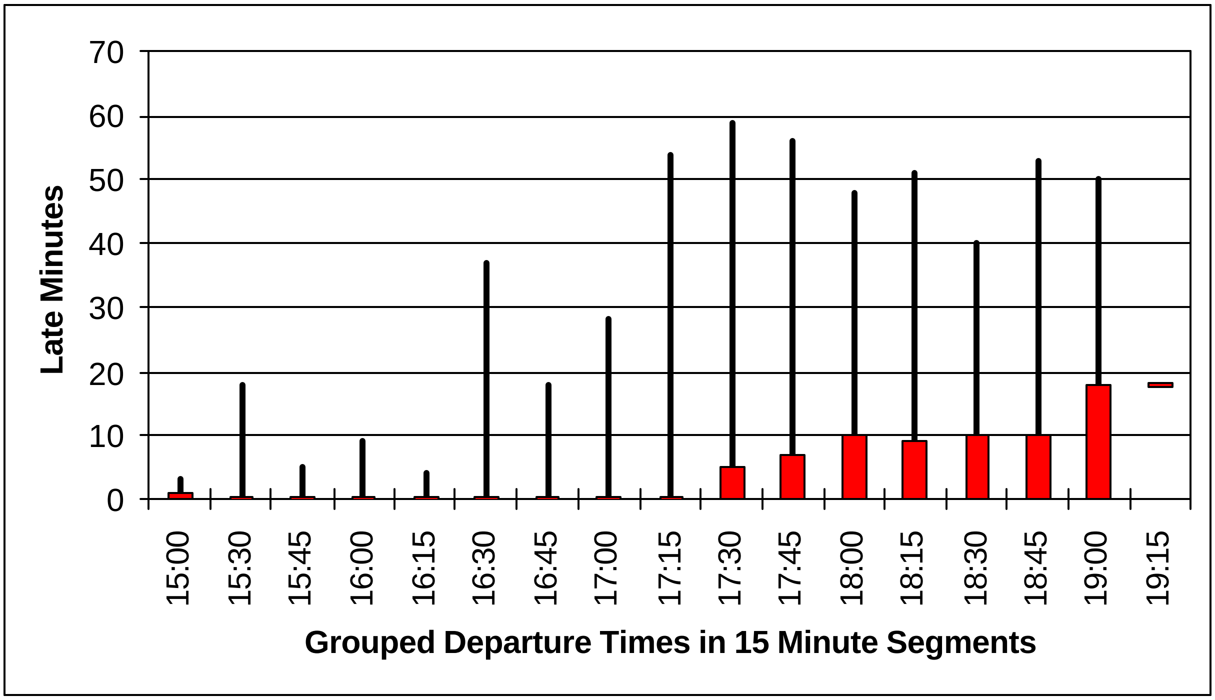
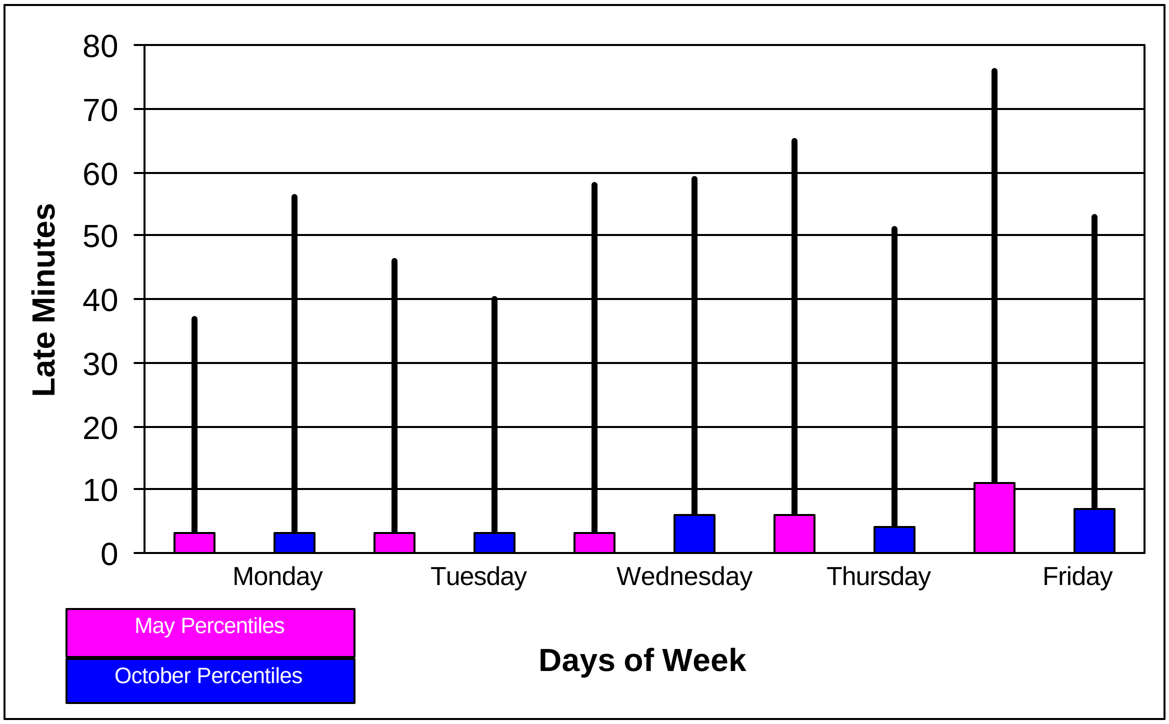


Figure 8-3 displays the box-plots of late minute distribution for both May and October combined showing all bus lines by day of the week. Lateness of two minutes or more is common every day of the week in both months. However, Friday appears to be more prone to late departures, and slightly more so in May.

Figure 8-3 All the Lines Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



The summary data help to provide the general view of schedule adherence at the PABT for the eleven bus lines as a whole. The following section examines the pattern of each bus line individually.

8.5 Summary of Statistical Analysis of Baseline Data for each Bus Line

Figures are provided in the sections that follow depicting baseline results for each bus line in the following two categories:

- Late Performance by Line, by Scheduled Departure; and
- Late Performance by Line, by Weekday.

8.5.1 Performance Summary for Bus Line 133

Figure 8-4 displays the 25th to 75th percentiles of late minutes of buses operating for line 133 by their departure time. Five extreme late buses over 35 minutes are observed by the length of the whisker at 4:30pm, 5:30PM, 6:00PM, 6:30PM, and 7:00PM. The box plot is a way of summarizing the distribution of late minutes. In a box plot, 25th percentile and 75th percentile are shown as lower and upper boundaries, respectively, of the box. The 25th percentile is the point at which 25% of buses have lower late minutes. The 75th percentile is the point at which 75% of buses have lower late minutes. In other words, 25% of buses have higher late minutes. In Figure 8-4, at 6:30PM, 25% of buses are more than 20 minutes late. At 7:00PM, the 75th percentile is roughly 7 minutes. The other 3 extreme cases are not significant since 75% of buses do not experience late departures. Still, there does appear to be a problem with lateness for buses between 6 and 7 PM.

Figure 8-4 Line 133 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

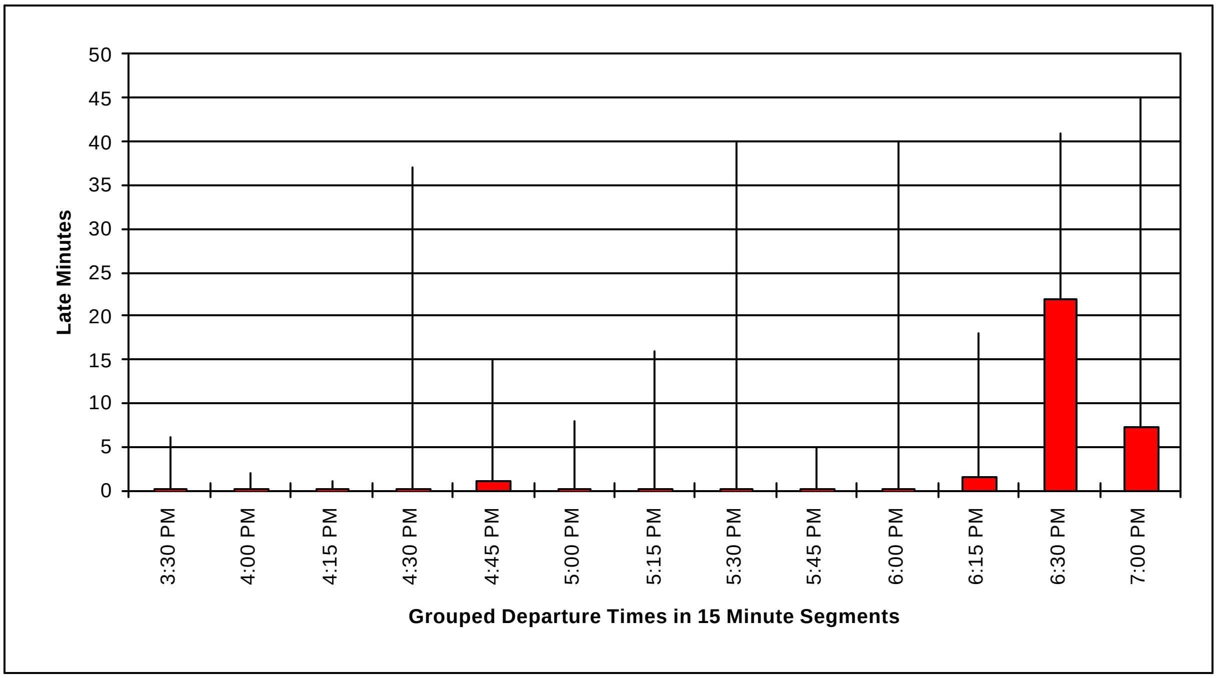
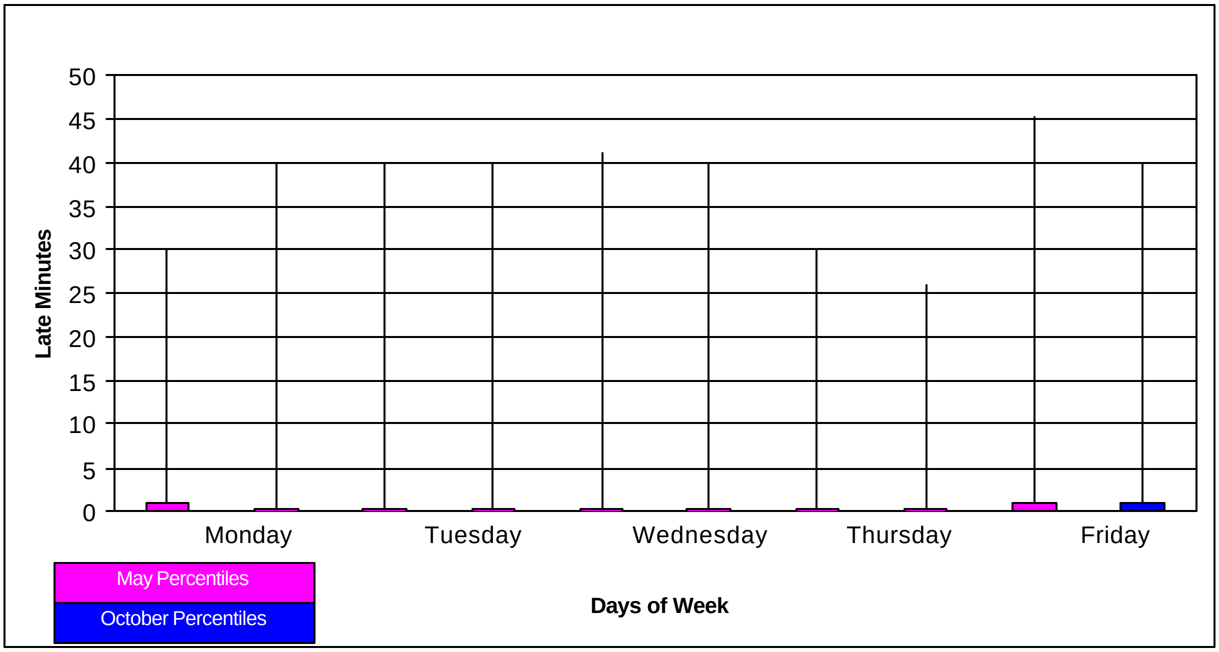


Figure 8-5 displays the 25th to 75th percentiles of late minutes of buses operating for line 133 by day of the week. The box plots for both May and October are shown to demonstrate overall similar performance for both months. The late minute distribution over days of week is different than that over departure times. During the month of October, with the exception of Thursday, at least one bus is at least 40 minutes late. Additionally, during the month of May on each Monday and Thursday, at least one bus is 30 minutes late. On other days, lateness reaches 40 minutes for one or more runs. Conversely, the 75th percentiles for both May and October are as low as zero minutes late for almost each day, thereby indicating very good overall schedule adherence.

Figure 8-5 Line 133 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.2 Performance Summary for Bus Line 135

Figure 8-6 displays the late performance of buses operating for line 135 by their scheduled departure time. Line 135 has a relatively narrow time window for departures. The latest departure is observed at around 5:15PM, which is above 25 minutes. The other departure time groups have better performances, which are generally below 10 minutes. late Additionally, 75th percentiles are as low as zero (0), an indication of very good on-time departure overall.

Figure 8-6 Line 135 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

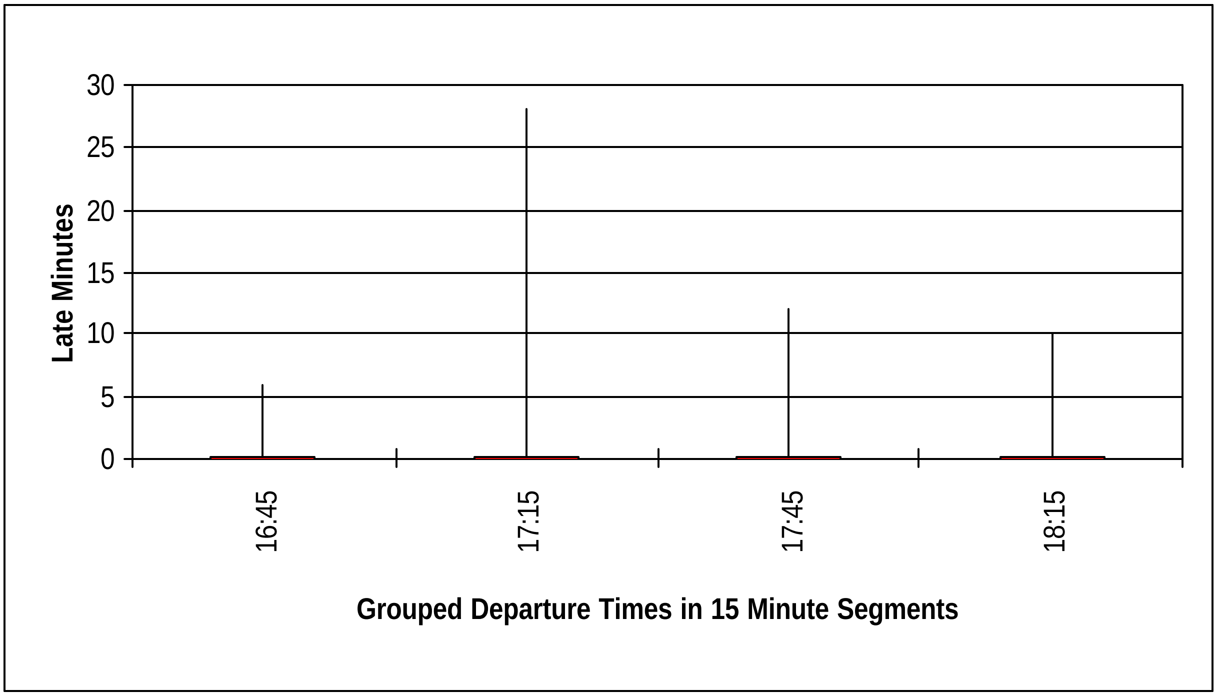
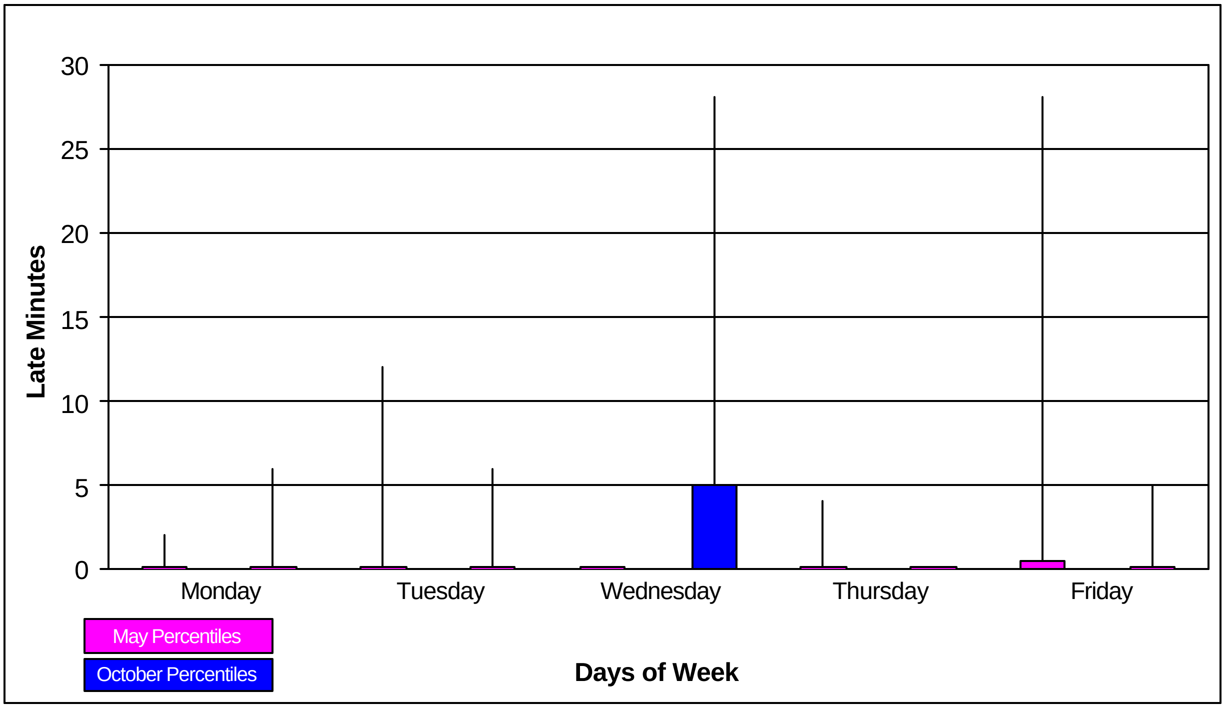


Figure 8-7 displays the box-plots of late minutes of buses operating for line 135 by day of week. In Figure 8-7, there are two points of interest. The first one is the late minute distribution on Wednesdays of October. The latest bus departure is seen as over 25 minutes, where the 75th percentile is at 5 minutes, which means 25 % of buses departing on Wednesdays during October is late for more than 5 minutes. The second point of interest is seen on the late minute distribution of Fridays during May. Although the 75th percentile is low enough, there is at least one late departure over 25 minutes.

Figure 8-7 Line 135 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.3 Performance Summary for Bus Line 138

Figure 8-8 displays the box-plots of late minute distribution of buses in line 138 by their departure time. There is not any significant 75th percentile of interest, as they are all 3 minutes or much less. For four of the time segments, at least one bus run had a late departure time over 20 minutes.

Figure 8-8 Line 138 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

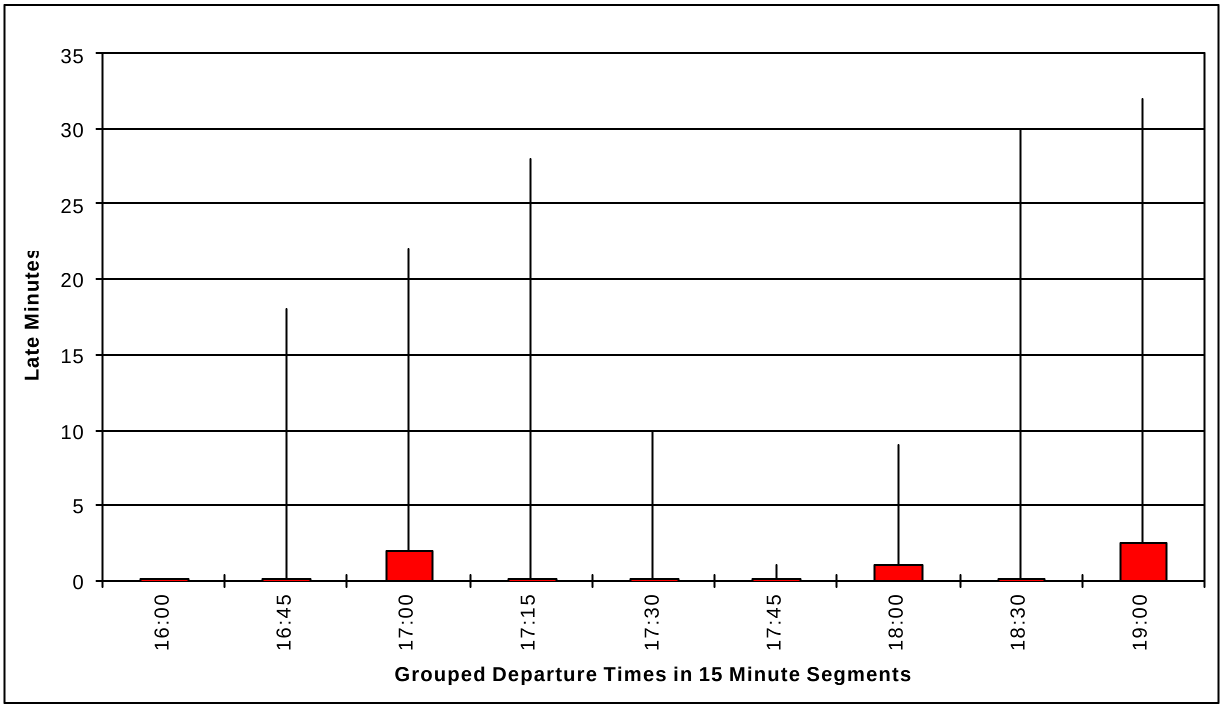
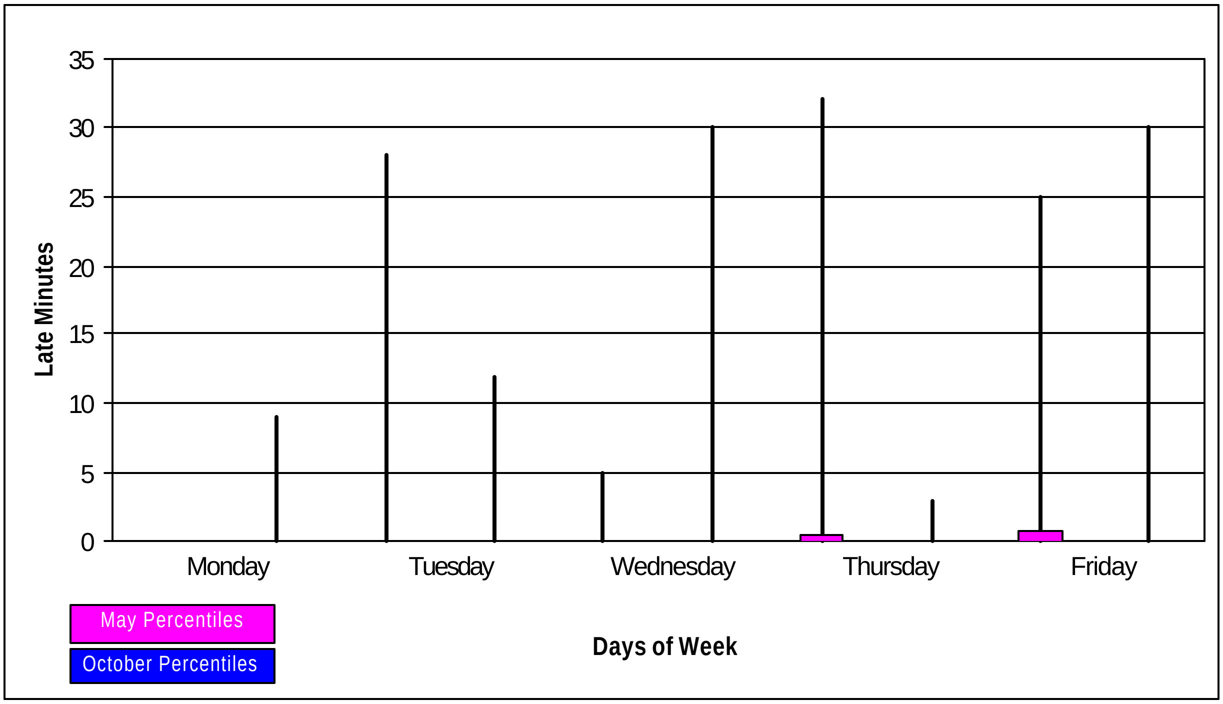


Figure 8-9 displays the box-plots of late minute distribution of buses in line 138 by day of week. In Figure 8-9, the late-minute patterns reveal on-time departures for 75% of the buses on most days. Only in May on Thursdays and Fridays are there delays of a minute or two. Still, a small number of buses were very late, with departures over twenty minutes late on every day except Monday.

Figure 8-9 Line 138 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.4 Performance Summary for Bus Line 144

Figure 8-10 displays the box-plots of late minute distribution by their grouped departure times in 15-minute segments. It is seen that there is least one (1) bus that is late more than 50 minutes at 5:00PM, although 75 % of buses are on time or only a minute late. The next point of interest is the pattern of lateness from 5:30 PM onward. This graph shows us that 75 percent of buses departing at 5:45PM are late more than 5 minutes, where 25^{th} of them are late more than 15 minutes. For the departure time at 6:00PM the 75^{th} percentile of lateness of buses is close to 10 minutes, where the maximum point is around 25 minutes. In the group of 6:15PM departures, at least one bus is late for more than 30 minutes.

Figure 8-10 Line 144 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

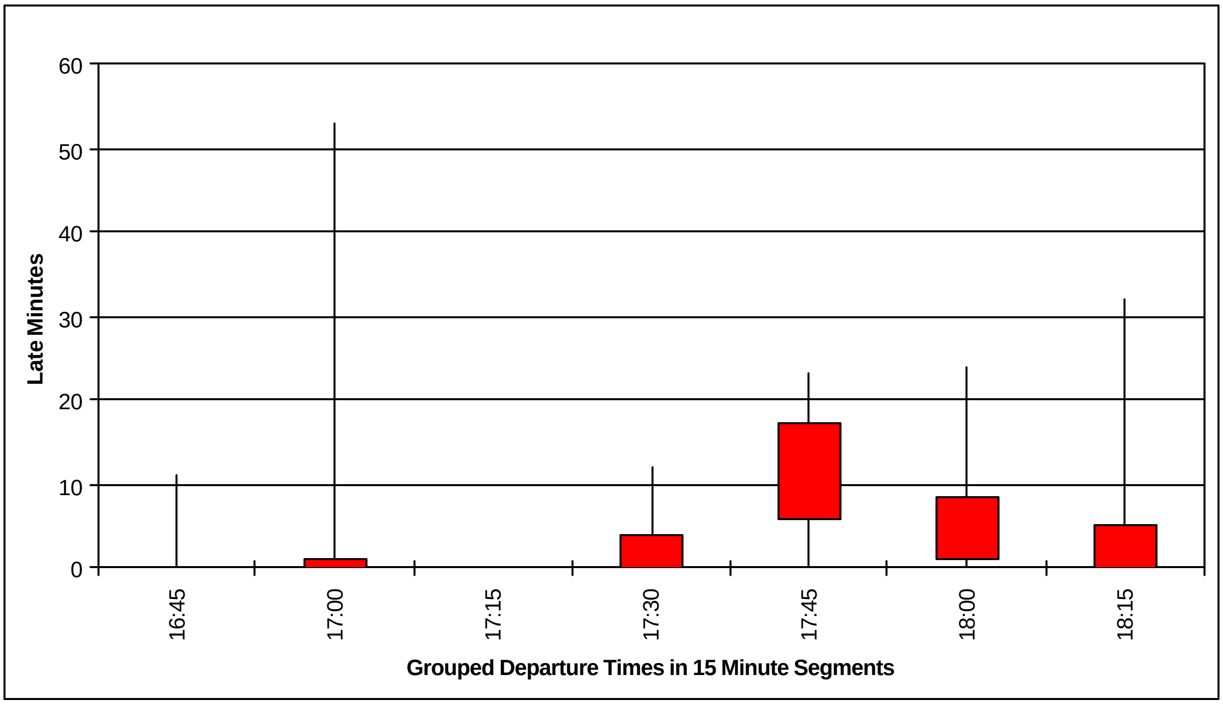
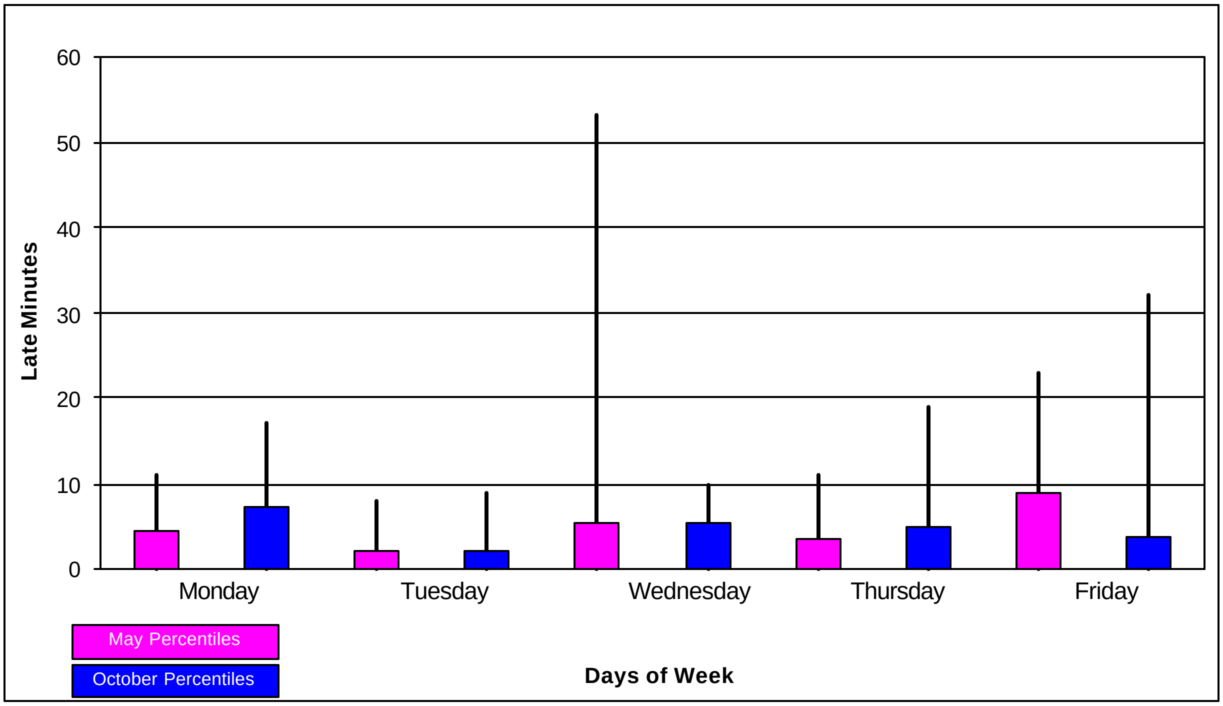


Figure 8-11 displays the box-plots of late minute distribution of buses operating in line 144 by day of week. Whereas there is a general pattern of lateness on every day of the week regardless of the month, the 75th percentiles indicate that the delay is generally under 10 minutes for most runs. Two points of interest are the maximum late minute occurring on Wednesdays of May, which is more than 50 minutes, and that 25% of buses departing on Fridays during May are late for about 10 minutes or more.

Figure 8-11 Line 144 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.5 Performance Summary for Bus Line 162

Figure 8-12 displays the box-plots of late minutes of buses by their scheduled departure time. Bus 162 has difficulty departing on time during the PM rush. At 17:15PM where there is at least one bus that is an hour late, although the 75 % of buses departing at that time are late for no more than 5 minutes. At 5:30PM, at least one bus is observed, which is late for more than 40 minutes and the 25 % of buses are also late for more than 10 minutes. For the departures at 5:45PM, the lateness is more than 75 minutes which indicates a serious problem, and again the 25% of buses are late for more than 8 minutes. For the maximum points of 6:00PM and 6:15PM are close and higher than 50 minutes, where the late minutes distribution for 6:15PM is much more serious, since the 75th percentile is around 15 minutes. In other words, 25% of buses are late for more than 15 minutes. Although the maximum lateness of 6:45 departures is in the level of 15 minutes, which means 75% of buses are five or more minutes late. Finally, for the departures at 7:00PM, are more than 15-minutes level.

Figure 8-12 Line 162 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

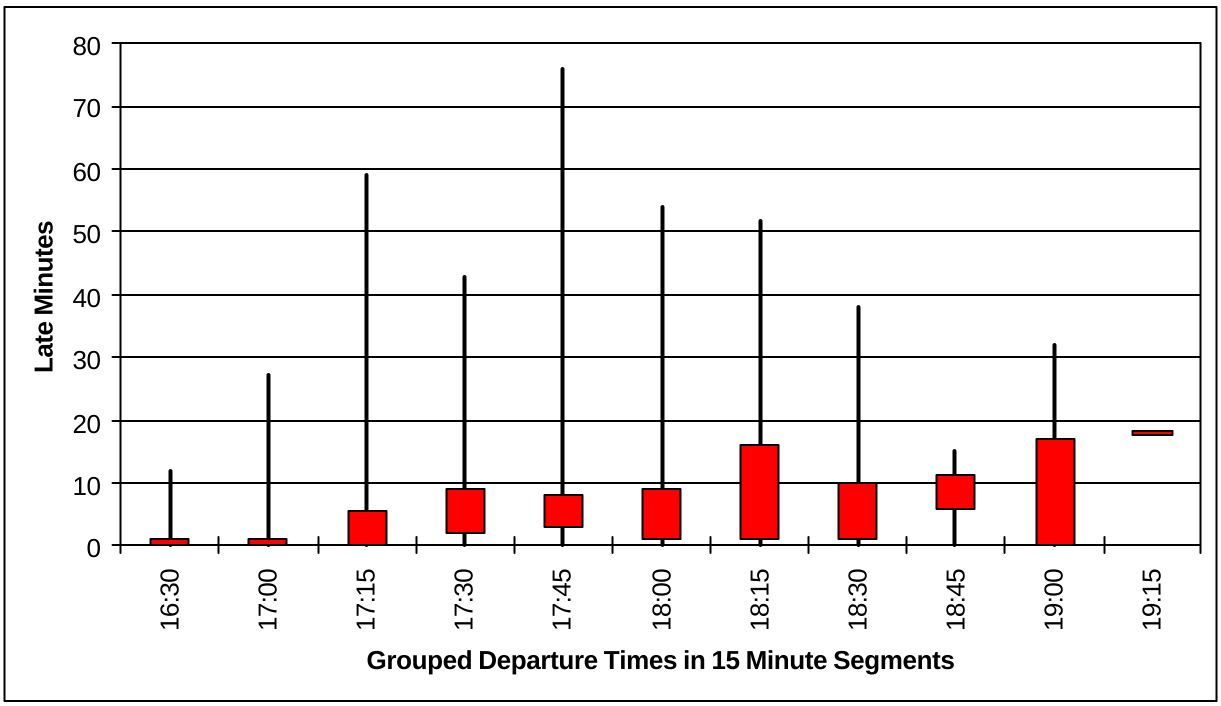
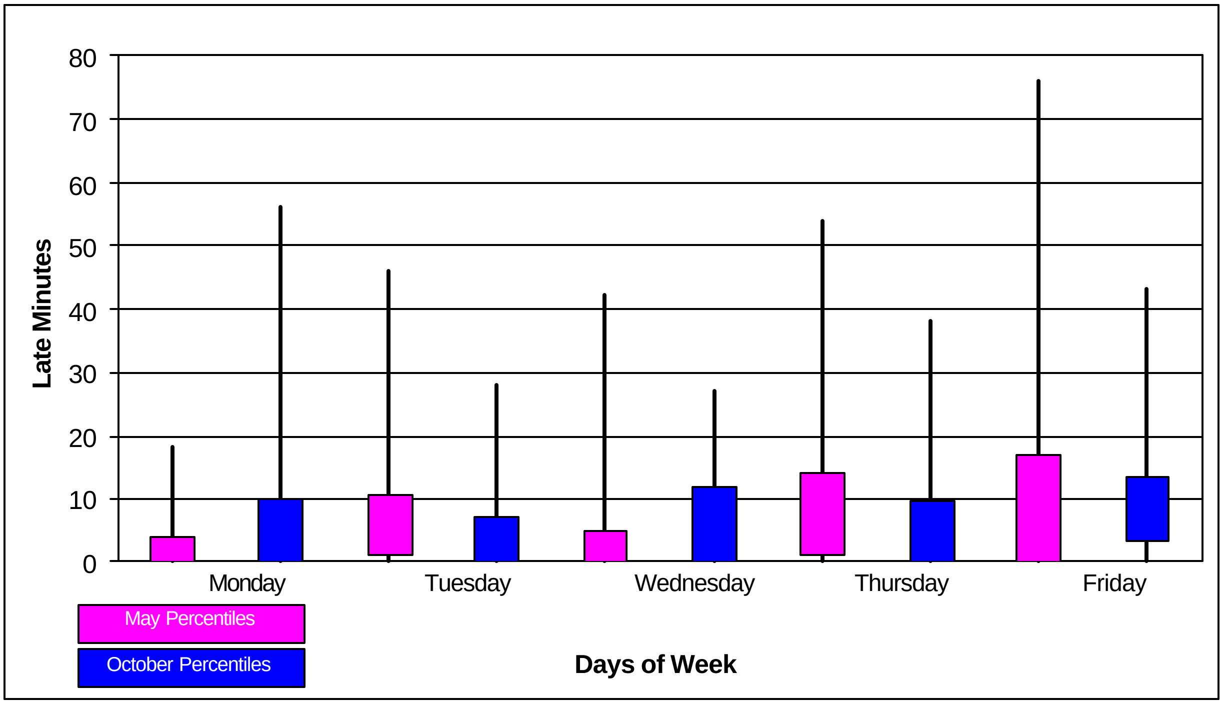


Figure 8-13 displays the 25th to 75th percentiles of late minutes of buses operating for line 162 by day the week. During October 25% of buses departing on Monday, Wednesday, Thursday, and Friday are late for more than 10 minutes, which indicates a pattern of poor performance. The departures in May are not much different, except on Monday and Wednesday, when the performance is slightly better.

Figure 8-13 Line 162 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.6 Performance Summary for Bus Line 163

Figure 8-14 highlights the 25th to 75th percentiles of late minutes of buses operating in line 163and demonstrates a pattern of lateness after 5:15PM. At least one bus late more than 40 minutes is observed on each departure scheduled after 5:15PM, except the one at 18:30PM. The 75th percentiles of those departure groups indicate that a delay of eight or more minutes is common.

Figure 8-14 Line 163 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

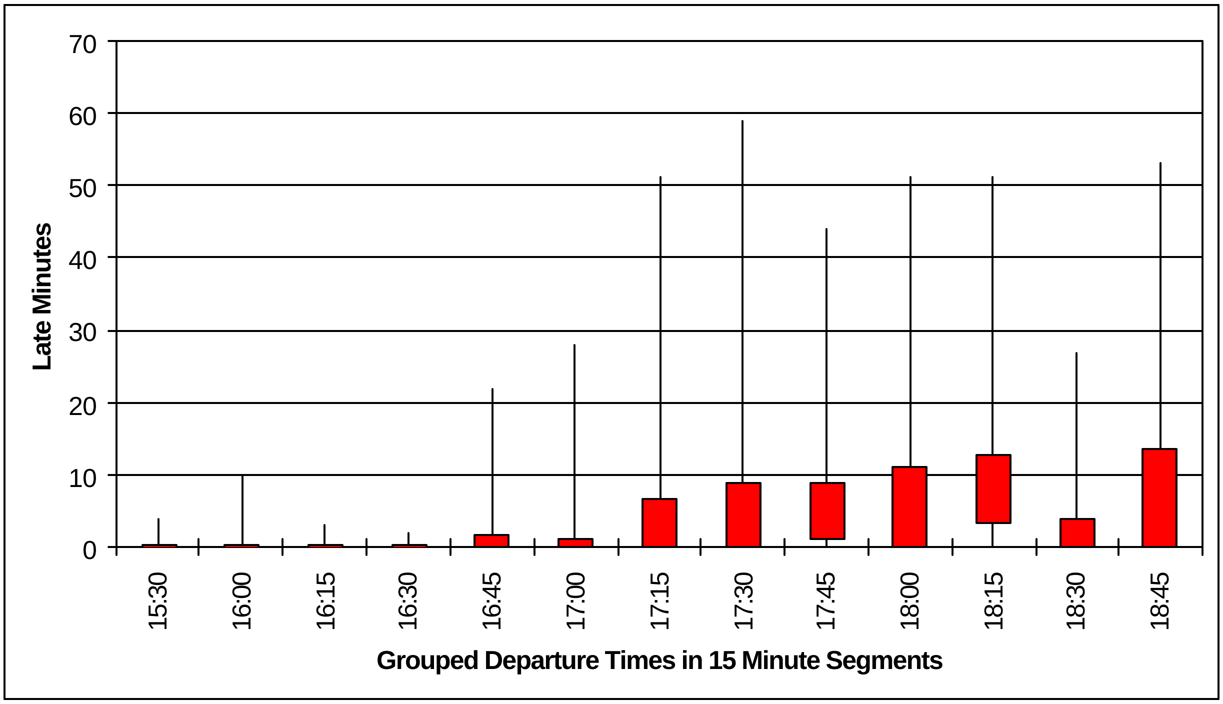
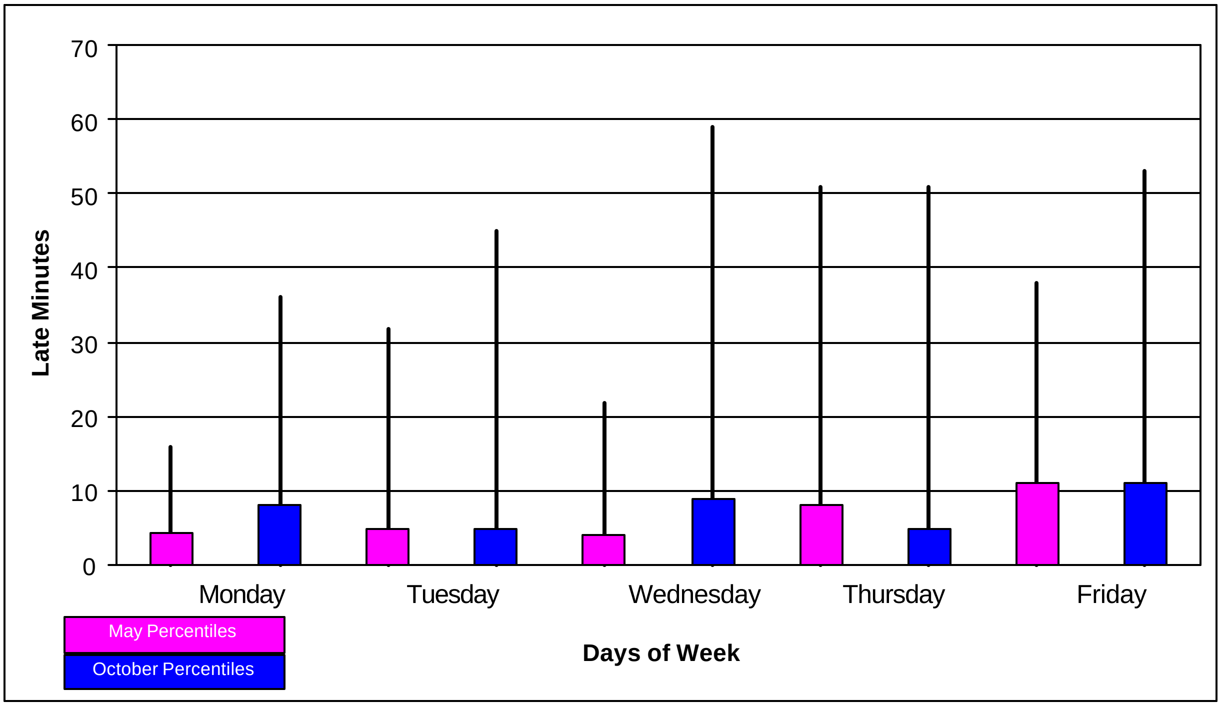


Figure 8-15 displays the box-plots of late minutes of buses operating in line 163 by day of weeks. Both May and October have a similar distribution of late minutes. It is also observed that the maximum late minutes of October are slightly higher than that of May. The 75th percentiles of May and October on Friday is slightly higher than 10 minutes.

Figure 8-15 Line 163 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.7 Performance Summary for Bus Line 164

Figure 8-16 displays the 25th to 75th percentiles of late minutes of buses operating for line 164 by their scheduled departure time. The first point of interest is located at 3:30PM. The apparent anomaly is either the result of a few data points that might result from discontinuance of the run or potential errors in the data. The second point of interest is a persistent pattern of lateness after 5:45 PM with typical delays of 5 to 10 minutes and frequent delays of 20 or more minutes.

Figure 8-16 Line 164 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

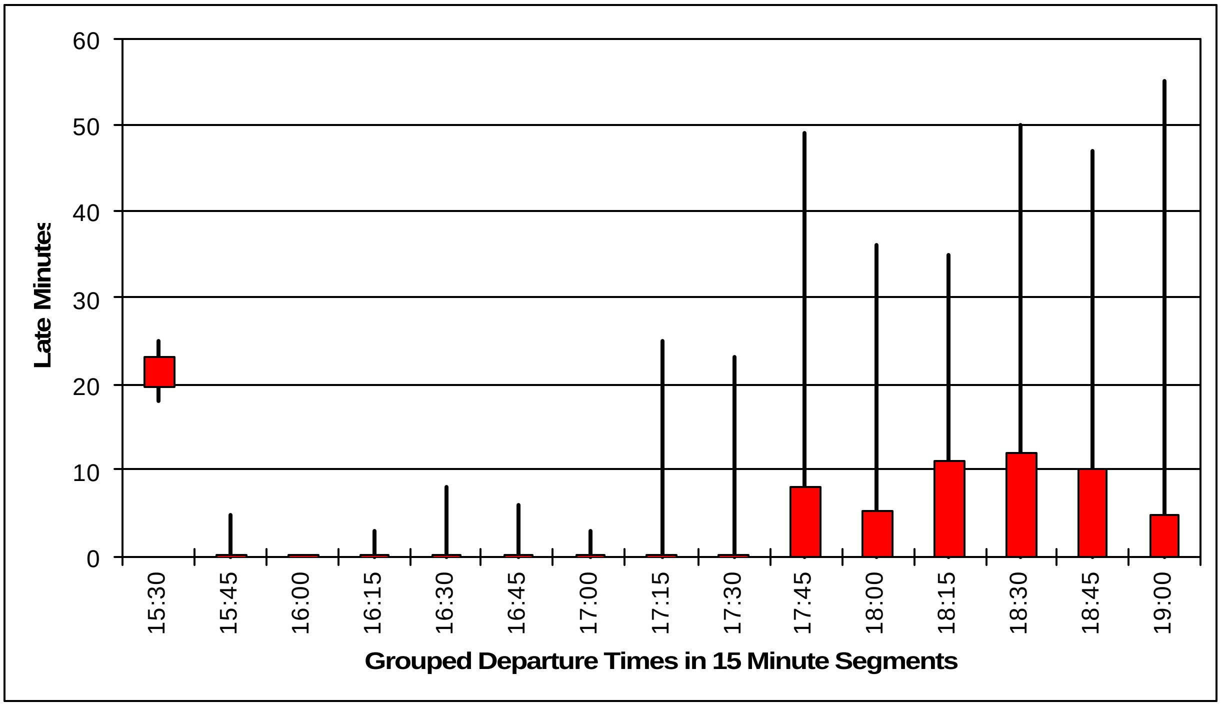
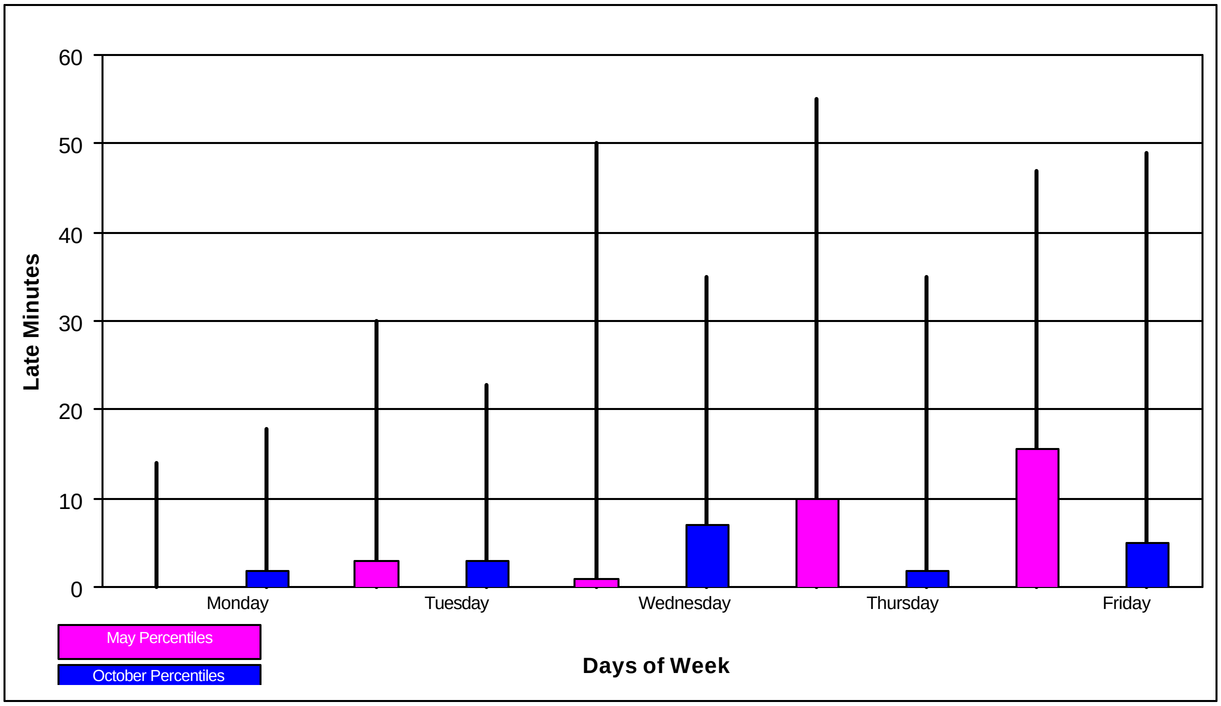


Figure 8-17 displays the box-plots of late minute distribution of buses in line 164 by day of the week. The performance of May is poorer than that of October. In particular, departures of May scheduled on Wednesday, Thursday and Friday have high maximum late points in the level of 50 minutes. In addition, 75th percentiles are located around 10 minutes and 15 minutes on Thursdays and Fridays respectively.

Figure 8-17 Line 164 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.8 Performance Summary for Bus Line 191

Figure 8-18 displays the 25th to 75th percentiles late minutes of buses operating for line 191 by their scheduled departure times. The 6 PM departures reveal that 75% of buses are late more than 8 minutes. The maximum late minutes of departures scheduled for 6:15PM and 6:30PM are also dramatic and in levels of 40 minutes and 50 minutes respectively.

Figure 8-18 Line 191 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted

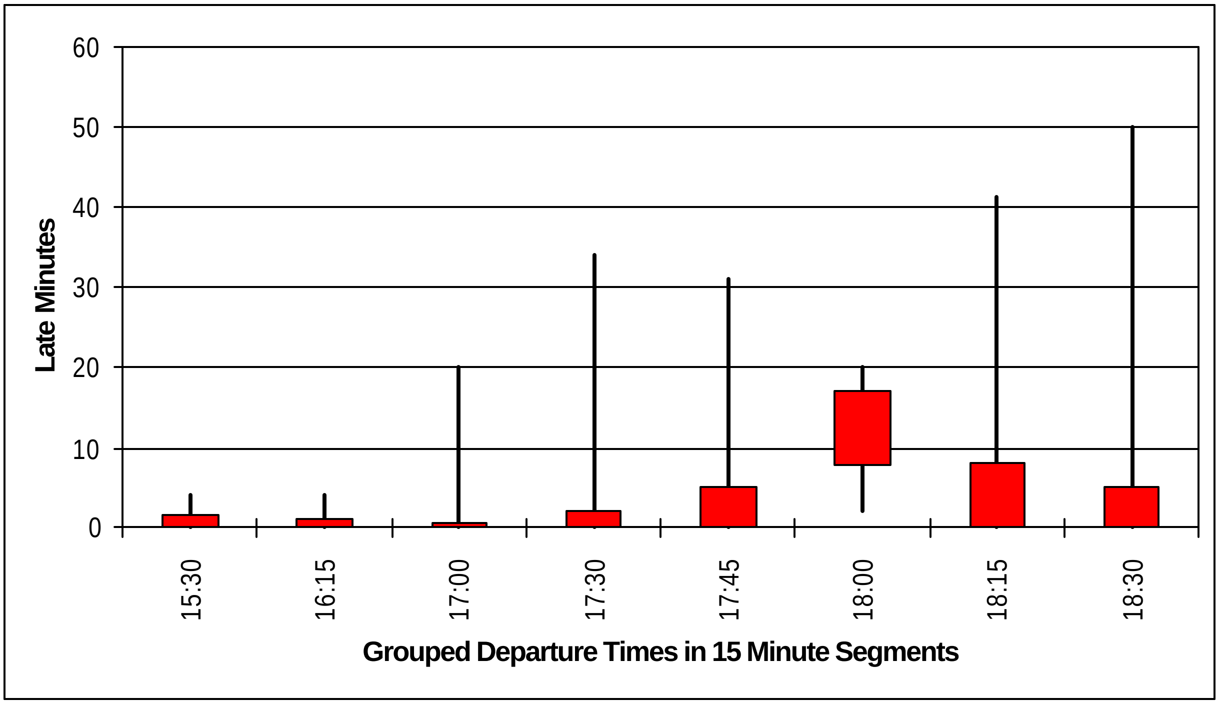
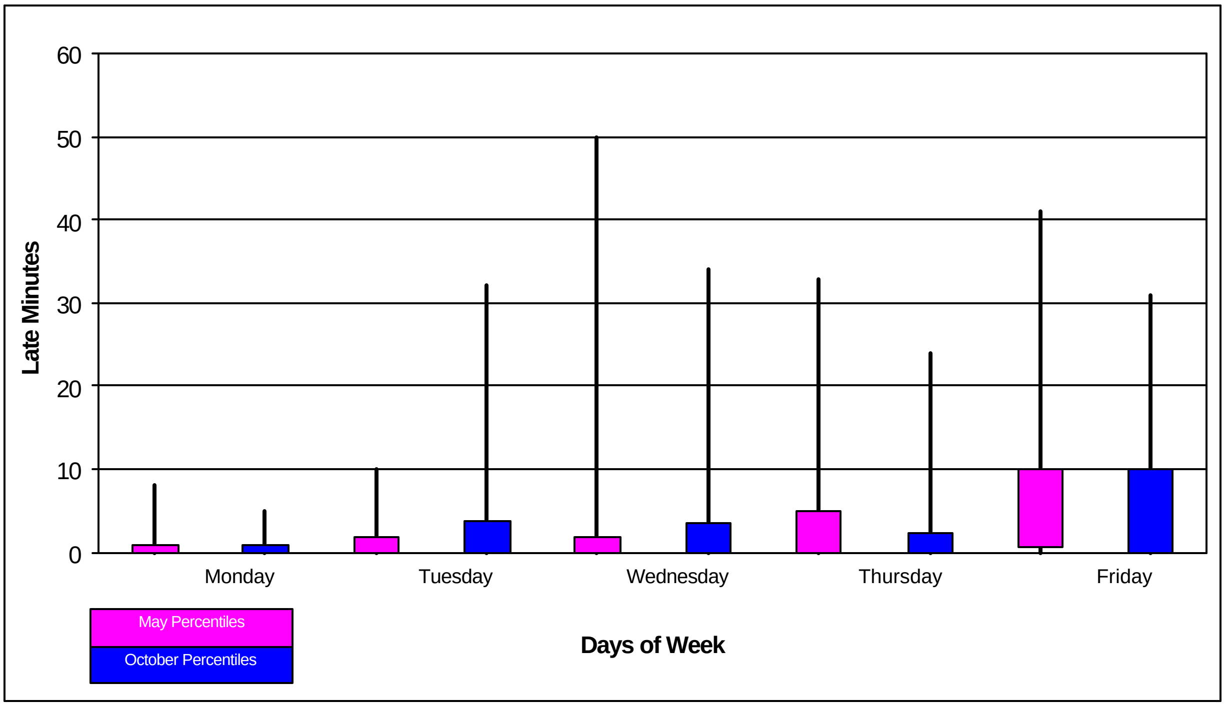


Figure 8-19 displays the box-plots of late minute distribution of buses operating for line 191 by day of the week. Problems of lateness are common on Friday, as the 75th percentiles of both May and October are around 10 minutes, and their maximum late minutes are as high as 50 and 40 minutes respectively.

Figure 8-19 Line 191 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.9 Performance Summary for Bus Line 192

Figure 8-20 displays the 25th to 75th percentiles of late minutes of buses operating for line 192 by their scheduled departure time. The first point of interest is the maximum lateness observed at 5:45PM, which is more than one hour. The 75th percentiles of departures scheduled between 5:45PM to 6:45PM are also high and in level of 10 minutes. Finally, the most serious case is observed at 7:00PM departures: 75% of buses are late for more than 10 minutes. Moreover, the 75th percentile is higher than 30 minutes, which means that 25% of buses are late for more than 30 minutes. Obviously, this performance indicates serious problems to be investigated.

Figure 8-20 Line 192 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

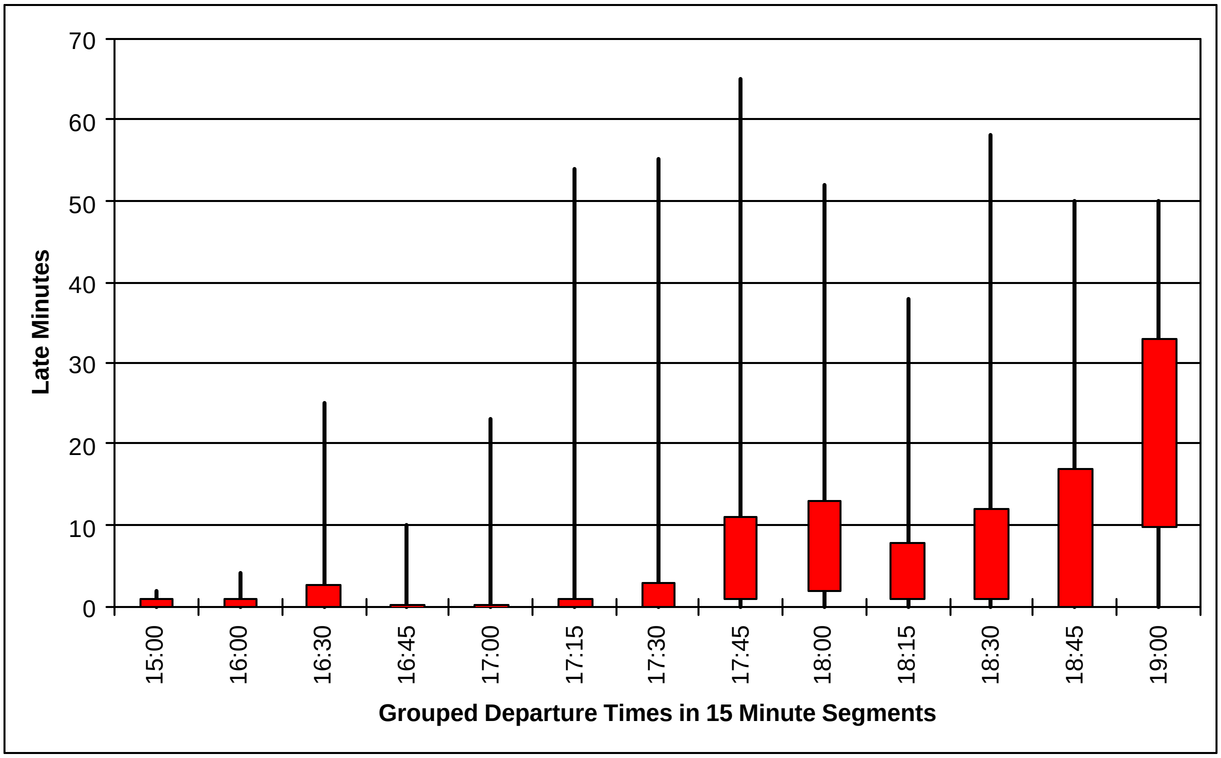
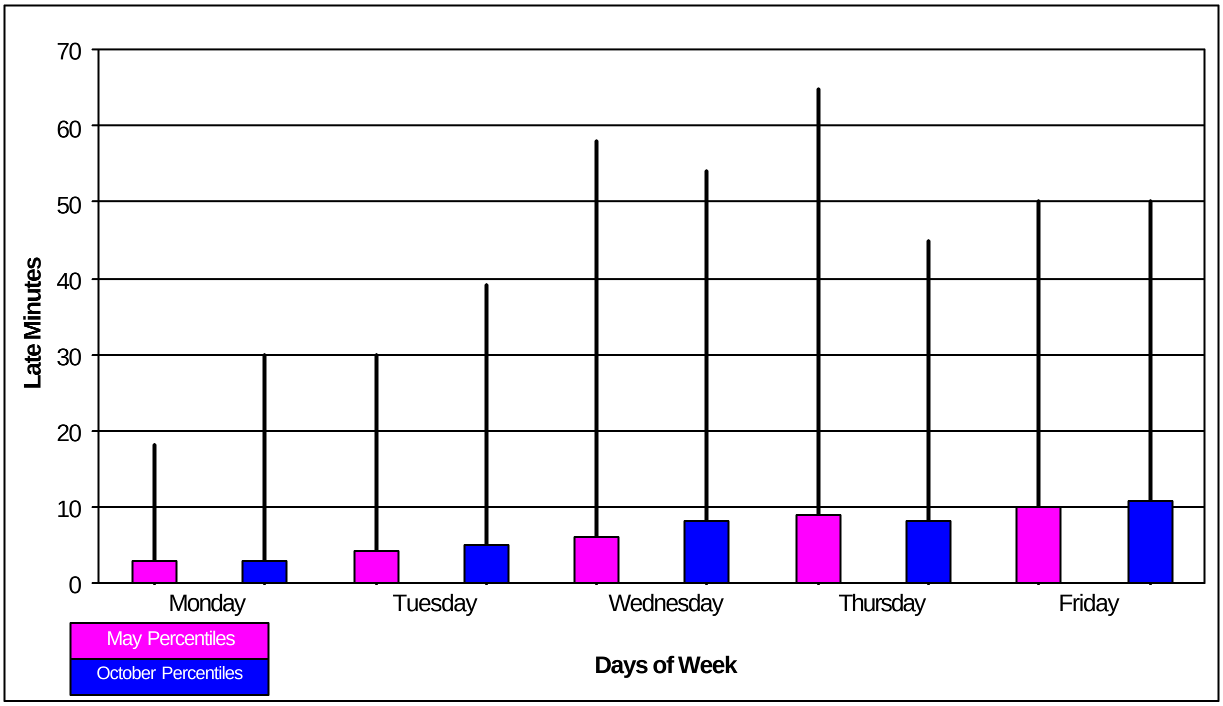


Figure 8-21 displays the 25th to 35th percentiles of late minutes of buses in line 192 by day of the week. The distribution of lateness over days of week seems fairly homogeneous. This shows us that the lateness is more sensitive to the departure time than scheduled departure day, although performance generally worsens as the week progresses.

Figure 8-21 Line 192 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.10 Performance Summary for Bus Line 194

Figure 8-22 displays the 25th to 75th percentiles of late minutes of buses operating for the line 194 by their scheduled departure times. In general delays in Line 194 are less than 5 minutes, but exceptions can be seen. There are three maximum lateness over 40 minutes, which occur at 5:15PM, 5:30PM, and 6:15PM. of the worse performance happens with departures scheduled for 6:30PM, in which 25% of runs are at least 15 minutes late. This is relatively high percentile comparing to other departure times.

Figure 8-22 Line 194 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

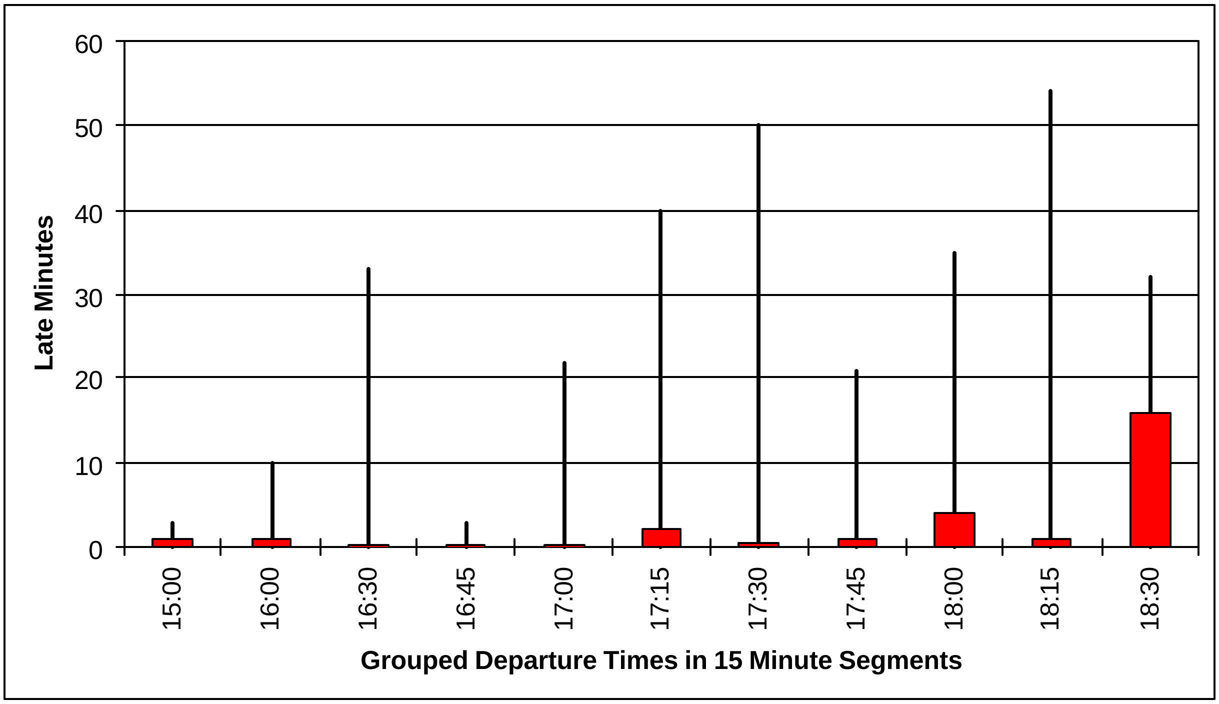
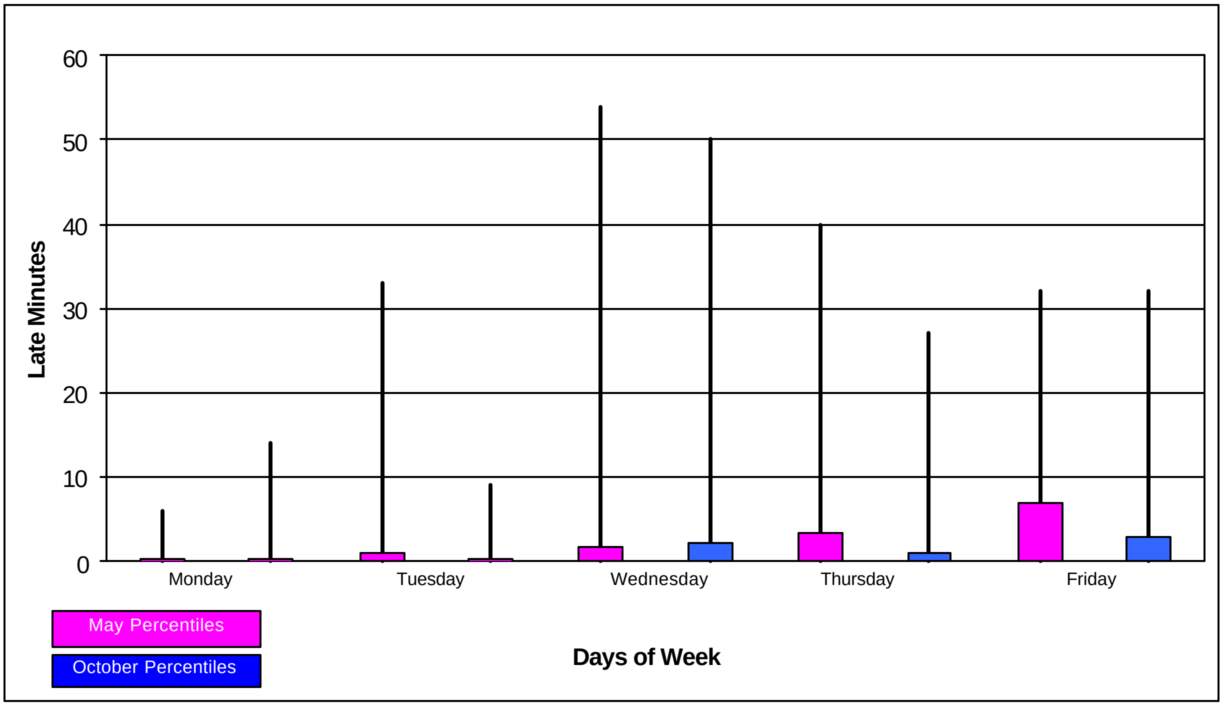


Figure 8-23 displays the 25th to 75th percentiles of late minutes of buses operating for the line 194 by day of the week. The distribution of 75th percentiles over days of week is quite low, which indicates a homogeneous performance that is not especially sensitive to scheduled departure days.

Figure 8-23 Line 194 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.5.11 Performance Summary for Bus Line 195

Figure 8-24 displays the 25th to 75th percentiles of late minutes of buses operating for line 195 by their scheduled departure times. The last three box plots, showing the late minute distributions of departures scheduled for 6:00PM, 6:15PM, and 6:30PM indicate some serious performance problems. The first point of interest is located at 6:00PM, where the maximum late minute is around 45 minutes and 75th percentile is above 25 minutes. The second point of interest is at 6:15PM, which shows that 75% of buses are late for more than 7 minutes. Finally the last point of interest if the 75th percentile of late minutes for the departures scheduled at 6:30PM, which show that 25% of buses are late for more than 15 minutes.

Figure 8-24 Line 195 Minutes Late By Time of Departure, May and October 2000 (25th to 75th Percentile Highlighted)

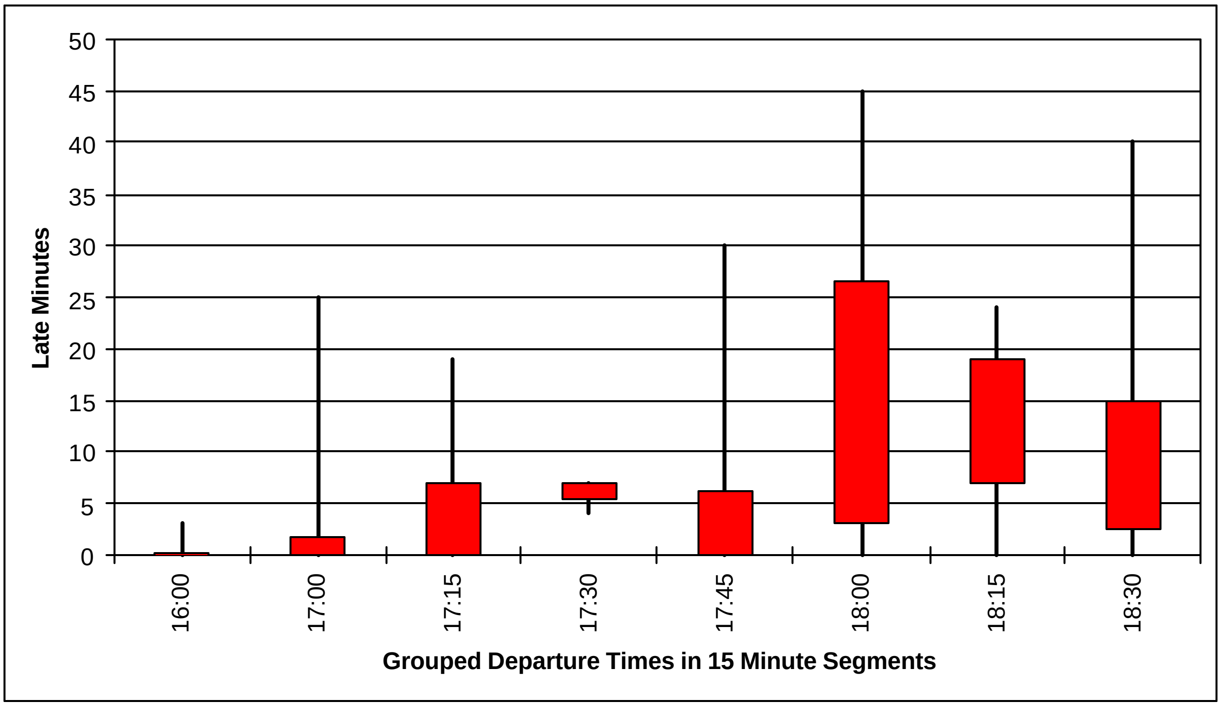
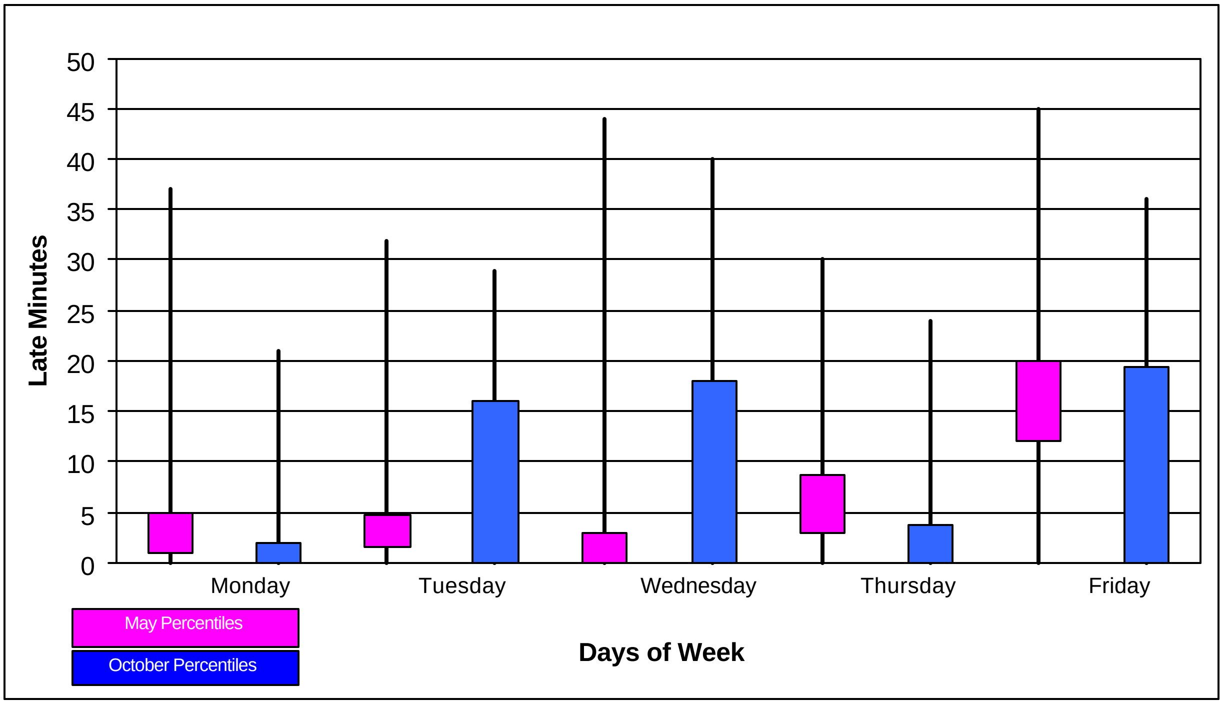


Figure 8-25 displays the 25th to 75th percentiles of late minutes of buses operating for line 195 by day of the week. Although maximum late minutes are observed throughout the week, the 75th percentiles of late minutes on Tuesday, Wednesday, and Friday during October are considerably higher than that of May. Another point of interest is the performance of buses scheduled for Fridays of May. The 25th percentile occurs at 12 minutes. In other words, 75% of buses scheduled to depart on Fridays during May are late for more than 12 minutes.

Figure 8-25 Line 195 Minutes Late by Day of Week and Month, May and October 2000 (25th to 75th Percentile Highlighted)



8.6 Survey of Starters and Chutemen

Fourteen starters and three chutemen completed the one-page questionnaires distributed in early August of 2001. This section summarizes the results of the survey. Each question provided a space for the starter to provide an explanation for each "yes" or "no" response. This qualitative information, when provided, was helpful to the evaluation team in the interpretation of results.

Table 9-1 presents the results of the survey. The general impression is that both starters and chutemen would like to have more information on the whereabouts of buses than is currently available to help them perform their jobs. Starters and chutemen need to communicate information about buses frequently during rush hours and it would appear that improvements in information would benefit them in doing their job. Responses to each question are discussed below.

Table 9-1. Summary of Chuteman and Starter Responses to Survey

	Interview Question	**Chuteman N=3**	**Starter N=14**
1	Do you have enough information on the location of buses *inside* the PABT to do your job effectively?	Y=1 N=2	Y=6 N=8
2	Do you have enough information on the location of buses *outside* the PABT to do your job effectively?	Y=1 N=2	Y=2 N=12
3	Would knowing the exact location of buses *before* they enter the terminal change the way that you do your job?	Y=3	NA
4	Do you use data on historical patterns of late arrivals to assist you in doing your job?	Y=1 N=2	Y=7 N=7
5	If no, would having this information be useful to you?	Y=2 NA=1	Y=6 N=1 NA=7
6	Is communication with chuteman/starter an important part of your job?	Y=3	Y=12 N=2
7	Please indicate the number of times during the peak period that you communicate on average.*	5-6 times = 1 >6 times = 2	0 times = 1 1-2 times = 1 5-6 times = 3 >6 times = 9
8	Would having a better idea of the actual (instead of scheduled) arrival times help you to assist bus riders?	NA	Y=13 N=1
9	How many minutes past a bus' scheduled and/or arrival time do you wait, on average, before deciding to switch the bus?**	2-5 times = 2 0-1 times = 1	NA
10	Does the time it takes to record start time and ridership take away from your other responsibilities?	NA	Y=6 N=8
11	Is the daily information for the lines that you handle always accurate and delivered at the beginning of your shift?	Y=3	NA
12	Is managing the paperwork necessary for every shift a difficult part of your job?	NA	N=14

*Selections were: 0 times, 1 – 2 times, 3 – 4 times, 5 – 6 times, or over 6 times.
**Selections included: 0 – 1 minute, 2 – 5 minutes, 6 – 10 minutes, 11 – 15 minutes, or over 15 minutes.

Question 1: Do you have enough information on the location of buses inside the PABT to do your job effectively?
The anticipated response to this question was “no”. It was actually startling to see that this question yielded a 43% “yes” response from the starters and one of the three chutemen. According to the written explanation provided for this question, most starters indicate that they do not have adequate information, which contradicts their “yes” response. The chuteman who answered yes stated that dispatch sheets and schedules provide adequate information for this purpose.

Question 2: Do you have enough information on the location of buses outside the PABT to do your job effectively?
The anticipated response to this question was “no”, and the 86.7% of the starters and 66.7% of the chutemen answered consistent with the expectation. Those starters and chutemen that indicate that they do have this information also state that it is necessary for them to call the control center to get it or that schedules provide adequate information for this purpose.

Question 3: Would knowing the exact location of buses before they enter the terminal change the way that you do your job?
This question was asked only of chutemen and they all answered affirmatively as expected.

Question 4: Do you use data on historical patterns of late arrivals to assist you in doing your job? The anticipated response to this question was “yes”. It was assumed that historical data would have great importance to starters. However, it appears that each starter approaches his job differently. The results indicate that 50% of starters rely on this information. Others, who indicated “no”, state that they cannot rely on historical data because conditions in the garage are too dynamic. Two of the three chutemen said they do not use historical data, and no explanations were offered about the reason for their responses.

Question 5: If no [to question 4], would having this information [i.e., historical data] be useful to you?
The anticipated response to this question was “yes”. All but one of the seven starters who responded to this question said that they would benefit from having this information. The two chutemen who don’t currently use such data said that they would find historical data useful for their jobs, too.

Question 6: Is communication with chuteman/starter an important part of your job?
The anticipated response to this question was “yes”. Most starters and all chutemen responded that affirmatively.

Question 7: Please indicate the number of times during the peak period that you communicate on average.
Five to six times during the peak hour were the normal responses from both starters and chutemen. Two starters provided anomalous responses of zero and one communication per hour, but no explanation was provided for those numbers.

Question 8. Would having a better idea of the actual (instead of scheduled) arrival times help you to assist bus riders?
This question was asked only of the starters, and the anticipated response was “yes”. Most starters responded that they could benefit from having this information.

Question 9. How many minutes past a bus’ scheduled and/or arrival time do you wait, on average, before deciding to switch the bus?
Only chutemen were asked this question. Two of the three chutemen wait 2-5 minutes, whereas one chuteman said he waited only a minute before switching a bus.

Question 10. Does the time it takes to record start time and ridership take away from your other responsibilities?
Only starters responded to this question, and the anticipated response to this question was “yes”. Surprisingly, only 43% responded “yes”. Written responses indicate that lost personal items such as baggage or wallets are recurring problems, and that patrons frequently ask questions about bus departures. However, they did not feel that required paperwork distracted them from their other responsibilities.

Question 11: Is the daily information for the lines that you handle always accurate and delivered at the beginning of your shift?
Only chutemen were asked this question and all answered affirmatively.

Question 12. Is managing the paperwork necessary for every shift a difficult part of your job?
Starters only responded to this question, and the anticipated response was “yes”. Quite surprisingly, every starter felt that paperwork was not intensive. However, some written responses indicated that during days with big delays, filling out paperwork can present more of a challenge.

8.7 Interview with NJ Transit Bus Scheduler

In addition to the surveys with chutemen and starters, a personal interview was conducted with a scheduler at NJ Transit through e-mail. The following section presents the questions and responses from this interview. In general, it can be concluded from the interview that the automated storage of the bus log data made possible by the TRANSMIT system should greatly facilitate the retrieval and use of the information by the Planning staff at NJ Transit.

1. *Please identify what written records (e.g., starter/chuteman logs, etc.) of daily bus activities in the PABT are stored.*
   Response: We store all starter sheets.

2. *Please describe the process by which the PABT records are stored.*
   Response: Copies of starter sheets are mailed to us, and the sheets are sorted by the geographic area they serve. This is how our Planning staff is organized, so they are given to the planners for the route in question.

   How are they placed in storage / Where are they stored?

Response: Each Planning group stores starter sheets in their own file cabinets, according to route and date.
How often does storage take place?
Response: Storage is usually done ad hoc – whenever the planners have time to put things away.

When records are stored, are they saved, archived, or transferred into any format other than original written records (e.g., scanned or microfiched)?
Response: No. They are maintained in original format.

3. *Once a written record is stored, what further purpose does it serve and how often is it accessed? For example, are the records used to produce reports or other types of analysis? Does NJ Transit use written records as historical data for planning or other purposes? If so, can you elaborate on this process?*
Response: These records are used routinely to investigate complaints, to develop service changes, etc. Normally, the most recent reports are used for this purpose. Occasionally, there is a need to do more historic analysis.

4. *For the purposes of analysis, are records placed in tables, spreadsheets, combined with other historical data or used in other programs or in other formats? If so, can you elaborate on this process?*
Response: The information on the starter sheets is normally (manually) transcribed into a spreadsheet application for the purpose of averaging loads, determining trends, etc. They may or may not be combined with information gathered from our firebox system.

5. *Depending on the nature of how records are stored and/or combined with other data, how long do you normally store these written records?*
Response: We keep starter sheets for 24 months, unless there is a specific reason to keep them longer. They remain in file cabinets until they are purged.

6. *If records are kept for long periods, are they stored off-site (e.g., in a storage facility)?*
Response: We have enough trouble keeping track of the two years we keep here. We have never stored off-site (I am sure that if we did, we would never be tempted to use the data).

7. *Have you or anyone else ever experienced problems in accessing and using stored data?*
Response: Yes. (See details below.)

Has it taken a long time to get data out of storage?
Response: Yes. Since everyone stores their own starter sheets, they generally lay hands on them when they need them. However, if someone else (me, for example) needs something when that person is out, it can take quite a while to find things.

Have you ever found some of the data missing?
Response: Yes. Sheets sometimes get lost or misplaced.

Have you had difficulty using the data in the format in which it was stored, etc.?

Response: Yes. On individual sheets, there can be times when a starter is pulled away to attend to more difficult tasks, and so passenger-loading information is not collected. Also – and this is common – when starters switch operators assignments to cover the work (due to the vagaries of traffic, etc.) we spend a lot of time trying to reconstruct what actually happened. For example, while the starter sheet will look like the schedule was maintained – and to the customer it was – from a scheduling perspective, drivers were not doing their scheduled work. So it makes it difficult to decipher to find out if the problem is one of scheduling or something else. It is extremely tedious to figure all this out and then enter everything manually. But at the moment, it's the only thing we have that reflects the real operation.

9 Resources for Completion of Phase III Evaluation

The implementation of the test plans described in previous sections of this report will require the following resources to complete:

- Access to NJ Transit staff at the Port Authority Bus Terminal in New York City for conducting interviews and surveys with key informants.

- Access to data from the TRANSMIT server to obtain data sent and received by the chutemen and starters as they use the HHDs. It is anticipated that the data will be available in the form of reports from the server, which will be made available to the evaluation team.

- Funding from USDOT ITS Joint Program Office sufficient for the evaluation team to complete the tasks of the Phase III evaluation.

Table 10-1 below presents an estimate of the level of effort required to complete the Phase III evaluation by the evaluation team. Hours are shown by task and by team members Battelle, Castle Rock Consultants, and URS/BRW.

Table 10-1. Level of Effort for Phase III Evaluation of Transit Application of TRANSMIT

Task	Battelle	Castle Rock	URS/BRW	Total Hours
Update Evaluation Plan	**10**	**30**	**26**	**66**
Review plan for post deployment changes	2	14	13	29
Revise plan and publish	8	16	13	37
Revise Test Plans	**16**	**54**	**72**	**142**
Post implementation visit	8	12	16	36
Complete design of questionnaires	8	14	36	58
Identify key informants and schedule interviews		8	16	24
Design data acquisition from TRANSMIT server		20	4	24
Collect Post Deployment Data	**8**	**46**	**44**	**98**
Conduct Interviews with key informants	8	16	36	60
Collect data from TRANSMIT server				
October 2002 data		10	4	14
May 2002 data		20	4	24
Analyze Data and Write Report	**266**	**110**	**108**	**484**
Analyze interview results	8	16	40	64
Analyze TRANSMIT server data				
May 2002 data	76	16	8	100
October 2002 data	65	16	8	79
Draft Phase III report and send to DOT and stakeholders	83	38	36	157
Prepare final Phase III report	34	24	16	74
Archive Data		**20**		**20**
Project Management	**45**			45
Total Hours	**345**	**260**	**250**	**855**

As discussed in Section 3.4, the schedule for completion of all tasks would occur by January 31 of 2003. That end date is necessitated by collection of post-deployment terminal operations logs in October of 2002 for comparison to the baseline operations logs for October of 2000.

10 Post Deployment Evaluation

The report on the evaluation of the NJ Transit application of TRANSMIT will focus on the results of the analysis of the before- and after-comparison of transit operations using the TRANSMIT operations logs, interviews and surveys, and hand held devices. It will also draw upon information captured in earlier documents related to the evaluation to provide the context for the results. The suggested format of the report and its contents are sketched in the outline shown in Table 10-1 below.

Table 11-1. Evaluation Report Proposed Format and Contents

Section	Description
Executive Summary	Highlights of the report focusing on the results and lessons learned
Introduction	Background on: National Evaluation Program: its objective, roles, and responsibilities, and the availability of results of other evaluations ITS Integration Program: FY99 Congressional Earmarks and their requirement for evaluation History of TRANSMIT from field operational test to deployment, previous evaluation, focus of the current deployment phase
System Description	Use of toll-tag technology in TRANSMIT and the system architecture Description of the NJ Transit application
Evaluation Goals and Measures	Focus on mobility and efficiency as goals for evaluation and hypotheses for assessing those goals. Presentation of the measures that are used in the assessment.
Technical Approach	Discussion of each type of test used in the evaluation. These include: Log data recorded manually by NJ Transit operations staff and used for “before” data System data from the TRANSMIT server used for “after” data Interviews and surveys with key informants at NJ Transit
Results	Measurement of the benefits and impacts of the TRANSMIT data and HHDs on operations at the PABT: Schedule adherence analyzed by bus line, time of day, time of week Chutemen’s and starter’s experience with hand held device Scheduler experience with TRANSMIT server data Impact on job performance and overall efficiency of operations
Conclusions	Discussion of the lessons learned from the evaluation Recommendations that can be drawn for various aspects of the study, including TRANSMIT, transit applications of ITS, and evaluations.

11 Risk Assessment

11.1 Overview

The risks associated with completing a successful evaluation are discussed in the following paragraphs. Some risks can be associated with being able to definitively determine whether the project implementation achieved or did not achieve the hypothesis put forward in the evaluation plan. Being able to state that the system had no impact to on-time departures is as valuable as determining that departure times are improved. This is not considered to be a risk for the evaluation. The following three areas, however, have been identified as risks for this evaluation but are not considered to be significant:

Route rescheduling changes characteristics of "after" data
Analysis of the "before" data reveals consistent patterns of lateness by line and time of day between the two month's worth of data. One identified risk is that these data could be utilized by stakeholders to alter bus schedules, thus skewing the comparison of "before" and "after" HHD implementation with performance improvements attributed to schedule changes. This risk will be mitigated by determining what changes may have been made to schedules between "before" and "after" data collection. Also, since the "before" data was derived from existing NJ Transit records, data will be available to identify changes due to rescheduling and could be collected and analyzed if this skewing was subsequently thought to be a problem.

Inability to collect "after" data for same months
The deployment has been delayed several times. The risk to the evaluation is that continued delays could jeopardize the collection of post-deployment data in May 2002. The risk can be mitigated by selecting another month for data collection, but additional funding would be required to collect new baseline data for a comparable month.

Statistically insignificant changes in "after" data
There is potential that the "after" data may not provide statistically significant changes to the overall data. However, since there is strong correlation between the data collected for the two months, it is believed that any improvement trends will be detected in the analysis.

Problems with TRANSMIT data acquisition
The NJ Transit application uses new software being developed by a contractor (PBFI) for TRANSCOM. The evaluation team depends upon reports being produced from the software in a form usable for the evaluation. The risk is that the data are not appropriate for the before/after comparison. The evaluation team will continue to work closely with the project team to minimize the likelihood of this risk being realized.

Appendix A. Sample Operator Logs

Figure A-1. Sample Chute Sheet

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EFFECTIVE September 5, 2000

PLATFORM - 224

PO	RUN#	SCHD.	DESTINATION	DOOR	
	52	425	SE	1	basement
	9	425	X UR	3	
taxi	95	435	SE	1	basement
taxi	220-162	435	AR	3	
38st	224-144	445	FAIRLAWN	2	
	10	445	X UR	3	
	57	450	SE	1	basement
we	37	500	RT	1	IN
taxi	223-162	500	AR	3	
we	35	508	GSP	1	IN
38st	207-144	508	FAIRLAWN	2	IN
	32	508	X PAR	3	IN
	36	510	PKY UR	6	IN
	14	516	SE	1	basement
taxi	226-162	516	AR	3	
we	100	524	SE	1	
	38	524	X PAR	3	IN
	16	530	RT	1	
38st	213-144	530	FAIRLAWN	2	IN
38st	210-162	530	AR	3	IN
we	102	530	PKY UR	6	
we	84	536	SE	1	IN
we	41	536	X PAR	3	IN
taxi	240	542	SE	1	
38st	231-144	542	FAIRLAWN	2	IN
	17-162	542	AR	3	
38st	239	548	SE	1	
we	85	548	X PAR	3	IN
taxi	89	550	PKY UR	6	IN
38st	232	554	SE	1	IN
38st	230-162	554	AR	3	IN
we	94	600	RT	1	IN
	49	600	X PAR	3	IN
taxi	88	606	SE	1	IN
mk	235-144	606	FAIRLAWN	2	IN
mk	233-162	606	AR	3	IN
we	93	610	PKY UR	6	IN
	12	612	GSP	1	
we	90	612	X PAR	3	IN
mk	237-144	618	FAIRLAWN	2	IN
mk	234-162	618	AR	3	IN
we	91	620	SE	1	IN
	53	624	X PAR	3	IN
mk	238-164	628	AR	1	IN
mk	236-162	630	AR	3	IN
or	21	630	PKY UR	6	
	220-164	636	AR	1	IN
	97	636	X RT	3	IN

PLATFORM - 223

PO	RUN#	SCHD.	DESTINATION		DOOR
ubl	18-190	436	X PAT		1
	49	436	P PASS		2
	26	450	X PAT	IN	1
taxi	21	450	RUTH		2
	19	500	X PAT		1
	32	500	P PAT	IN	2
	30	510	X PAT	IN	1
ubl	46	510	X RUTH		2
ubl	20	510	SEC		3
ubl	31	518	X PAT	IN	1
ubl	29	518	X RUTH	IN	2
	34	526	X PAT	IN	1
	55	526	X RUTH		2
me	213	528	SEC		3
	11	534	X PAT		1
we	37	534	P PAT	IN	2
	12	540	X PAT		1
me	215	540	X RUTH	IN	2
me	212	540	SEC		3
taxi	63	548	X PAT	IN	1
me	201	548	X RUTH	IN	2
me	214	550	SEC		3
ubl	25	556	X PAT	IN	1
me	209	556	X RUTH	IN	2
	13	604	X PAT		1
	43	604	P PAT	IN	2
ubl	64	604	SEC		3
	42	612	X PAT	IN	1
me	210	612	X RUTH	IN	2
	15	614	SEC		3
	14	620	X PAT		1
me	211	620	X RUTH	IN	2
	21	628	X PAT		1
	22	628	X RUTH		2
me	216	628	SEC		3
	46	636	X PAT	IN	1
	50	636	P PAT	IN	2
	17	644	X PAT		1
	213	644	X RUTH	IN	2
me	212	644	SEC		3
	49	652	X PAT	IN	1
	214	652	RUTH	IN	2

Figure A-2. Sample Starter Sheet

NJ TRANSIT BUS OPERATIONS
BUS DISPATCH SHEET

6 / 26 / 00

LINE # 111 / 112 / 113 / 114 / 117 | LINE NAME - CLARK / DUNELLEN BRIDGEWATER / RAHWAY

GATE# 222

STATION STARTER -

DATE -

WEATHER -

BUS NO.	RUN NO.	SCHD. TIME	ACT. TIME	VIA	NO. OF PASS	DESTINATION	BUS NO.	RUN NO.	SCHD. TIME	ACT. TIME	VIA	NO OF PASS	DESTINATION
	8	3:30		113-S		DUN		14	5:45		113		X CR/P
	10	3:30		112		UCTS							
								5	5:50		114		X U/D
	11	4:00		113-N		CR		45	5:50		114		MS
	13	4:15		114		X U/BM							
	6	4:15		114		MS		49	5:55		117		SOM
	19	4:15		113		X CR/D		55	5:55		113		X CR/D
	5	4:30		111		JG / IKEA		51	6:05		114		X U/BM
								46	6:05		114		MS
	29	4:45		114		X U/BM		54	6:05		113		X CR/P
	52	4:45		114		MS							
	13	4:45		113		X CR/D		56	6:15		113		X CR/D
	27	4:50		117		SOM		10	6:15		113-N		CR
	28	5:05		114		X U/D		14	6:20		114		X U/BM
	50	5:05		114		MS		47	6:20		114		MS
	34	5:10		113		X CR/D		11	6:30		113		X CR/D
	57	5:10		113-N		CR							
								7	6:40		114		X U/D
	48	5:20		114		X U/BM		6	6:40		114		MS
	24	5:20		114		MS							
								42	6:55		113		X CR/D
	31	5:25		117		SOM							
	30	5:25		113		X CR/P		19	7:00		112		T-AVE
	12	5:35		114		X U/BM							
	26	5:35		114		MS							
	37	5:35		113		X CR/D							
	27	5:35		113-N		CR							

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