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Using Data from an Electronic Fare Collection System to Identify the Travel Behavior of Seniors and People with Disabilities

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Using Data from an Electronic Fare Collection System to Identify the Travel Behavior of Seniors and People with Disabilities

August 2010

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Foreword

The Federal Transit Administration (FTA) sponsored this research to assist transit agencies in to the use of data from electronic fare collection systems efficiently, so that the information generated can be used to improve services for seniors and persons with disabilities. Expected use of this information may include prioritizing transit amenities, assessing existing and needed infrastructure, providing services at particular time of day and at particular locations using the type of vehicles needed to provide transit services, explaining compliance with the federal regulations of the Americans with Disabilities Act (ADA), thus, helping to improve the overall mobility of seniors and people with disabilities.

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Preface

The information developed and presented in this document was prepared for the Federal Transit Administration (FTA) by researchers at the Lehman Center for Transportation Research at Florida International University. The project team included Dr. Fabian Cevallos, Xiaobo Wang, and Jon Skinner. The project was contracted through March 31, 2010.

Acknowledgment

The project was managed through the FTA Office of Mobility Innovation. The FTA project manager was Charlene Wilder, Transportation Program Specialist, who provided overall guidance in this research. Her contributions were important to the direction and pertinence of the results. The project team would like to thank Roberto Galves, Jr., Associate Planner at Broward County Transit (BCT) for providing the data and testing the queries in this study. Finally, the project team would also like to thank Dr. Jill Strube for her assistance with editing this report.

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

SUMMARY

The main objective of this research is to present the different uses of data collected from the electronic fare collection system to help transit agencies improve the delivery of services. Using these data, information can be generated to improve services for seniors and people with disabilities. The research uses computerized mechanisms to take full advantage of the data to determine the travel characteristics and behavior of this important segment of the population. The expected use of this information may include prioritizing transit amenities, assessing existing and needed infrastructure, providing services at particular times of day and at particular locations using the appropriate type of vehicles to provide transit services, explaining compliance with the federal regulations of the Americans with Disabilities Act (ADA), and improving the overall mobility for seniors and people with disabilities.

Study Objectives

The FIU Research Team conducted a literature review on the potential uses of farebox data as well as on issues that deal with the mobility of seniors and people with disabilities. The Team then concentrated on developing methodologies to help identify the travel behavior and patterns of seniors and persons with disabilities. The methodologies developed in this project were tested, lessons learned were documented, and the results are presented.

Use of Data from Electronic Fare Collection Systems

Electronic Fare Payment (EFP) systems, also known as Automatic Fare Collection (AFC) systems, use electronic communication, data processing, and data storage techniques to automate the manual fare collection process.

Fare Payment Systems combine fare media, such as magnetic stripe cards, smart cards, and cash with electronic communications systems, data processing computers, and data storage systems. EFP systems store large amounts of data in computerized files that include all the transactions that take place during the fare collection process.

To demonstrate the different uses of the EFP data, a vast dataset from Broward County Transit was used in this research. BCT has been actively using the GFI farebox system since the early 1990s and the system has reached maturity. Data from this system is currently used to support many planning and operational activities at the agency. The collected dataset was stored in a Sybase database and the SQL Server 2008 Integration Services (SSIS) utility was used to transfer the data to a SQL Server database. Database files are independent of the operating system, allowing them to be copied between supported platforms. The SSIS utility is very helpful when manipulating large amounts of data from or into an external file. Integration Services provide different destinations for loading data into different types of data stores.

Flow of Data

In order to fully understand the processes associated with obtaining and utilizing data from an EFC system, it is essential that transit agency staff understand how data flow throughout the system. EFC data is generated at the farebox onboard the agency vehicles. The data are loaded and stored into a database, which can be queried to retrieve information. A query is essentially a precise request for information retrieval within a database or information system. For example, a user may want to find the total number of passengers that rode the transit system on a given day. Upon properly requesting the data, the query will return the requested results.

Retrieving data from a Farebox System

Retrieving data from a farebox system is an extremely important part of the data flow. Not all farebox systems work identically, but for the most part the usage, storage, and retrieval of information are similar. After the data has been loaded into a database or a data warehouse, data can be queried. Structured Query Language (SQL) is likely to be the most common language utilized for querying databases. Although other programs are available, SQL is among the most widely used and probably the easiest for skilled personnel.

Examples Pertaining to Seniors and People with Disabilities

Traditionally, farebox records have been used to calculate transit agency performance measures. Obtaining measures such as rideship, revenue, fare recovery ratio, passengers per hour, and passengers per revenue mile are all common practices. However, few individuals realize that the same farebox data can be analyzed to learn detailed information about particular populations. Although it is not a common practice yet, transit agencies can discover a wealth of information about their elderly and disabled riders.

Using farebox data to study these populations can be accomplished the same way that regular EFC analyses are performed. However, to isolate the data records associated with special populations, transit professionals must perform additional procedures. In most cases, specific queries must be made to only select certain records. Three examples are shown in Section 3 and more are illustrated in Section 5 and Appendix A.

Electronic Fare Collection Case Study

In this project, sample data from Broward County Transit (BCT) was used to demonstrate the application of EFC data. BCT has a mature and fully functional Electronic Fare Collection (EFC) system for 100% of the fleet. The ridership and revenue information from the system has been used for planning and operations purposes. The finance and accounting departments also use this information for regular periodic fiscal reporting.

In addition to collecting cash fares, BCT transit riders are able to use bus passes. BCT's bus pass is a credit-card size fare card with magnetic swipe. The Bus Pass offers flexible pricing and is fully automated for use on all BCT buses. As a rider boards, he or she simply slides the card through the magnetic swipe card reader. The farebox beeps when the Bus Pass is accepted. BCT passes allow riders to board more quickly and easily.

For each person who rides BCT and pays for the trip with some form of fare card – a monthly pass, a 10 ride pass, a 7 day pass, or a daily pass - the Transaction Table in the EFC system stores data: date, time, route number, run number, and direction.

The Broward County Transit "Ride-and-Save" program is a pre-tax commuter benefit program that provides an additional way for employees and employers to save money. Employees can save money on their commuting costs by purchasing BCT bus passes with pre-tax dollars, while employers can save money on their payroll taxes.

As individuals board the transit vehicles, the farebox records the type of payment along with other variables: bus route number, date and time, revenue, dump count and bill count, etc. This information is stored in the database.

Potential Uses of EFC Data

EFC data can be used to answer the following questions:

What Bus Routes Have the Most Elderly and Disabled Riders? Determining which routes have the most elderly and disabled riders provide key information that can help agencies determine where and how to prioritize route services and stop infrastructure.

At what times do most elderly and disabled riders prefer to travel? The output data could then be used to create charts of graphs detailing the amount of elderly passengers by time, as well as the percentage of elderly passengers by time spans during the day. Having this information can be used to assess the service provided to this segment of the population.

Identifying Travel Trends of Elderly and Disabled Riders. This information can be used to then study travel trends of special populations. With these data, transit planners can have the additional information necessary to effectively plan for services to the elderly and disabled population.

Examining Origin / Destination Data. The monthly pass card data can be further used to determine travel trends for particular riders. Since the monthly pass card is typically used by one person for an entire 31-day period, the Transaction Table can easily be searched to find all trips recorded for each individual pass card. In addition to route number, the transaction table contains data about bus number, run number, trip number, and the direction the bus is headed. This data can be used to then study travel trends.

Combining EFC Data with other Datasets. EFP systems now generate large amounts of data on a daily basis. This is important, as the collection, processing, and safekeeping of passenger fare revenues and ridership data are an integral part of the operations of a public transit agency. With pertinent data from EFP systems now readily available, transit planners have more information to help them decide how and where to allocate resources. However, without proper database storage, tools, and processes to take advantage of the data, planners and transit staff cannot begin to analyze transit usage or trends, or identify travel characteristics.

Combining EFC data with other transit ITS systems like Automatic Vehicle Location (AVL), Automatic Passenger Counter (APC), Geographic Information System (GIS), or Stop Inventories can provide the needed information for better decision making. The information can assist planners where to improve the physical characteristics of the stop, or where to assign senior-friendly low-floor vehicles. Most agencies now use APC data to invest resources at stops that have high levels of passenger activity. Stops can be further scrutinized by incorporating the activity of the elderly and persons with disabilities as well.

1.0 INTRODUCTION

Most transit agencies in the U.S. collect data from electronic farebox systems. The data usually contain critical information about seniors and people with disabilities. Yet, there is a lack of tools or mechanisms that allow the extraction of this type of information efficiently. Therefore, research is needed to identify computerized mechanisms to take full advantage of the data to determine the travel characteristics and behaviors of this very important segment of the population. It is expected that transit planners will use the results from this research to help provide a transit service that is fair and equitable and takes into consideration all population groups.

The elderly and disabled communities have particular characteristics that must be understood to be able to provide transit service that is sensitive to their needs. The ability to access and use public transportation may be limited by a series of physical, cognitive, visual, mental, or other disabilities. In addition, direct access to public transportation is often restricted due to the lack of adequate infrastructure, leading to inadequate transit service and posing a serious challenge to the mobility of seniors and people with disabilities. Therefore, transit providers need to be aware of these limitations when planning and providing transit service, to help this group of the population maintain active and productive lives.

This research concentrates on using existing data at the transit agencies to assess the travel behavior and patterns of seniors and people with disabilities. Understanding their travel patterns and preferences will provide transit planners with the necessary information to plan ahead. Expected use of this information may include prioritizing transit amenities, assessing existing and needed infrastructure, providing services at particular time of day and at particular locations using the type of vehicles needed to provide transit services, explaining compliance with the federal regulations of the Americans with Disabilities Act (ADA), thus, helping to improve the overall mobility of seniors and people with disabilities.

Electronic Fare Collection Systems

Electronic Fare Payment (EFP) systems, also known as Automatic Fare Collection (AFC) systems, use electronic communication, data processing, and data storage techniques to automate the manual fare collection process. The use of this technology offers multiple benefits. The most significant advantage is that EFC systems make fare payment more convenient for travelers and revenue collection less costly for transit providers. EFP systems help reduce the cost of labor-intensive cash handling and the risk of theft, improve reliability and maintainability of fareboxes, and permit sophisticated fare pricing based on distance traveled and time of day. EFP systems can also help with the automation of financial and accounting processes (*1*).

Technology improvement in automated fare collection and passenger recording is outstanding. EFP systems now generate large amounts of data on a daily basis. This is important, as the collection, processing, and safekeeping of passenger fare revenues and ridership data are vital to a public transit agency. However, without proper database storage, tools, and processes to take advantage of the data, planners and transit staff cannot begin to analyze transit usage and trends, or identify travel characteristics.

Using Data for EFP

Since the EFP dataset used in this research was very large and stored in a Sybase database, the SQL Server 2008 Integration Services (SSIS) utility was used. This utility is very helpful when manipulating large amounts of data from or into an external file. Integration Services provide different destinations for loading data into different types of data stores. Further, using an Integration Services destination, it is possible to load data into flat files, process analytic objects, and provide processed data for other tasks. The loaded data can be found by accessing tables and views in databases and by running queries.

However, some tasks were performed before importing the data to the SQL Server 2008, because the data used for the case study came from a Sybase database. Sybase was installed, and the database was connected by entering the username and password. Later, the open Interactive SQL window was used to output data by means of Structured Query Language (SQL) statements. Sample SQL statements are presented in Section 3, Section 5, and Appendix A.

2.0 LITERATURE REVIEW

Data Sources

Fare Payment Systems combine fare media, such as magnetic stripe cards, smart cards, and cash with electronic communications systems, data processing computers, and data storage systems. EFC systems store large amounts of data in computerized files that include all the transactions that take place during the fare collection process. When a passenger pays the fare, the farebox would record the fare transaction and store the data on board each vehicle. The data are not usually transferred into a database immediately. Data transfers from the farebox to the database server are typically completed when the vehicles arrive at the garage. These data transfer can be accomplished by using a direct cable connection or by means of different wireless communication technologies.

Further, to maintain transit ITS systems and gain operational benefits, several important components are required of transit agencies. It is essential that costs be appropriately considered for not only these technology systems, but also for organizational support, infrastructure, and associated tools.

Benefits of EFCs to the Elderly and People with Disabilities

Most passengers are thrilled upon discovering they no longer need to pay their fares with exact change. Having to obtain and insert exact change into a farebox is an aggravating chore for all transit patrons, but especially for elderly and people with disabilities. People who suffer from arthritis, poor eyesight or hearing, and motor coordination problems are very likely to have difficulties handling, inserting, and confirming that payment has been processed.

Any drastically different technology or payment methods will likely need to be accompanied by passenger re-training, particular for the elderly and people with disabilities. The aging process is associated with a decrease in cognitive ability – especially in short-term memory. Older people are more likely to learn new things when concepts are related to previously learned concepts as anchors (2). The elderly are much more likely to learn something by doing as opposed to learning by memory. Therefore, travel training workshops are especially important to these groups.

Travel training in pairs or groups requires individuals to go through the actual steps for traveling on public transportation. For elderly drivers who may have never used public transportation, travel training is especially useful and easier than learning by themselves. Comprehending the steps needed to obtain an elderly rider pass, remembering farebox and boarding information, and recharging EFP cards are sure to be daunting for an elderly transit user. By incorporating the actual travel procedures in the lessons, the elderly are more likely to remember the required steps and be more at ease when they travel by bus.

Transit agencies around the country have implemented these EFP technologies and witnessed higher ridership and increased efficiencies. While smart cards and stored fare cards are already popular in some of the nation's larger transit agencies, these media will likely be utilized at medium and smaller sized agencies in the future as the underlying technology becomes more widely available. Seasonal, monthly, weekly, and daily passes are all more easily implemented once EFP technologies have been installed. With a solid EFP system in place, it becomes easier to sell tickets and passes through the Internet. People suffering from mobility problems may order passes via the Internet and avoid having to make a special trip to a transit sales site.

In farebox systems, different fares are used by different segments of the population. For example, college students may use the student pass and seniors may use reduced fare senior passes. This research will help transit planners understand the travel patterns and preferences of various population groups to improve their ability to plan ahead. With pertinent data from EFP systems now readily available, transit planners have the information they need to help them decide how and where to allocate resources.

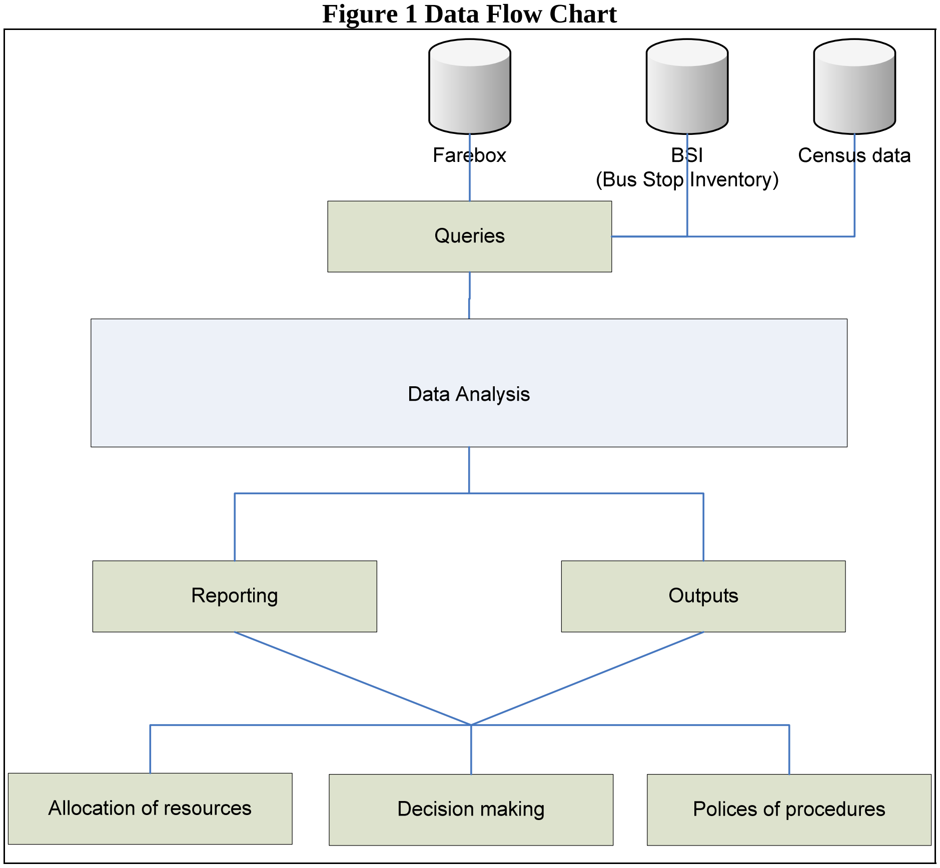
3.0 METHODOLOGY

Flow of Data

In order to fully understand the processes associated with obtaining and utilizing data from an EFC system, it is essential that transit agency staff understand how data flow throughout the system. EFC data is generated at the farebox onboard the agency vehicles. This data is loaded into a database, through a variety of methods which will be explained later, and stored for later queries. A query is essentially a precise request for information retrieval within a database or information system. For example, a user may want to find how many total passengers rode the transit system on a given day. Upon properly requesting the data, the query will return the results.

The user may then analyze the results of the query. Although transit agency planners, schedulers, or managers may analyze the data manually, there are methods for automating the data analysis process. Computer programs can be written to routinely run specific queries and produce specific reports. These reports can even be imported into a variety of programs to produce graphs or charts automatically. With this information in hand, transit agency administrators are better prepared to make important decisions. Figure 1 depicts the data flow from data to decision making.

Figure 1 Data Flow Chart



Collecting Data from a Farebox System

Collecting data from a farebox system is an extremely important part of the data flow, and there is more than one way to accomplish this task. Not all farebox systems work identically, but for the most part the usage, storage, and retrieval of information are similar. The following details how farebox information is typically generated and ultimately downloaded:

1. A senior or person with disabilities inserts their swipe card, generally a monthly or weekly pass, into the machine (**Figure 2**).

2. If the senior or person with disabilities does not have a swipe card, they place the proper amount of fare, bills and coins, noted in **Figure 3,** into the machine while the vehicle driver enters the corresponding passengers' fare type into keyboard behind the farebox, see **Figures 4 & 5**.

3. Vehicle drivers drive to the bus pool and the driver, technician, or designated employee will turn in all fares (**Figures 6 & 7).**

4. An electrical device scans the farebox machine and gets data from the vehicle. Those data are then stored on the server (**Figures 8 & 9)**.

Figure 2 BCT Farebox System

Figure 3 BCT Fare Prices

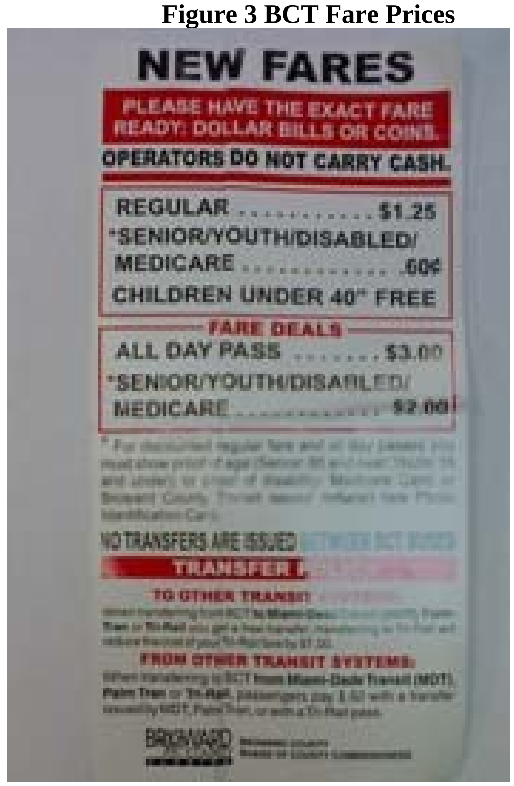


Figure 4 Driver's Side of Farebox

Figure 5 Key Guide for Farebox

Figure 6 Bus Pool Area

Figure 7 Area for Fare Return

Figure 8 Hand Held Scanning Device

Figure 9 Scanning Location on Farebox

Some transit agencies may not use a hand held scanning device, but download the data wirelessly at the end of the day as the bus passes through a specific location. Another method still in use is to download the data manually via an external device and then upload the data into the database.

Querying Farebox Data

Once the data has been downloaded into a database or a data warehouse, data may be queried. SQL is one of the most common programs utilized for querying transit data. Although other programs are available, SQL is among the most widely used and probably the easiest for skilled personnel. Generating appropriate SQL statements is not necessarily difficult, but can be challenging for anyone without training. Transit agencies will want to have staff on hand who are familiar with programming tasks to be able to query the data. Two querying examples are provided below in order to familiarize the reader with SQL.[*] Note that the terms used in the SQL code examples in this section are based on definitions provided in Appendix A.

Example 1 – Calculating a performance measure based on unclassified fares. Fareboxes on occasion jam up during the course of operations. In order to correct this problem, the bus operator presses a 'dump key' that dumps all cash and coins into the holding box. Since all the revenue is dumped instantaneously, the system does not have a chance to classify the revenue. This example shows how to find and determine the mean value and standard deviation of the percentage of total revenue is unclassified revenue. *Farebox_YearRidership_0501TO0512_VIEW* is a view created from the database table. For detailed information about this view, please refer to Appendix A.

Step 1: Prepare a formula to obtain sample data. In this case, we will use the Farebox data set as our data source; sample data are calculated using the following formula: *Unclassified factor* = *Unclassified Revenue/ Revenue*

Step 2: Prepare the SQL to compute the mean value and standard deviations.

```
SELECT Avg(uncl_r/ (curr_r)) as [mean
value] ,STDEV(uncl_r/ (curr_r)) as [standard
deviation]
FROM Farebox_YearRidership_0501TO0512_VIEW
WHERE (route < 99) and curr_r!=0 or uncl_r!=0
```

---

[*] **Special Note**
In both of the examples, the farebox data came from a GFI Genfare farebox. Since other farebox systems exist on the market, crafting the appropriate queries may involve using different SQL statements than those mentioned within this report. Other SQL statements may need to make reference to the appropriate database, event table, and field in the corresponding table.

As an example: **SELECT** Avg (dba2.ev.KeyA+dba2.ev.Key22)

Where "dba2" refers to the corresponding database, "ev" responds to the main event table, and "KeyA" or "Key22" refers to the appropriate field within the event table.

For information on Cubic Fareboxes, please refer to Appendix C.

Example 2 – Calculating a performance measure based on revenue to ridership ratio. The ratio of revenue to total ridership is an important tool for administrators and policy makers. If the ratio is known, goals can be set for the future. Tracking the ratio over time can help predict future budgeting and cash flows. *Farebox_YearRidership_0501TO0512_VIEW* is described in this example.

Step 1: Prepare the formula to obtain sample data. In this case, we will use the Farebox data set as our data source; sample data are calculated using the following formula: *Revenue Ridership Ratio = Revenue / Ridership*

Step 2: Prepare SQL to obtain sample data and compute the mean value and standard deviations.

```
SELECT      Avg((curr_r)/riders)      as      [mean
value]    ,STDEV((curr_r)/riders)    as    [standard
deviation]
FROM Farebox_YearRidership_0501TO0512_VIEW
WHERE (route != 99)
```

In the Sybase database, the field riders is defined as the sum of the following variables (Table 3):
key1+key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+ttp4+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp20+ttp21

Analysis of EFC Data

Once the SQL statements have been run, the software will return query results. The results from the above examples will return a specific value – in both cases, a simple ratio of all bus routes. However, with a slightly different SQL statement, a larger dataset can be retrieved. Had the statement in Example 2 been slightly manipulated to return ratio values for all bus routes, data would be returned to the user in a tabular format. The table below shows the results of the query for the second example for bus routes from route 1 to route 10, including the system-wide ratio at the bottom.

Route	Avg((curr_r)/riders)	STDEV((curr_r)/riders)
(Route)	(Revenue:Ridership Ratio)	Standard Deviaton
1	0.44	0.29
2	0.47	0.36
3	0.48	0.61

4	0.47	0.37
5	0.42	0.40
6	0.42	0.33
7	0.50	0.36
8	0.51	0.35
9	0.43	0.34
10	0.44	0.34
System Wide	0.44	0.34

With the above information in hand, transit agency planners have more information at their disposal to make decisions about certain factors or choose to perform further analysis. For example, agency personnel may want to further investigate why the revenue to ridership ratio is so low for route 22. Transit staffs also have the option to import the data into Excel to create charts and graphs that will aid in explaining the findings to administrators or elected officials.

To even further streamline the analysis of EFC data, programs can be written to generate reports like the one above if values are over a certain amount. For example, a list showing the revenue to ridership ratio may be generated once a week for bus routes with a ratio lower than a specific threshold. This type of report generation alerts managers of problem areas on a routine basis. Staff members are spared the time needed in examining the data for problems. Instead, reports are generated automatically that highlight these alerts. Although this may necessitate further programming and SQL statements, once in place, the process is likely to save valuable time and resources.

Specific Examples Pertaining to Seniors and the Disabled Community

Traditionally, farebox records have been used to calculate transit agency performance measures such as passengers per hour and passengers per revenue mile. However, few individuals realize that the same farebox data can be analyzed to learn detailed information about specific populations. Although it is not a common practice yet, fareboxes offer a wealth of information about elderly and disabled riders.

Using farebox data to examine the travel behavior and trends of specific populations like the elderly or people with disabilities can be accomplished the same way that more general EFC analyses are performed. In order to isolate the data records associated with special populations, additional procedures must be instituted. In most cases specific queries must be made to only select certain records. Three examples are shown in the following pages, and more are illustrated in Section 5.0.

Example 1 - Retrieve senior or disabled passenger ridership by time of day. In order to obtain the necessary information about elderly and disabled individuals, it is necessary to isolate data on the given group. As described above, when individuals board the bus, the driver enters the type of passenger and fare payment on the keypad. Based in this example, the driver chooses one of four possible choices, listed below.

Field	*Data Type*	*Description*
key7	Integer	Senior & disabled fares
ttp3	Integer	Reduced day pass received
ttp8	Integer	31 day disabled rolling pass
ttp9	Integer	31 day senior rolling pass

In this situation, the main focus of the SQL statement is to summarize all four fields in which the passenger is a senior or disabled. The data is requested by hourly totals. Data for total general riders is requested as well. The SQL statement is presented below (for information about *Farebox_Year_Month_Hour_Weekday_Rider_View*, see Appendix A). Note that the terms used in the SQL code examples in this section are based on definitions provided in Appendix A.

```
select convert(varchar,Hour) +':01--
'+convert(varchar,(Hour+1))+':00' as TimeOfDay,
,convert(int,sum( 0.19 *ttp3 +ttp8+ttp9)) as
senior_disabled_pass_riders , sum(key7) as
senior_disabled_fare_riders, convert(int,sum( key7+0.19 *ttp3
+ttp8+ttp9)) as senior_disabled_riders ,sum(riders) as
general_riders
from Farebox_Year_Month_Hour_Weekday_Rider_View
group by Hour
order by Hour
```

The above SQL statement will return a report, which can be further manipulated to create charts similar to **Figure 10, Figure 11, and Figure 12**.

Figure 10 Senior / Disabled Ridership

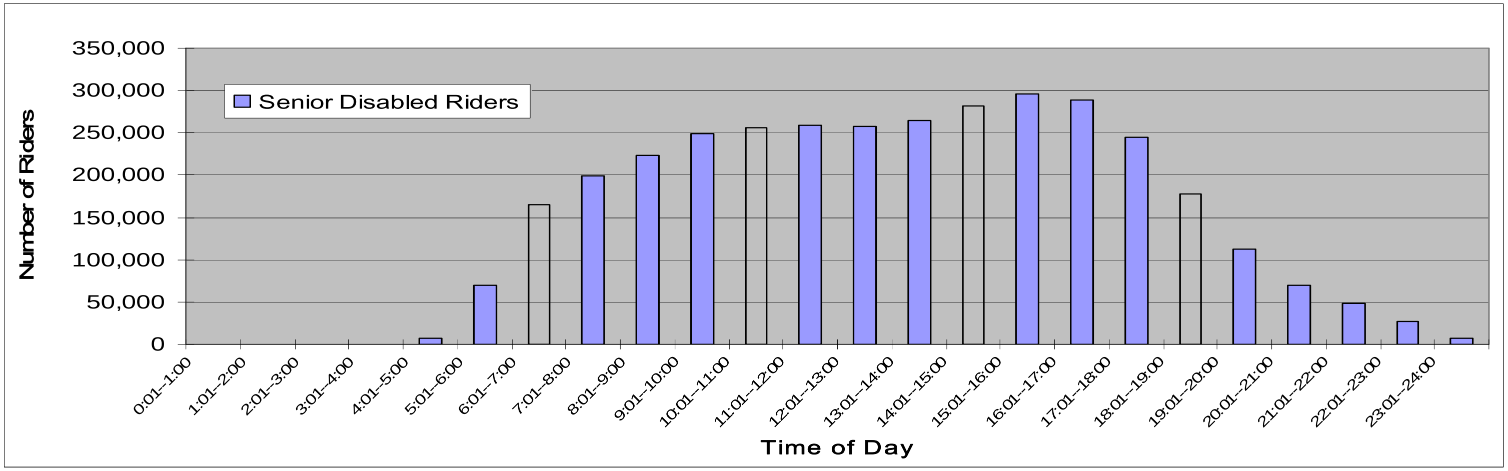


Figure 11 Senior / Disabled Ridership Compared to General Ridership

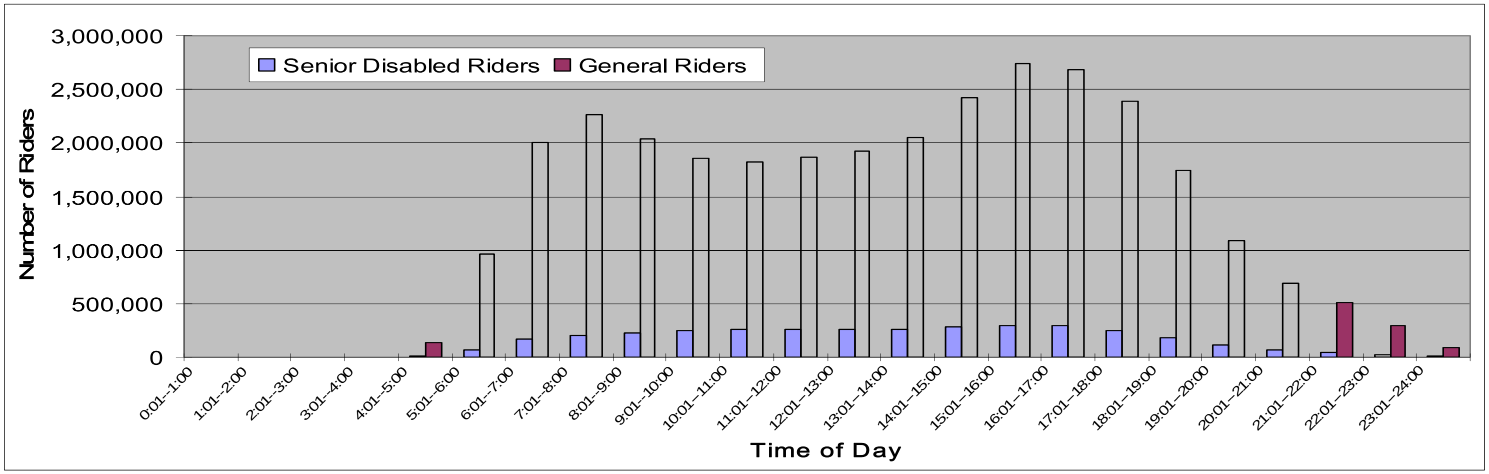
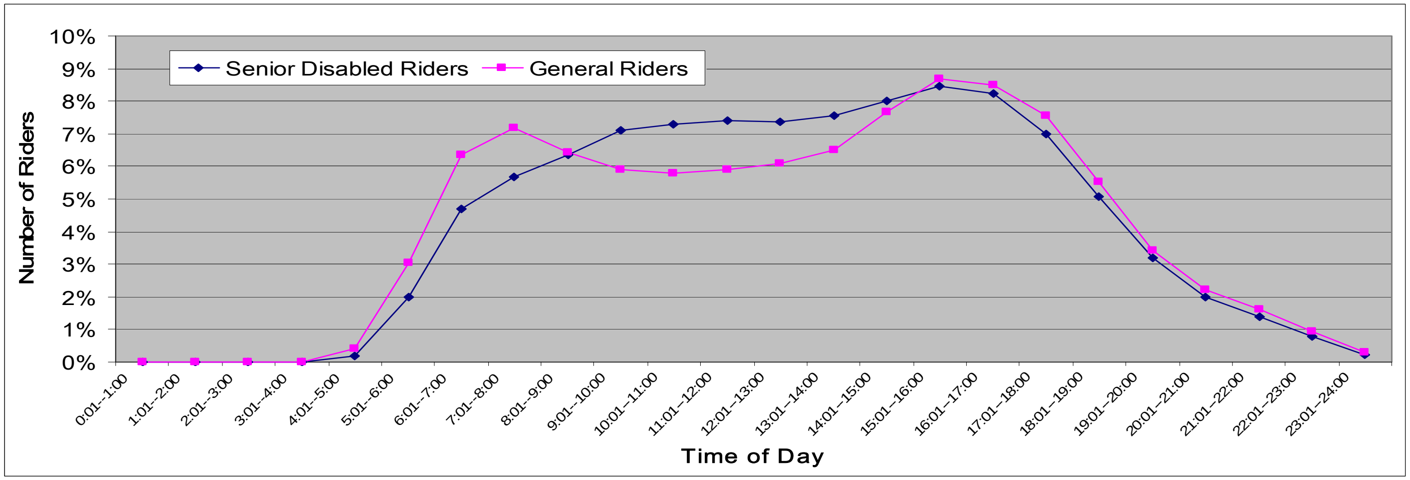


Figure 12 Senior / Disabled Ridership Percentage by Time of Day



Example 2 - Retrieve senior, disabled and general passenger ridership by month. This measure looks at the data by passenger type for each month. In this example, the four types of possible keypad entries for elderly and disabled riders are compared with general ridership. This information may help transit planners identify trends and reallocate resources more appropriately during seasons of high and low elderly ridership. For information about *Farebox_Year_Month_Hour_Weekday_Rider_View*, please see Appendix A.

```
Select Month, ,convert(int,sum( 0.19 *ttp3 +ttp8+ttp9)) as
senior_disabled_pass_riders , sum(key7) as
senior_disabled_fare_riders, convert(int,sum( key7+0.19 *ttp3
+ttp8+ttp9)) as senior_disabled_riders ,sum(riders) as
general_riders
from Farebox_Year_Month_Hour_Weekday_Rider_View
group by Month
order by Month
```

The above SQL statement will return a report, which can be further manipulated to create charts similar to **Figure 13 & Figure 14** (see following page).

Figure 13 Senior / Disabled Ridership by Month

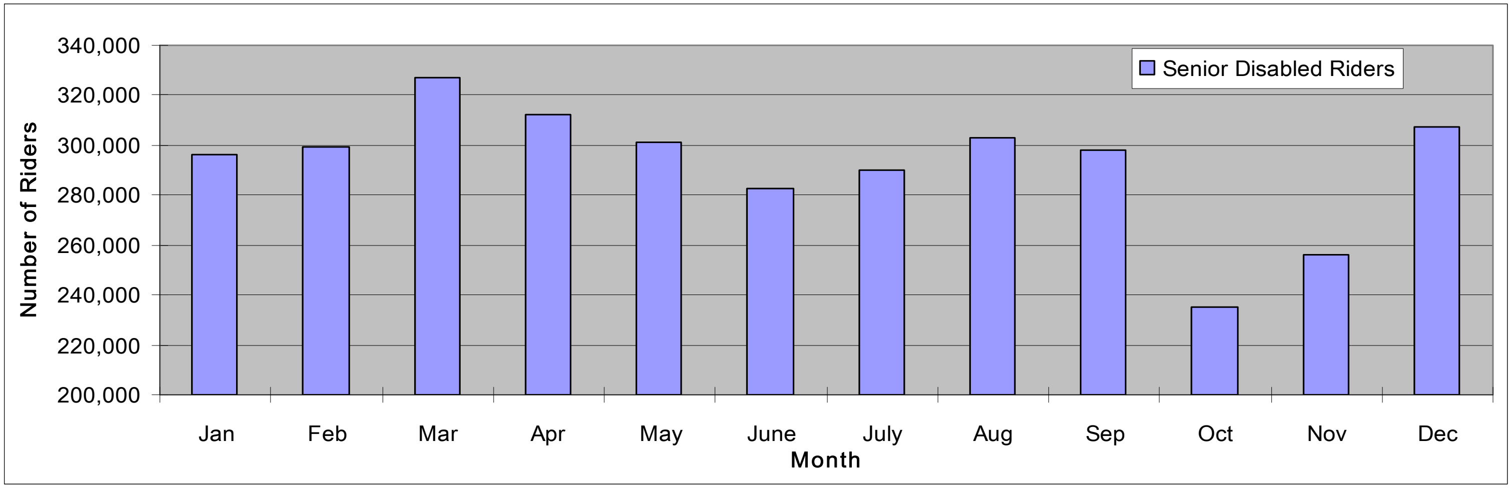
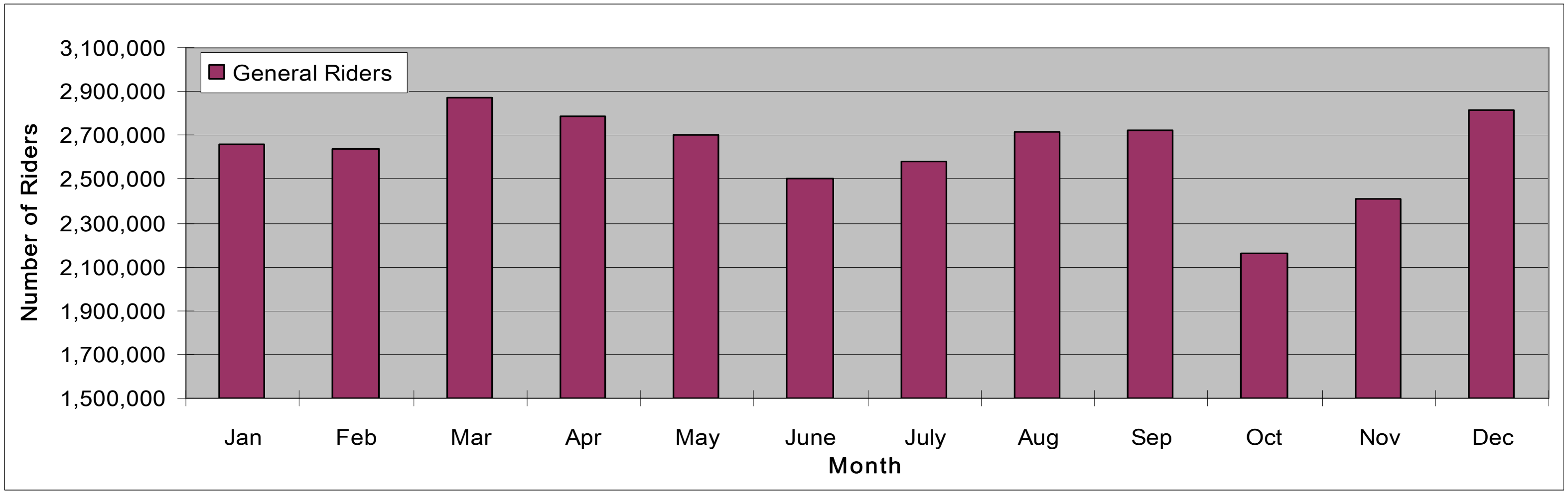


Figure 14 General Ridership by Month

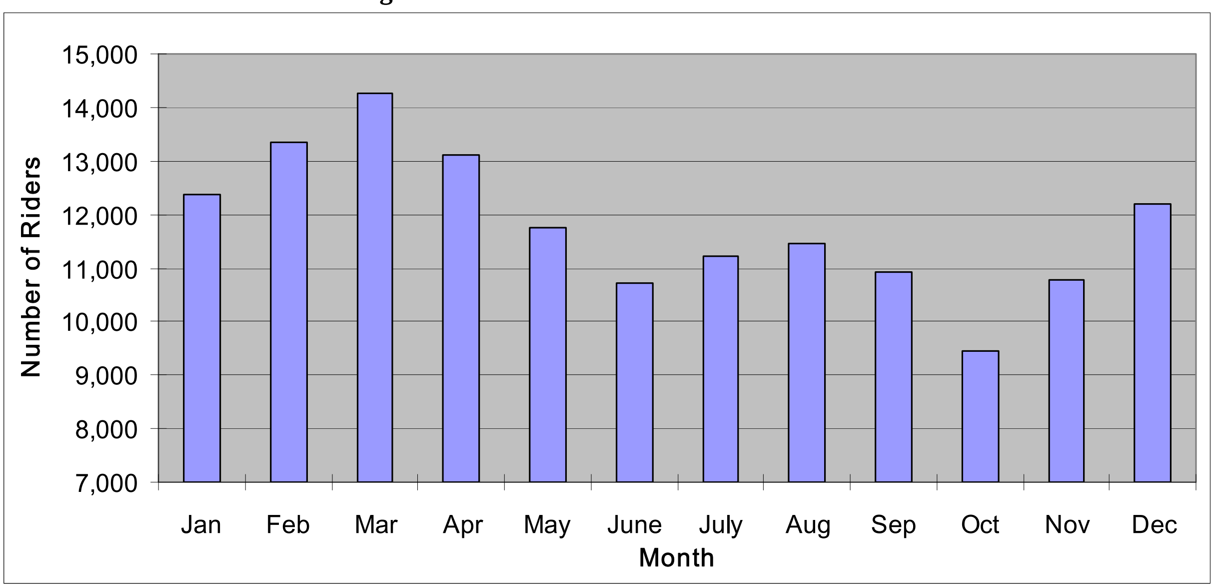


Example 3 - Display senior, disabled and general ridership for a specific route. If even more detail is needed to study a certain area of the community, it is possible to isolate data by bus route. Again, like the previous examples, the four types of possible keypad entries for elderly and disabled riders are summarized. General ridership totals are also requested. The following statement requests data by month and is told to retrieve information only for Route 11. Appendix A provides information about *Farebox_Year_Month_Hour_Weekday_Rider_View*.

```
select Month,convert(int,sum( 0.19 *ttp3 +ttp8+ttp9)) as
senior_disabled_pass_riders , sum(key7) as
senior_disabled_fare_riders, convert(int,sum( key7+0.19 *ttp3
+ttp8+ttp9)) as senior_disabled_riders ,sum(riders) as
general_riders
from Farebox_Year_Month_Hour_Weekday_Rider_View
where route=11
group by Month
order by Month
```

The SQL statement returns a report, which can be further manipulated to create graphics like **Figure 15**.

Figure 15 Senior/ Disabled Riders on Route 11



4.0 CASE STUDY

Broward County Transit EFP System

Broward County Transit (BCT) has a mature and fully functional Electronic Fare Collection (EFC) system for 100% of the fleet. The ridership and revenue information from the system has been used for planning and operations purposes. The finance and accounting departments also uses the collected information for periodic fiscal reporting. The BCT system accepts fare payment via prepaid term passes or cash on-board and allows riders to board more quickly and easily.

BCT Bus Passes. In addition to paying by cash, BCT transit riders are able to use a bus pass. BCT's bus pass is a credit-card-sized fare card with a magnetic strip. The Bus Pass offers flexible pricing and is fully automated for use on all BCT buses. As a rider boards, he or she simply slides the card through the farebox from right to left. The farebox beeps when it accepts the Bus Pass.

Table 1 Types of BCT Bus Passes

Regular One Way Fare (Cash)	Basic fare for one-way travel. No transfer pass is given to board another bus.
All Day	Available only aboard all BCT buses. Unlimited rides all day on all routes.
All Day Passes Reduced Senior / Youth / Disabled / Medicare	Discounted fares are available for Youth*, Senior*, Disabled** & Medicare***.
10-Ride	10 rides any day, any time. Expires after the 10th ride is taken.
7-Day	Unlimited rides for 7 consecutive days. Starts the first day card is used. Expires after the seventh day.
31-Day-Adult	Unlimited rides for 31 consecutive days. Starts on the first day the card is used. Expires after the 31st day.
31-Day Reduced Passes Senior / Youth / Disabled / Medicare	Discounted fares are available for Youth*, Senior*, Disabled**, Medicare*** & College Student†.

* For youth fare (18 years and younger) and Senior fare (65 years and older) proof of age is required. ** For Disabled fare, proof of disability is required by either: 1. Medicare card 2. Letter from doctor stating 50 percent or more permanent disability 3. Social Security Income (SSI) printout or check 4. BCT photo ID card. *** Medicare card and BCT photo identification card. † Must present a current student ID card at time of purchase. Source: BCT website

The BCT fare structure is shown in Table 2. Additionally a new transfer policy is in place. When transferring from BCT to another area transit system like Miami-Dade Transit (MDT), Palm-Tran or Tri-Rail, passengers get a free transfer and must pay the appropriate fare on the other transit system. When transferring to BCT from another area transit system, passengers pay $.50 with a transfer issued by MDT, Palm Tran, or with a Tri-Rail pass

Table 2 BCT Fares @ keys

	Effective Date			
	Oct. 1	Oct. 1	Oct. 1	Oct. 1
Transit Fare Types	**2006**	**2007**	**2008**	**2009**
Regular One-Way Fare (Base Cash)	$1.00	$1.25	–	$1.50
- Reduced Youth		$0.60	–	$0.75
- Reduced-Senior / Disabled / Medicare		$0.60	–	$0.75
10-Ride Bus Pass		$10.00	$11.50	$13.00
All Day Pass		$3.00	–	$3.50
All Day Reduced Pass				
- Senior / Disabled / Medicare		$2.00	–	$2.50
- Youth		$2.00	–	$2.50
31-Day Adult Pass		$40.00	$46.00	$52.00
31-Day Reduced Pass				
- Senior / Disabled / Medicare		$20.00	$23.00	$26.00
- Youth Pass		$20.00	$23.00	$26.00
- College Student Pass (New)		$20.00	$23.00	$26.00
7-Day Bus Pass		$11.00	$12.00	$13.00

The Broward County Transit "Ride-and-Save" program is a pre-tax commuter benefit program that provides an additional way for employees and employers to save money. Employees can save money on their commuting costs by purchasing BCT bus passes with pre-tax dollars, while employers can save money on their payroll taxes. This program is a win-win opportunity for all involved. BCT's continues to educate employees and employers about commuting options and how to take full advantage of this Federal program (BCT website).

Employer-Paid Benefit. Employers can pay for their employees to commute on BCT by purchasing a 31-Day bus pass. Employers get a tax deduction for the expense.

Employee-Paid Benefit. Employers can allow their employees to purchase a BCT 31-Day bus pass using pre-tax income; the employer provides a pre-tax deduction program for their transit costs.

Fare Share Benefit. Employers can provide a portion of the cost of a BCT 31-Day bus pass. The employee also pays a portion using pre-tax income while the employer offers a pre-tax deduction program (Source: BCT website).

Farebox

Data from the BCT farebox system is stored in a Sybase SQL Anywhere database. In this database, two of the most important tables are the event table and the transaction table (Table 3 and Table 4). When riders board a BCT bus, they have several options to pay the fare. The rider may choose to pay in cash for a one-way ride or an all-day pass, turn in a transfer issued by one of the other metropolitan transit agencies, or swipe one of the several categories of pass cards used by the agency. Riders may also use rare options for boarding: emergency passes and courtesy passes.

As individuals board the vehicle, the farebox records the category of payment along with a few other variables: the bus route number, the date and time, revenue, dump count and bill count. This information is then stored in the event table. If a rider boards with one of the dozen plus pass cards (cards issued by the agency enabled with a magnetic strip), then additional information is recorded into the transaction table. The transaction table is essentially a record of all bus boardings that used a swipe card for payment. Since each swipe card contains a unique identification number, the transaction table can help track travel trends. For example, for someone using a 31-day rolling pass card, all trips taken during this 31-day period may be identified. This information can help generate data about travel behavior, such as time and day(s) of travel, transfers, and frequency.

Event Table

The EFC data for BCT is stored in two databases allowing transit planners to make several types of analyses. To best present the application of potential uses, this report first covers common methods used to analyze data from the Event Table. As described earlier, the Event Table tracks fare payments as passengers board the bus, and lumps all payments into a single record approximately every hour. Route and time information are presented on each record as well.

Identifying travel behavior. Tables 3 and 4 show two of the main tables for the [1]GFI fare collection system (*3*).

[1] GFI Genfare, A Unit of SPX Corporation

Table 3 Farebox Event Table

Fields	*Data Type*	*Description*
route	Integer	Route number
Ts	Variable char(50)	Timestamp
curr_r	Float	Revenue
uncl_r	Float	Unclassified revenue.
dump_c	Integer	Dump count
bill_c	Integer	Cumulative bill count
key1	Integer	Issue Dade/Palm/TriRail transfer
key2	Integer	Reduced student fare
key3	Integer	No pay child/excp,VIP,ret,spc.
key4	Integer	Century village
key5	Integer	Regular fare
key6	Integer	Dade & Palm Beach transfers accepted
key7	Integer	Senior & disabled fares
key8	Integer	Tri-Rail accepted
key9	Integer	Checked
keyA	Integer	Reduce fare day pass sold($1.25)
keyB	Integer	Issue courtesy day pass
keyC	Integer	Issue day pass sold($2.50)
ttp1	Integer	Courtesy pass received
ttp2	Integer	Emergency ride received
ttp3	Integer	Reduced day pass received
ttp4	Integer	1 day pass received
ttp5	Integer	Student pass
ttp6	Integer	31 day adult rolling pass
ttp7	Integer	31 day adult rolling pass
ttp8	Integer	31 day disabled rolling pass
ttp9	Integer	31 day senior rolling pass
ttp10	Integer	7 day rolling pass
ttp11	Integer	10 day ride pass
ttp12	Integer	Employee pass
ttp13	Integer	Family pass
ttp14	Integer	31 day college
ttp21	Integer	Short payment
riders	Integer	

For each person who rides BCT and pays for the trip with some form of fare card – a monthly pass, a 10-ride pass, a 7-day pass, or a daily pass - the Transaction Table stores data regarding trip time, route number, run number, and direction. In the Transaction Table, each person’s boarding is stored as a single record. This differs from the Event Table where all boardings in an hour are aggregated.

Transaction Table

Table 4 Farebox Transaction Table

Fields	*Data Type*	*Description*
loc	Integer	Location# (garage #)
Id	Integer	Join field to master list
tr_seq	Integer	Transaction sequence number
seq	Integer	Stored value card sequence number
type	Integer	Record action type
ttp	Integer	TTP card used on
Fs	Integer	Fare structure ID
des	Integer	Designation
aid	Integer	Issuing agency ID of the media used
mid	Integer	Manufacturer ID of the media used
tpbc	Integer	Checked
flags	Integer	Status flags
id1	Integer	Join field to master list
tr_seq2	Integer	Transaction sequence number
Ts	variable char(50)	Timestamp
type1	Integer	Checked
bus	Integer	Checked
route	Integer	Route number
run	Integer	Checked
trip	Integer	Trip
dir	variable char(50)	Directions
N	Integer	Checked
id_key	Big integer	Record ID
col1	variable char(50)	
col2	variable char(50)	
col2	variable char(50)	

5.0 POTENTIAL APPLICATIONS

5.1 Obtaining Information from the Event Table

The EFC data for BCT is stored in two databases, allowing for several types of analyses to be made. To best present the application of potential uses, this report first covers methods to analyze data from the Event Table. As described earlier, the Event Table tracks fare payments as passengers board the bus, and lumps all payments into a single file approximately every hour. Each record also indicates route and time information.

5.1.1 What Bus Routes Have the Most Elderly and Disabled Riders?

Determining which routes have the most elderly and disabled riders is valuable knowledge that can help agencies determine where and how to prioritize route services and stop infrastructure. Although transit agencies may already have an idea of what routes have the most elderly riders, EFC data can easily sort through the millions of associated records and confirm or reject previous assumptions. Terms for all code examples in this section are based on definitions provided in Appendix A.

```
select ev.route,sum(curr_r), sum(uncl_r), sum(key7) as old_riders FROM
"DBA"."ev"
where ev.ts >= '2007-03-01 04:00:00' and ev.ts < '2007-03-02 04:00:00'
group by route
order by route desc;
output to c:\user\reports\sysold1.txt
format ascii;
```

Since the Event Table classifies records by date and hour for each route, compiling yearly route ridership will involve aggregating all records for each route. The final table shows the top ten routes that accommodate the highest number of elderly riders. The SQL is described below.

```
select top 10 ev.route,sum(curr_r), sum(uncl_r), sum(key7) as old_riders
FROM "DBA"."ev"
where ev.ts >= '2007-01-01 04:00:00' and ev.ts < '2007-02-01 04:00:00'
and (dow(ts)>= 2 and dow(ts)<=6)
group by route
order by route desc;
output to c:\user\reports\systold2.txt
format ascii;
```

Table 5 Top 10 BCT Routes with Highest Number of Elderly and Disabled Riders in Jan 2007

Rank	Bus Route	Yearly # of Elderly & Disabled
1	18	5099
2	1	3842
3	72	3016
4	56	2935
5	2	2904
6	4	2808
7	36	2614
8	11	2121
9	7	2100
10	28	1980

While the above table shows total yearly route ridership, it might also be beneficial to calculate ridership for the typical weekday and weekend seniors and people with disabilities. These figures will give service planners a better idea of daily usage. For Tables 6 and 7, randomly selected days were chosen: February 15, 2007 was chosen to represent weekday data and March 15, 2007 was chosen to represent weekend data. The following SQL is used to calculate BCT weekday routes; note that dow(ts) defined as “>=2 and <=6” indicates weekday activity (1=Sunday and 7=Saturday).

```
select ev.route,sum(curr_r), sum(uncl_r), sum(key7) as old_riders FROM
"DBA"."ev"
where ev.ts >= '2007-02-15 04:00:00' and ev.ts < '2007-03-15 04:00:00'
and (dow(ts)>= 2 and dow(ts)<=6)
group by route
order by route desc;
output to c:\user\reports\sysold3.txt
format ascii;
```

Table 6 BCT Weekday Routes with Highest Number of Elderly & Disabled Riders in Select Time Period

Rank	Bus Route	# of Elderly and Disabled
1	18	3657
2	1	2567
3	4	2388
4	72	2328
5	56	2222
6	36	2144
7	2	2027
8	11	1813
9	7	1564
10	28	1329

The following SQL is used to calculate BCT weekend routes, note that dow(ts) equals to 1 or 7 means it’s weekends. Terms are based on definitions provided in Appendix A.

```
select ev.route,sum(curr_r), sum(uncl_r), sum(key7) as old_riders FROM
"DBA"."ev"
where ev.ts >= '2007-02-15 04:00:00' and ev.ts < '2007-03-15 04:00:00'
and ((dow(ts)= 1 or dow(ts)=7))
group by route
order by route desc;
output to c:\user\reports\sysold4.txtformat ascii;
```

Table 7 BCT Weekend Routes with Highest Number of Elderly & Disabled Riders

Rank	Bus Route	# of Elderly and Disabled
1	1	1028
2	18	775
3	36	680
4	4	655
5	11	647
6	56	509
7	72	469
8	2	446
9	10	379
10	28	351

5.1.2 What Is the Monthly Ridership For Some of These Routes?

Monitoring monthly ridership is important because many areas of the country have large populations of seasonal residents. These individuals, often retired, may live in two or three different residences during the course of a typical year. In Broward County, additional elderly residents create added demand on bus services during the winter months. If large variations in senior ridership exist, then transit agencies may need to formulate a plan for providing additional services during busy times of the year, and shifting those services elsewhere when few seasonal residents are utilizing services.

Table 8 Monthly Ridership for BCT Route 441

Month	# of Elderly & Disabled	Total # of Riders	Percentage of Riders Neither Elderly or Disabled
1	2800	41111	6.81%
2	3051	39644	7.70%
3	2874	41158	6.98%
4	1954	36620	5.34%
5	1794	37807	4.75%
6	2816	69694	4.04%
7	1221	36299	3.36%
8	1235	39641	3.12%
9	1092	32529	3.36%
10	1370	34758	3.94%

11	1934	36465	5.30%
12	2142	37257	5.75%
Yearly	24283	482983	6.04%

5.1.3 What Bus Routes Have the Largest Percentage of Elderly and Disabled Riders?

Determining routes with a high percentage of elderly and disabled riders is also quite useful. When allocating scarce resources, this variable might be the deciding factor. Routes with high percentages of these riders ideally should be served by low floor or kneeling buses, and assigned to the friendliest and safest bus drivers. Also, popular stops should have the necessary infrastructures installed for safe waiting and boarding.

For final table, show top ten routes with the highest number of elderly riders and the percentage of elderly and disabled riders.

Table 9 BCT Routes with the Highest Percentage of Elderly and Disabled Riders

Rank	Bus Route	% of Elderly & Disabled
1	4	14.28%
2	17	12.69%
3	56	9.70%
4	57	8.39%
5	15	6.20%
6	11	6.12%
7	1	5.81%
8	83	5.75%
9	7	5.37%
10	3	5.33%

If this data query reveals routes with too few riders, a minimum threshold may be to set to ensure that only bus routes with at least a certain number or percentage of elderly and disabled riders are selected. For example, a function can be added to only select those routes with a specific number of elderly or disabled riders per year.

Table 10 Top 10 BCT Routes with Highest Percentage of Elderly & Disabled Riders with more than 3,000 elderly & disabled riders per year

Rank	Bus Route	Number of Elderly & Disabled	Total Yearly Elderly Riders
1	56	4886	50372
2	11	5694	93085
3	1	10775	185437
4	7	5270	98183
5	28	3837	72594
6	72	9535	185496
7	10	4463	88496

8	81	3012	61436
9	36	8648	193514
10	2	6968	170617

5.1.4 When (at what times of day) do the elderly and disabled ride the most?

Sometimes it is important to determine when is the time that most elderly & disabled population would take the bus. Thus transit agencies can help allocate more buses with ADA assistance in that time period. The following table shows route 441 with the largest number of elderly and disabled by time of day in a particular month:

Bus route 441

Month	Corresponding time	Time Span	# of Elderly & Disabled
May 2005	11:00 am – 11:30 am	30 mins	117
May 2005	2:30 pm – 300 pm	30 mins	51
May 2005	3:30 pm – 4:15 pm	45 mins	46

When this task is performed for the route with the largest percentage of elderly and disabled, route 51 shows the highest percentages of riders.

Bus route 51

Month	Corresponding time	Time Span	% of Elderly & Disabled
May 2005	9:00 am – 9:32 am	32 mins	19
May 2005	1:30 pm – 2:30 pm	60 mins	15
May 2005	3:30 pm – 4:07 pm	37 mins	12

This information could then be used to create charts of graphs detailing the amount of elderly passengers by time, as well as the percentage of elderly passengers by time spans during the day.

5.1.5 What bus routes and times are the busiest?

Although bus routes with large numbers of passengers may signify healthy revenues, they can also lead to some problems. Crowded conditions might be just an annoyance for most riders, but can pose serious problems for the elderly and the disabled. A rider in a wheelchair or with a walker is likely to have significant problems maneuvering within the bus if the vehicle is so crowded that other transit riders must stand in the aisles. Boarding and exiting the vehicle in a timely manner may become very difficult, and at times impossible.

Likewise, an elderly rider may have trouble safely finding a place to sit or a pole to hold. This type of situation may increase the likelihood of falls and injuries. Seniors and people with disabilities may be safeguarded against such crowds if transit agencies monitor ridership and consistently supply appropriate transit service to meet demand.

By examining the busiest segments of the day, agencies can determine where additional resources should be allocated. The routes with extremely high numbers of riders may be considered for increased service frequency as a means to alleviate onboard crowding. Alternatively, larger buses may be assigned to serve the route, thereby providing additional seating and more space for riders.

This task may involve matching ridership with scheduling information. Since the EFC system does not record the number of buses or their trip length, ridership totals must be compared against the actual number of buses traveling the route at a given time and the capacity of the bus.

In order to obtain the related data, the following SQL is performed (terms are based on definitions in Appendix A).

```
select ev.route, hour (ts), sum(key7) as old_riders ,
sum(key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+ttp4
+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp20+ttp21) as riders
FROM "DBA"."ev"
where ev.ts >= '2005-05-01 04:00:00' and ev.ts < '2005-06-01 04:00:00'
group by route
order by route desc;
output to c:\user\reports\0505\sysold5.txt
format ascii;
```

The partial results of this query are provided in the table below:

Route	Month	Corresponding Time	Total riders	Total elderly riders
61	May 2005	5:15 pm – 6:00 pm	78	15
441	May 2005	4:30 pm – 5:30 pm	76	17
77	May 2005	9:30 am – 10:00 am	65	16

This query will result in a very long list of times and routes. To better organize the query, we will next rank the list of events that are over capacity, by total number of elderly riders.

Route	Month	Corresponding Time	Total riders	Total elderly	Bus Type & Size
441	May 2005	4:30 pm – 5:30 pm	76	17	40 foot – 50 person cap
77	May 2005	9:30 am – 10:00 am	67	16	40 foot – 50 person cap
61	May 2005	5:15 pm – 6:00 pm	78	15	30 foot – 40 person cap

Alternatively, this information can be sorted by the amount each current record is over capacity:

Route	Month	Corresponding Time	Total riders	Total elderly	Bus Type & Size	# Over capacity
61	May 2005	5:15 pm – 6:00 pm	78	15	30 foot – 40 person cap	38
77	May 2005	9:30 am – 10:00 am	65	16	25 foot – 30 person cap	35
441	May 2005	4:30 pm – 5:30 pm	76	17	40 foot – 50 person cap	26

5.1.6 What bus routes that have the lowest usage of the 31-day pass?

This analysis looks at which bus routes have the lowest usage of the 31-day pass. For seniors and persons with disabilities, using the pass is considered much more convenient than paying for fares in cash. For transit agencies, the use of passes and electronic boarding devices speeds the boarding process, which ultimately results in faster bus running times and reduces the need to handle cash fares. Using passes and reducing bus routes with low usage could be targeted for educational outreach to elderly and disabled riders. For this analysis we will start with the highest elderly ridership. To obtain the related data, the following SQL is performed (terms are based on definitions in Appendix A).

```
select ev.route, month (ts), sum(key7) as old_riders , sum(ttp8+ttp9) as
pass_users ,
sum(key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+ttp4
+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp20+ttp21) as riders
FROM "DBA"."ev"
where ev.ts >= '2007-01-01 04:00:00' and ev.ts < '2007-02-01 04:00:00'
group by route, month (ts)
output to c:\user\reports\sys1.txt
format ascii;
```

The partial results of this query are provided in the table below:

Bus Route	Elderly with Cash Payment	Elderly & Disabled with Pass Usage	Total Elderly & Disabled	Percentage not using monthly pass (Rank by this column)
31	480	7498	7978	93.98%
14	929	12913	13842	93.29%
22	823	10532	11355	92.75%
30	431	4576	5007	91.39%
60	1032	10875	11907	91.33%
6	524	5216	5740	90.87%
40	1133	11056	12189	90.70%
50	1319	10286	11605	88.63%
441	265	2051	2316	88.56%
20	517	3932	4449	88.38%

5.2 Obtaining Information from the Transaction Table

For each person who rides BCT and pays for the trip with some form of fare card – a monthly pass, a 10-ride pass, a 7-day pass, or a daily pass - the Transaction Table stores data regarding trip time, route number, run number, and direction. In the Transaction Table, each person's boarding is stored as a single record. This differs from the Event Table where all boardings for an hour are aggregated.

The following queries are used in Sybase database. They are developed based on the purpose from user. Riderships and revenues are calculated according to different conditions. After desired data fields are selected, data is then outputted into external file and such file could be imported by SQL server. The following SQL was run on a Sybase database (terms are based on definitions in appendix A).

5.2.1 How to calculate the total revenue and unclassified revenue as well as total ridership by hour (time of day) in a given time period

```
select distinct hour (ts), sum(curr_r), sum(uncl_r),
sum(key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+t
tp4+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp20+ttp21) as
riders FROM "DBA"."ev"
where ev.ts >= '2003-10-01 04:00:00' and ev.ts < '2004-10-01 04:00:00'
and not (ev.ts >= '2004-01-01 04:00:00' and ev.ts < '2004-02-02
04:00:00') and not (ev.ts >= '2004-05-31 04:00:00' and ev.ts < '2004-
06-01 04:00:00') and not (ev.ts >= '2004-07-04 04:00:00' and ev.ts <
'2003-07-05 04:00:00') and not (ev.ts >= '2004-09-06 04:00:00' and
ev.ts < '2004-09-07 04:00:00') and not (ev.ts >= '2003-11-27 04:00:00'
and ev.ts < '2003-11-28 04:00:00') and not (ev.ts >= '2003-12-25
04:00:00' and ev.ts < '2003-12-26 04:00:00') and (dow(ts)>= 2 and
dow(ts)<=6)
group by hour(ts) ;
output to c:\user\all_routeW_FY2004.txt
format ascii;
```

5.2.2 How to obtain large number of tokens used on each bus and garage location in a given time period

```
select ml.loc_n, ml.bus, ev.ts,ev.ttp21 from dba.ml
inner join dba.ev
where ev.ts >='2006-1-1 4:00' and ev.ts<='2006-2-1 4:00' and ev.ttp21
> 0;
output to F:\work\bill.txt
format ascii;
```

5.2.3 How to calculate the total revenue and unclassified revenue as well as total ridership by hour (time of day) and route in a given time period in weekdays

```
select distinct(route), hour (ts), sum(curr_r), sum(uncl_r),
sum(key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+t
tp4+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp20+ttp21) as
riders FROM "DBA"."ev"
where ev.ts >= '2003-07-01 04:00:00' and ev.ts < '2003-08-01 04:00:00'
and not (ev.ts >= '2003-01-01 04:00:00' and ev.ts < '2003-01-02
04:00:00') and not (ev.ts >= '2003-05-26 04:00:00' and ev.ts < '2003-
05-27 04:00:00') and not (ev.ts >= '2003-07-04 04:00:00' and ev.ts <
'2003-07-05 04:00:00') and not (ev.ts >= '2003-09-01 04:00:00' and
ev.ts < '2003-09-02 04:00:00') and not (ev.ts >= '2003-11-27 04:00:00'
and ev.ts < '2003-11-28 04:00:00') and not (ev.ts >= '2003-12-25
04:00:00' and ev.ts < '2003-12-26 04:00:00') and (dow(ts)>= 2 and
dow(ts)<=6) and route = 18
group by hour(ts), route ;
output to c:\user\reports\0703\Rider_Time\c1W0703.txt
format ascii;
```

5.2.4 How to calculate the total revenue and unclassified revenue as well as total ridership by hour (time of day) and run number in a given time period

```
select ev.route, hour(ts), sum(curr_r), sum(uncl_r),
sum(key2+key3+key4+key5+key6+key7+key8+KeyAst+keyA+keyB+keyC+keyD+ttp1
+ttp2+ttp3+ttp4+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13) as
riders FROM "DBA"."ev"
where ev.ts >= '2002-03-01 04:00:00' and ev.ts < '2002-03-02 04:00:00'
and route = 17
group by route, hour(ts);
output to c:\user\reports\0202\test_rt17.txt
format ascii;
```

5.2.5 How to calculate the total revenue and unclassified revenue as well as total ridership by hour (time of day) and run number in a given time period and route number in weekdays

```
select distinct(route), (run), hour (ts), sum(curr_r), sum(uncl_r),
sum(key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+t
tp4+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp20+ttp21) as
riders FROM "DBA"."ev"
where ev.ts >= '2004-02-01 04:00:00' and ev.ts < '2004-03-01 04:00:00'
and not (ev.ts >= '2004-01-01 04:00:00' and ev.ts < '2004-01-02
04:00:00') and not (ev.ts >= '2003-05-26 04:00:00' and ev.ts < '2003-
05-27 04:00:00') and not (ev.ts >= '2003-07-04 04:00:00' and ev.ts <
'2003-07-05 04:00:00') and not (ev.ts >= '2003-09-01 04:00:00' and
ev.ts < '2003-09-02 04:00:00') and not (ev.ts >= '2003-11-27 04:00:00'
and ev.ts < '2003-11-28 04:00:00') and not (ev.ts >= '2003-12-25
04:00:00' and ev.ts < '2003-12-26 04:00:00') and (dow(ts)>= 2 and
dow(ts)<=6) and route = 189
group by hour(ts), route, run ;
output to c:\user\reports\0204\Rider_Time\rt189W0204.txt
format ascii;
```

5.2.6 How to calculate the monthly revenue and ridership for each route

```
select loc_n, route, sum(curr_r), sum(uncl_r), sum(dump_c),
sum(bill_c), sum(key1), sum(key2), sum(key3), sum(key4), sum(key5),
sum(key6), sum(key7), sum(key8), sum(key9), sum(keyAst), sum(keyA),
sum(keyB), sum(keyC), sum(keyD), sum(ttp1), sum(ttp2), sum(ttp3),
sum(ttp4), sum(ttp5), sum(ttp6), sum(ttp7), sum(ttp8), sum(ttp9),
sum(ttp10), sum(ttp11), sum(ttp12), sum(ttp13), sum(ttp21),
sum(key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+t
tp4+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp21) as riders
FROM "DBA"."ev"
where ev.ts >= '2004-02-01 04:00:00' and ev.ts < '2004-03-01 04:00:00'
group by loc_n, route;
output to c:\user\reports\0304\sum_0304.txt
format ascii;
```

5.2.7 How to calculate the current revenue and ridership for a particular garage in a given time period

```
select distinct(route), hour (ts), sum(curr_r), sum(uncl_r),
sum(key2+key3+key4+key5+key6+key7+key8+keyA+keyC+keyD+ttp1+ttp2+ttp3+t
tp4+ttp5+ttp6+ttp7+ttp8+ttp9+ttp10+ttp11+ttp12+ttp13+ttp20+ttp21) as
riders FROM "DBA"."ev"
where ev.ts >= '2004-07-01 04:00:00' and ev.ts < '2004-08-01 04:00:00'
and not (ev.ts >= '2004-01-01 04:00:00' and ev.ts < '2004-01-02
04:00:00') and not (ev.ts >= '2004-05-31 04:00:00' and ev.ts < '2004-
06-01 04:00:00') and not (ev.ts >= '2004-07-05 04:00:00' and ev.ts <
'2004-07-06 04:00:00') and not (ev.ts >= '2003-09-01 04:00:00' and
ev.ts < '2003-09-02 04:00:00') and not (ev.ts >= '2003-11-27 04:00:00'
and ev.ts < '2003-11-28 04:00:00') and not (ev.ts >= '2003-12-25
04:00:00' and ev.ts < '2003-12-26 04:00:00') and (dow(ts)= 7) and
route = 1
group by hour(ts), route ;
output to c:\user\reports\0704\Rider_Time\189W0704.txt
format ascii;
```

5.2.8 How to obtain the revenue for each route and bus number for each day in a given time period

```
select day(ev.ts), ev.route, sum(ev.curr_r), ml.bus from dba.ml,dba.ev
where ev.id=ml.id and ev.loc_n=ml.loc_n and ev.ts between '2007-12-15'
and '2007-12-18 4:00' and route =22
group by bus,ev.route,day(ev.ts);
output to C:\Rebdata.txt
format ascii;
```

5.2.9 How to compare total revenue with collected currency

```
select sum(curr_r),
sum((penny*0.01)+(nickel*0.05)+(dime*0.10)+(quarter*0.25)+(half*0.50)+
(SBA*1)+(one*1)+(two*2)+(five*5)+(ten*10)+(twenty*20)) as revenue FROM
"DBA"."ml"
where ts >= '2004-10-01 04:00:00' and ts < '2004-11-01 04:00:00' and
loc_n=1;
output to c:\user\reports\1004\cash_c_1004.txt
format ascii;
```

5.2.9 How to obtain special fares and bus number and time stamp in a given time period

```
select ml.key7,ml.bus,ml.ts from dba.ml where
ml.bus=525 and ml.tday between '2007-10-01' and '2007-10-01'
output to C:\user\reports\century_village.txt
format ascii;
```

5.2.10 How to obtain the number of special transfers for each route in a given time period

```
select seq, route,sum(key7)
from  DBA.ev
where ev.ts >= '2007-01-01 10:00:00' and ev.ts < '2007-01-01 11:00:00'
and key7 >0
group by seq,route
order by seq,route;
output to c:\user\transfer.txt
format ascii;
```

5.2.11 How to obtain bus number and farebox number by garage

```
select distinct(bus), (fbx_n), (loc_n) FROM "DBA"."ml"
where ts >= '2004-03-01 04:00:00' and ts < '2004-06-15 04:00:00'
group by bus, fbx_n, loc_n;
output to c:\user\reports\0504\sum_0301-051504. txt
format ascii;
```

5.2.12 How to obtain timestamp, route number and run number as well as farebox number in a given time period

```
select ts, route, n, run ,ml.fbx_n FROM "DBA"."ev","DBA"."ml"
where ev.ts >= '2008-08-3 04:00:00' and ev.ts <= '2008-8-10 04:00:00'
and ml.loc_n=ev.loc_n and ml.id=ev.id
and ml.tday between '2008-08-3' and '2008-8-10';
output to c:\user\reports\0603\cashbox.txt
format ascii;
```

5.2.13 How to obtain transaction information and sort by card sequence number in a given time period

```
select tr.loc_n, tr.ts, tr.tr_seq, tr.type, tr.route, tr.run, tr.bus,
tr.dir, tr.n, tr.type, ppd.seq, ppd.ttp FROM "DBA"."tr" key join
"DBA"."ppd"
where tr.ts >= '2005-05-01 05:00:00' and tr.ts < '2005-06-01 05:00:00'
order by ppd.seq;
output to c:\user\reports\0505\Tr_0505.txt
format ascii;
```

5.2.16 How to obtain pass numbers and total transaction counts for each pass in a given time period

```
select seq, count(seq) as total from "DBA"."tr" key join "DBA"."ppd"
where ts >= '2002-04-01 04:00:00' and ts < '2002-04-02 04:00:00' group
by seq;
output to c:\user\reports\0402\tr_sum1.txt
format ascii;
```

5.2.17 How to measure increases and decreases in Elderly and Disabled Pass Usage throughout the year

The Transaction Table can also be used to monitor pass usage over time. Examining the number of 31-day passes being used during a given time period can help determine if pass usage is changing. Although not as important to service planners, pass usage may be pertinent to administrators and the agency's marketing department. If pass usage is not growing at a steady rate, the agency may need to attempt different marketing strategies to reach a larger audience.

Instead of a monthly pass, BCT utilizes a 31-day rolling pass. This type of pass can be used for any consecutive 31 days, and as a result, pass usage usually overlaps two months. Therefore, to determine usage over a long period of time, pass usage should be checked intermittently as opposed to a uniform day each month. To determine if pass usage is increasing or decreasing, check the number of passes used by seniors and disabled individuals. The table below shows the differences in pass usage on four days in 2008. Individual queries are run for each day and pass type, as shown below, and then aggregated into Table 11. The following SQL is used to obtain data for table 11.

```
SELECT sum(key3), sum(ttp3)
 FROM "DBA"."ev"
where ev.ts >= '2008-05-01 05:00:00' and ev.ts < '2008-05-01 23:59:00'
```

Table 11 Example of Pass Usage on Four Thursdays in 2008

Day	Number of Disabled and Senior pass users	Number of senior monthly pass users
Thursday May 1, 2008	3320	8776
Thursday May 8, 2008	3757	8506
Thursday August 24, 2008	1253	2062
Thursday September 18, 2008	3858	7957

5.3 Examining Origin / Destination Data

The monthly pass card data can be further used to determine travel trends for particular riders. Since the monthly pass card is typically used by one person for an entire 31-day period, the Transaction Table can easily be searched to find all trips recorded for each individual pass card. In addition to route number, the transaction table contains data about bus number, run number, trip number, and the direction the bus is headed. This data can be used to then study travel trends.

First it is necessary to separately isolate all records from individuals who used a 31-day disabled rolling pass (ttp8), and a 31-day senior rolling pass (ttp9). After selecting either group, records should be sorted by the stored value card sequence number (seq), and then by date (ts). This will effectively group records for each pass card used in chronological order. The SQL below is used to obtain data for the following tables.

```
SELECT ttp8,seq,ts,route,trip,run,dir
 FROM "DBA"."ev"
where ev.ts >= '2008-05-18 05:00:00' and ev.ts < '2008-09-18 23:59:00'
and ttp8!=0
```

The results of running this query should look something like this:

Ttp	seq	ts	route	trip	run	direction
8	12015	6/15/05 9:23 am	7	2	1	E
8	12015	6/15/05 6:06 pm	7	7	2	W
8	12015	6/17/05 10:10 am	8	2	1	N
8	13221	6/14/05 8:24 am	441	2	1	N

8	13221	6/14/05 10:24 am	441	3	3	S
8	13221	6/16/05 11:22 am	441	8	3	N

The next step in understanding origin and destination involves closely examining the trip histories for individual pass cards. As stated earlier, BCT uses magnetic stripe cards for pass usage, and while these cards cannot be recharged or retained by individual users over time, they are capable of recording travel history information during the allotted 31 days. While this information cannot reflect a user's long term travel habits, it can highlight a rider's monthly travel history, which is indicative of regular travel behavior.

It may be easiest to first look at the travel history from two pass cards. Tables 12 and 13 provide examples of two individual passes: the first shows historical travel information about a person with a disability, and the second shows information about a senior rider.

Table 12 Transaction Records for a 31-Day Card (Disabled Pass)

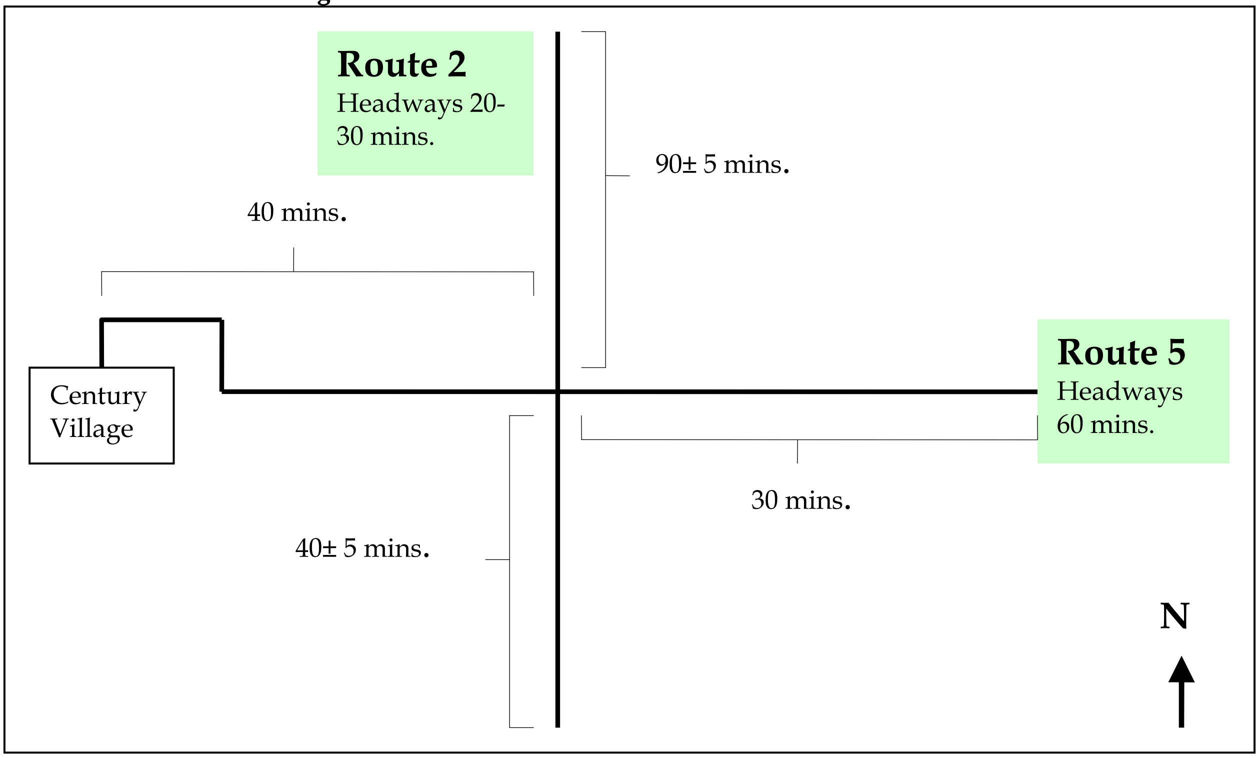
Seq	Ts	route	run	trip	direction
640615	6/15/05 8:23 am	2	2	1	E
640615	6/15/05 2:06 pm	2	7	2	W
640615	6/17/05 8:10 am	81	2	1	N
640615	6/18/05 8:24 am	81	2	1	N

Table 13 Transaction Records for a 31-Day Card (Adult Senior Pass)

Seq	Ts	route	run	trip	direction
11777	6/14/05 8:23 am	12	3	1	N
11777	6/14/05 2:06 pm	12	13	2	S
11777	6/14/05 8:10 am	441	2	1	N
11777	6/14/05 11:24 am	441	6	2	S

With the pass usage history, queries may even be run to select records in which senior pass users transfer between two particular bus routes. For example, it is possible to look at transfers between bus route 2, which runs north and south on University Drive, and bus route 5, which runs east-west on Pembroke Road. To formulate this query, all records must be sorted by pass ID (seq), and then by date (ts). All records will be selected in which bus route 5 is boarded, followed by bus route 2 within 70 minutes of boarding bus 5. Similarly, all records will be selected in which bus route 2 is boarded, followed by bus route 5, within 150 minutes of boarding bus 2. The limits for time between transferring is based on the maximum expected time required to board the first bus, alight, wait, and board the second bus. For example, a passenger boarding at the western end of Route 5 would need approximately 40 minutes to reach the appropriate area to transfer to Route 2. Upon alighting, the maximum wait time required, based on headways, would be 30 minutes. Thus 70 minutes (40 + 30) are allotted for transferring between these routes. See Figure 17.

Figure 16 Travel Times between BCT Route 2 and Route 5



Additionally the query can be confined to only look at one month's worth of time. Results of the query show the following results:

	Seniors	People with Disabilities
Board Route 5, Transfer to Route 2	207	186
Board Route 2, Transfer to Route 5	103	98

After obtaining the riders who use senior monthly pass, we may analyze the data, and conclude that many do in fact transfer from one route to another—which may have implications for changes to bus service or marketing.

The query can be refined even further to determine which riders are specifically riding from west to east and then south. Additional SQL statements are inserted to select only those records where Route 5 is boarded first. Also, since the transaction table contains a field for direction (dir), the query can be modified to select only the routes where elderly or disabled individuals are headed east on Route 5. We'll examine how many elderly and disabled riders then travel north or south.

```
SELECT ttp3,seq,ts,route,trip,run,dir
 FROM "DBA"."ev"
where ev.ts >= '2008-05-18 05:00:00' and ev.ts < '2008-05-18 23:59:00'
and ttp3!=0
```

Figure 17 Specified Direction Transfer Information

	Seniors	People with Disabilities
Board Route 5 headed eastbound, Transfer to Route 2 headed north	41	37
Board Route 5 headed eastbound, Transfer to Route 2 headed south	15	30

6.0 CONCLUSIONS & RECOMMENDATIONS

This report illustrates the EFC data flow and its usages. From the analysis of the data, several important findings are discovered. This section discusses the findings and the recommendations based on the analysis results.

Uses of EFC Data

The EFC data is used to determine which routes have the most elderly and disabled riders provide key information that can help agencies determine where and how to prioritize route services and stop infrastructure. Not only that, it also helps to find out at what times do most elderly and disabled riders prefer to travel , as well as identifying Travel Trends of Elderly and Disabled Riders.

EFC Data Benefits Elderly and People with Disabilities

Transit agencies around the country have implemented these EFP technologies and witnessed higher ridership and increased efficiencies. With a solid EFP system in place, it becomes easier to sell tickets and passes through the Internet. People suffering from mobility problems may order passes via the Internet and avoid having to make a special trip to a transit sales site.

The Importance of SQL Queries in Using EFC Data

EFC systems use databases to store the data. To use EFC data, the queries are developed based on the purpose from user. An IT specialist may be trained for some of these skills, but a reasonable amount of time should be allotted for such training. High turnover for transit employees involved with setting up and maintaining transit ITS systems could lead to significant problems.

Combining EFC Data with Other Datasets

For example, EFC data can be combined with other Transit Intelligent Transportation Systems (ITS) - AVL, APC, GIS, Stop Inventories.

With pertinent data from EFP systems readily available, transit planners have more information to help them decide how and where to allocate resources. New information may assist planners where to improve the physical characteristics of the stop, or where to assign senior-friendly low-floor vehicles. Most agencies now use APC data to invest resources at stops that have high levels of activity. Stops can be further scrutinized to examine the activity of the elderly and persons with disabilities. Personnel involved in using the EFP system should have an Analysis and ITS background to perform these kinds of analyses and data combinations.

Developing a Data Warehouse

Establishing a data warehouse can provide the data needed for more sophisticated analysis. There are many data storage systems for different data sets. Although many files have very similar structure or contain similar information including columns and data, each file may be built using a different data scheme. A data warehouse may help establish standards and translational information for the various datasets to more efficiently enable data sharing among professionals.

Generating an Automatic Process to Correct Mistakes

When logging on the EFC system, operators must log their route number, run number, and operator ID. If any of these are entered into the system erroneously, significant problems can result (“garbage in garbage out”). Correcting errors is especially important if the agency is maintaining a data warehouse. Using data from other transit ITS technologies like AVL or APCs can be used to cross check the farebox data to find mistakes and help identify systematic problems.

7.0 REFERENCES

1. Cevallos F., "Florida Advanced Public Transit Systems Program," Final Report, Prepared for the Florida DOT, Public Transit Office, April 2009.

2. Moschis, G. P., "Marketing to older consumers: A handbook of information for strategy development. Westport," CT: Greenwood Publishing Group, Inc., 1992.

3. Cevallos F., "APTS Data Archiving and Mining System (ADAMS)," Final Report, Prepared for the Florida DOT, Public Transit Office, September 2007.

4. Trepanier M., N. Tranchant, and R. Chapleau, "Individual Trip Destination Estimation in a Transit Smart Card Automated Fare Collection System," Journal of Intelligent Transportation Systems: Technology, Planning and Operations, Vol. 11, Issue 1, 2007.

5. Sutton, J., " GIS Applications in Transit Planning and Operations: A Review of Current Practice, Effective Applications and Challenges in the USA," Transportation Planning and Technology Vol. 28, Issue 4, August 2005.

APPENDIX A

1. Definitions of key terms used in tables and views

Terms used in most SQL statements.	
Avg()	Average Function which is used to calculate the average value of one dataset, this function is available in SQL Server
STDEV()	Standard deviation function which is used to calculate the sample standard deviation of one dataset. this function is available in SQL Server
Sum()	Sums the dataset. this function is available in SQL Server
Dow()	Day of Week determination. This function is available in Sybase.
Curr_r	Current Revenue
Uncl_r	Unclassified Revenue
ts	Time stamp
KeyX	Represents different rider groups

The Farebox_Year_Month_Hour_Weekday_Rider_View is created from the above *dbo.Farebox_YearRidership_0501TO0512* table. The following are SQL statement to create this view:

```
SELECT MONTH(CONVERT(datetime, SUBSTRING(ts, 2, 22))) AS Month,
DATEPART(hour, CONVERT(datetime, SUBSTRING(ts, 2, 22))) AS Hour,
DATENAME(WEEKDAY, CONVERT(datetime, SUBSTRING(ts, 2, 22))) AS Weekday,
riders, route, key7, curr_r, uncl_r, ttp8, ttp9, ttp3
FROM dbo.Farebox_YearRidership_0501TO0512
```

Many queries are based on *Farebox_Year_Month_Hour_Weekday_Rider_View*; the above SQL is the definition of that view, and the view is created to convert the data time into month, hour, and weekday for riders and senior riders.

The *Farebox_YearRidership_0501TO0512* table is a Farebox Event table which is described in table 3 of section four. The following is the database diagram for this table in SQL server 2008:

Farebox_YearRidership_0501TO0512

Column Name	Data Type	Allow N
route	int	☑
ts	varchar(50)	☑
curr_r	float	☑
uncl_r	float	☑
dump_c	int	☑
bill_c	int	☑
key1	int	☑
key2	int	☑
key3	int	☑
key4	int	☑
key5	int	☑
key6	int	☑
key7	int	☑
key8	int	☑
key9	int	☑
keyA	int	☑
keyB	int	☑
keyC	int	☑
keyD	int	☑
ttp1	int	☑
ttp2	int	☑
ttp3	int	☑
ttp4	int	☑
ttp5	int	☑
ttp6	int	☑
ttp7	int	☑
ttp8	int	☑
ttp9	int	☑
ttp10	int	☑
ttp11	int	☑
ttp12	int	☑
ttp13	int	☑
ttp14	int	☑
ttp21	int	☑
riders	int	☑
		☐

2. According to the farebox database table, ttp8 means "31-day disabled rolling pass" and ttp9 means "31-day senior rolling pass." Based on this information, we can build the following SQL to get the usage of fares and passes for seniors/disabled and general passengers by month. The data is selected from the above view.

```
select Month,sum(ttp8+ttp9) as senior_disabled_pass_riders ,
sum(key7) as senior_disabled_fare_riders, sum(riders) as
general_riders
from Farebox_Year_Month_Hour_Weekday_Rider_View
group by Month
order by Month
```

3. According to the farebox database table, (ttp8+ttp9+key7) means the ridership for senior and disabled. Based on this information, we can build the following SQL to get the ratios for seniors/total ridership by Month.

```
select Month,sum(ttp8+ttp9+key7) as senior_disabled_riders ,
sum(riders) as general_riders
,convert(float,sum(ttp8+ttp9+key7))/sum(riders) as ratios
from Farebox_Year_Month_Hour_Weekday_Rider_View
group by Month
order by Month
```

APPENDIX B

The following technical information was obtained from GFI's *CENTSaBILL Registering Bus Farebox System with TRiM Magnetic Ticket Processor* [2]. Although the actual farebox technical specifications will vary based on manufacturer, model, and year, the following information may be beneficial to agencies that are in the process of adopting a new farebox system.

1.1 Technical specifications:

1.1.1 Pass Reading The validity period encoded on each magnetic document used in the card reader is to be not less than one day and not more than 365. Normally the passes will be encoded with the date of issue and the date of expiration. Passes used prior to the date of validity or after the expiration date will not be valid.

The card reader is to function as a "read only" device and will not alter any of the encoded information on the pass. A subset of passes will be conditional use passes such as "off-peak only," "peak only," and "anytime" passes. Peak hours will be defined by CUSTOMER through the data system, and typically involve two time windows, one in the morning and one in the afternoon. "Off-peak only" passes will not be valid during these time windows, while "peak only" passes will be valid only during the time windows. "Anytime" passes will be valid at all times.

In consideration of potential fraud in successive multiple uses of a single pass the card reader will record the serial number of the valid pass just used and reject an attempt to use the same pass in the same card reader within an adjustable time span (factory set at five minutes). This is referred to as "passback control." In such events the driver's display will provide a visual indication that passback control has been invoked by displaying the word "PASSBACK."

1.1.2 Driver Program Cards The card reader is to be designed so that certain data routinely input by the driver can be entered into the farebox using a magnetic program card swiped through the reader rather than the driver keypad. Driver program cards will contain the driver's identification number. Once this number is placed in memory it will be appended to all data records until another driver identification number is entered through the keypad or with a magnetic card.

1.1.3 Processing Time The magnetic card reader will allow automatic processing of a correctly inserted, valid magnetic card in one-half second or less. Use of the magnetic

[2] CENTSaBILL Registering Bus Farebox System with Magnetic Ticket Processor Technical Specifications, Prepared By: GFI Genfare 751 Pratt Boulevard Elk Grove Village, Il 60007 847-593-8855 ISSUE DATE: 1/1/98

card reader will not impede passenger boarding or flow in any manner. The swiping of magnetic documents through the reader will be in the same general direction as the flow of patrons boarding the bus.

1.1.4 Passenger Indications The farebox will emit a "beep" to indicate that a fare has been paid with a proper and valid card.

1.1.5 Driver Indications When a valid pass is used, the driver's information display will indicate the type of pass read. Invalid, misread, or expired passes will be indicated with an appropriate message on the display, and the farebox will emit a sound distinctive from the "beep" of a valid fare. Passes rejected due to passback will also emit this distinctive sound.

1.1.6 Data Records, Transmission and Reports The card reader, in conjunction with the farebox, is to record the number and type of magnetic documents processed and other data pertinent to the operation of the system. This data will be uploaded to the data system through the farebox during probing.

1.1.7 Operating Environment The card reader will comply with all power and environmental specifications of the farebox.

1.2 Reliability

Documents inserted in the card reader will be read on first proper insertion with an accuracy of not less than 99.0%, assuming each document is valid and the document is not damaged so as to destroy the ability of the reader to correctly read the encoded data.

1.2.1 Identification and Labels

A decal or other graphics will be applied to the card reader in clear view of passengers to indicate the proper orientation of documents to be inserted.

1.2.2 Maintenance

The components of the card reader are to be modular in design for ease of servicing and replacement of subassemblies.

***Optional* Ticket Reader/Issue Machine (TRiM) - Magnetic Ticket Processing Unit**

General. To provide the ability to read and reencode magnetic fare documents, a ticket processing unit shall be provided. The Ticket Reader/Issue Machine (TRiM) mounts on the farebox and shall read and reencode magnetically encoded media such as tickets, transfers, and passes. Additionally, the TRiM shall time-stamp transfers, print the residual value of stored ride/value tickets on the face of the ticket, and encode and print on blank ticket stock fed from an internal cassette. The TRiM must be fully compatible with the farebox and capable of receiving and transmitting data from/to the farebox for the collection of ridership data and other purposes.

The TRiM shall issue transfers, receipts, or other agreed-upon documents using thermal paper printed upon issue. Issuance will be controlled by the farebox keypad and may reflect the amounts of money inserted and accepted. Each transfer issued has a machine-readable magnetic stripe allowing subsequent reinsertion into the TRiM.

The TRiM's shall also accept, read, verify, print upon and encode magnetic fare media such as passes, tickets, and transfers. Acceptance of and writing to documents will be controlled by the farebox keyboard and may reflect the amounts of money inserted and accepted.

1.2.3 Fare Media Acceptance and Ticket Handling

Reliability. Documents inserted shall be read on first proper insertion with an accuracy of better than 99.5%, assuming each document is valid and the document is not damaged sufficient to destroy the ability of the reader to correctly read the coded data.

Accuracy. Ticket re-encoding and verification accuracy shall be not less than 99.9% Re-encoding failure is defined as a ticket that cannot be read by the TRiM after re-encoding.

Determining Document Validity. The TRiM shall check the following data for validity on an inserted document:

- Expiration date
- Validity period
- Issuing agency
- Ticket type
- Passenger type
- Fare category
- Remaining value
- Transfer information
- Valid zones
- Passback
- Bad number

0.0.8 Transfer Acceptance. The TRiM shall accept transfers and determine their validity and authorized use. It shall accept the transfer, read it to determine validity, route of issue, and other agreed-upon restrictions of use, and capture or return the transfer as programmed.

A count of transfers accepted will be part of the information transmitted to the data system. The farebox will record in separate registers "Transfers Issued" and "Transfers Received."

The TRiM shall be programmed to:

- Permit or exclude round tripping on transfers.
- Provide for automatic acceptance or rejection of transfers after checking the validity parameters programmed.

Transfer Issuance with Cash Fare. If the proper fare has been paid, the TRiM shall issue a properly encoded ticket when the driver presses the appropriate button.

Transfer Issuance with Stored Value Card. Passengers wishing to transfer between buses using a stored value card will inform the driver upon initially boarding. The driver will then press a button and the base fare, and the transfer charge will be deducted and the appropriate information encoded on the card.

Alternately, an embedded transfer system shall be available where a stored value card is encoded with the date and time of first use (that trip) and on subsequent uses within a prescribed time frame, the TRiM shall read the prior usage (within a valid transfer time frame) and allow the payment of only the transfer fee on this second use. An example of this would be a passenger entering the first bus with a $20.00 stored value card, a $1.00 fare would be deducted (with a remaining value now on the card of $19.00) and the time and date of first use encoded on the card. On the second bus (within the valid transfer period), the TRiM would read the card, determine that a fare was already paid, and deduct only the $.25 transfer charge (resulting in a remaining value of $18.75 on the stored value card).

0.0.9 Pass and Ticket Processing. Passes and tickets used in the TRiM are preprinted and preencoded off the bus. Each document has an encodable magnetic stripe readable by the TRiM upon insertion. When a stored ride/value ticket is inserted, the TRiM shall deduct one ride or the proper amount from the quantity indicated on the ticket's magnetic stripe, re-encode the stripe, and print the quantity of remaining rides/value on the same side of the ticket as the stripe.

Two types of period (limited duration) passes shall also be supported. Passes whose validity periods are tied to a calendar interval (such as a month or week) are read-only passes. The TRiM shall read the ticket and check whether it is valid for the current date.

Other period passes may be issued with a given validity period not associated with a calendar interval. These passes, such as a 30-day or 7-day pass, shall be good for the specified number of days following their first use. These tickets will have their expiration date encoded on the magnetic stripe when first used. For all subsequent uses, the pass functions as a read-only pass. (These passes shall also have the expiration date printed on first use.)

Encoding on a Ticket. The magnetic stripe of the tickets shall be high-coercivity (typically 2700 Oersteds). All data on both the fixed and variable track shall be encoded at a minimum of 120 bits per inch and will be fully redundant. (Each track will have all data encoded twice with a separate zero pad and start and end sentinels, making the encoded data less susceptible to magnetic or physical damage.)

All encoded data is verified by the TRiM's read head before the ticket appears at the exit bezel. If the data read does not match what was written, the TRiM will reverse the ticket past the write head and try to write the data and verify it again. If, after three tries, the data cannot be verified, the TRiM will either capture the transfer and attempt to issue a new transfer or if the ticket is a stored value, abort the attempt.

A standard error detection scheme, 16-bit Cyclic Redundancy Check (CRC-16) shall be used to identify errors in decoded data. As long as one copy of each track's data remains intact, the card will be readable.

Printing on a Ticket. The TRiM shall print a ticket on blank ticket stock loaded inside it. Blank ticket stock is more secure than traditional transfer stock, having no value until printed and encoded by a TRiM. Ticket stock shall be supplied in a cassette with a capacity of at least 800 individually stacked tickets. Additional ticket stock shall be added before the existing stock is exhausted; a window in the TRiM will be provided to allow a visual indication of the amount of ticket stock remaining.

The printing shall be on the magnetic stripe side of the ticket. Printing will be of the thermal type, made up of dots with a resolution of not less than 190 dots per inch.

0.0.10 Passenger Indications. The farebox shall emit a "beep" to indicate that a fare has been paid with a proper and valid document. A warble shall indicate an invalid document. In normal circumstances no intervention is required on the part of the driver.

The 8-character passenger display shall show a variety of messages. These messages usually instructs the passenger to "INSERT" or some similar message. Other messages typically displayed include: "EXPIRED"; "VALID"; "N TRIPS" (where "N" is the number of trips remaining); "$XX.XX" (where $XX.XX is the remaining value); etc. Such messages shall be programmable.

Document Graphics. Three types of printing are required on magnetically encoded tickets:

- Direct thermal printing applied by the TRiM . This printing shall be created by a thermal printhead activating a direct thermal surface on the ticket.

- Thermal transfer printing applied by the Contractor's high-speed ticket encoder/printer. Thermal transfer printing (not to be confused with direct thermal printing) shall be used for information that changes periodically, such as month, year, serial number, etc. Thermal transfer printing is generated by computer in a manner similar to a laser printer. Thermal transfer printing may appear on both sides of the document, but it may not appear on the direct thermal area of a ticket. This printing is not done by the TRiM.

- Offset printing applied by the ticket manufacturer during the manufacturing process. Offset printing shall be used for printing which rarely or never changes, such as background patterns, rules, and directions for document use (including arrows showing how the document is to be inserted), warnings, etc. Offset printing may appear on both sides of the document. This printing is not done by the TRiM.

2. Data Collection and Reporting System

The data collection system will consist of a data probe(s) linked to an IBM PC-compatible computer capable of extracting and storing data from the bus fareboxes during routine servicing. The data system will be capable of generating reports for use by CUSTOMER for the generation of comprehensive management reports.

2.1 Data Collection System - General

Each data collection system will consist of the following:

- One or more data probes with junction box, supporting poles, lock boxes to secure the probe when not in use, interconnecting cabling, and an isolation box for transient voltage protection.

2.2 Data Computer

2.2.1 Computer Specification

The data computer will be IBM-compatible and capable of running commercially available software designed for IBM PC-compatible computers. Each computer will include the following:

- An 80486SX central processing unit operating at a minimum speed of 66 MHz
- A minimum of 4 MB of random access memory (RAM), expandable
- One 31/2" 1.44 MB floppy disk drive
- One 14-inch-diagonal color Super VGA monitor with antiglare shield
- Hayes-compatible modem, 9600 bps or faster, capable of using standard COM port 2
- Battery-powered real-time clock and calendar capable of keeping correct time for up to seven days without external power
- One 25-pin parallel port and one 9-pin serial port
- 101-key enhanced keyboard
- MS-DOS version 6.2 or higher operating system and BASIC programming language
- One 200 mbytes or greater internal hard disk with self-parking heads and an average access time of 28 milliseconds or faster; hard cards not acceptable
- Complete GFI data collection software
- All necessary manuals and documentation

All equipment will be delivered fully configured, with the hard drive formatted and DOS installed in a separate directory called DOS. The system will boot from the hard disk upon being switched on and will have been thoroughly tested prior to delivery.

Operation of the computer to generate data system reports will not prevent probing of the fareboxes. The data system will be protected against lockup of the processor. The computer will have the capacity to store the fare table, total number of buses and total revenue in event of a power failure. Self restart features will be incorporated. The hard disk drive will be capable of storing all of the data from 1,000 fareboxes with maximum route/run records; as new farebox records are added the oldest records on the disk drive will be automatically deleted. The CUSTOMER shall be able to specify how many days of detailed data and months of summary data will be saved.

The data system software will be written in a standard, commonly available computer language not proprietary to this application.

2.3 Reports

The following standard reports, at minimum, will be available from the data system. All reports will carry CUSTOMER's name, the date or period for which data is reported, and the date on which the report was generated and printed by the system. All reports will be generated through "user friendly" menu-driven software.

2.3.1 Individual Farebox/Bus Reports

For individual farebox reports, the printed report can show the following categories of data at minimum:

Current revenue (since last probing)
To-date revenue
Dump or unclassified revenue
Total full fare riders (ridership data will be supplied for
Key 1 - number of riders each fare table in use)
Key 2 - number of riders
Key 3 - number of riders
Key 4 - number of riders
Key 5 - number of riders
Key 6 - number of riders
Key 7 - number of riders
Key 8 - number of riders
Key 9 - number of riders
Key "*" - number of riders
TTP 1 - number
TTP 2 - number
TTP 3 - number
TTP 4 - number
TTP 5 - number
TTP 6 - number
TTP 7 - number
TTP 8 - number
TTP 9 - number
TTP 10 - number
TTP 11 - number
TTP 12 - number
Total tokens
Total tickets
Total passes
Total bills
Total coins by denomination

The first line of each individual farebox report (the "master list") will indicate the date and time of day the farebox was probed and the bus number and farebox number. Cumulative totals for the activity of that farebox between probings will be printed, corresponding to the column headings.

Trip-by-trip route/run data lists will be printed next, following printing of the master list. Each route/run record will be printed in the order in which it was created, along with notations of driver or route number(s) and the time record was created. It will be possible to transcribe this data from hard disk to other electronic storage medium for archiving or analysis purposes.

2.3.2 Daily Summary Report

The daily summary report may be printed on request at the end of the operating day. The end of the operating day may be designated by CUSTOMER as any time from 12:00 A.M. to 5:00 A.M. so that all buses that have operated on a given day will be accounted for, regardless of whether they are probed after midnight. The daily summary report will contain the same data categories listed above, less any that may be inactive or suppressed. Summary totals from master lists from all fareboxes probed that day will be provided. Route/run data will not be provided. The full matrix of fare tables (excluding any inactive or suppressed tables) will be printed showing the cumulative total ridership in each cell of the matrix. The daily summary report will also provide a report of total daily ridership.

The daily summary report will print a summary of the data from the exception report, indicating the total number of buses probed and not probed, security door and cashbox alarms, bypass alarms, maintenance required (including power supply), memory cleared, unknown driver, unknown bus, unknown route, unknown run and other anomalous data from the exception report. A list of the buses not probed, by bus number, will also be printed.

2.3.3 Periodic Summary Reports

The data system will also have the ability to generate summary reports for specific periods, as follows:

Monthly Summary Report: This report will summarize all activity fleetwide for a given month. Monthly summary information can be saved for up to 128 months. Totals are to be given for all pre-sets and keys, revenue, tokens, bills, tickets, etc., by day and totaled for the month. Optionally, bar charts will be printed giving total revenue by date and total ridership by date.

Annual Summary Report: This report will summarize the information given in the monthly summary report and give total by week, quarter and year to date. Optionally, each value of revenue, pre-set and key will be shown plotted by week in a separate bar chart.

Daily Route Summary Report: This report will summarize all totals by route for a given day fleetwide.

Monthly Route Summary Report: This report will summarize all totals by route for an entire month.

Route/Sum Report: This report will allow data over a period of time to be sorted first by route, then by run, or by time/date.

2.3.4 Route/Run Summary Report

The route/run summary report will be printed on request at the end of the operating day. It will contain the same headings listed above. Summary totals from the route/run lists will be printed in route number order, beginning with the lowest route numbers and progressing to the highest. Ridership will also be calculated and printed. For each route printed, the number of route run records included in the summary will be indicated.

It will also be possible to print more detailed reports on route/run data, sorting by and printing data for specific routes, runs and/or trips or all routes/runs. The same data as described in the last paragraph will be printed.

The report will present the individual route/run lists in order by time, with the earliest trip first; the route, run, trip and bus number will be shown on each record. The data in the route/run reports will be based on when the route/run record was actually created (actual date and time), regardless of when the bus was probed.

2.3.5 Exception Report

A daily exception report lists operator entry errors (invalid route, run driver or trip numbers) as validated against lists of valid numbers maintained by the data system.

2.3.6 Security Reports

The data system will have the ability to generate security reports, which will indicate all cashbox, door open and memory clear alarms. For each alarm, the time of day and the bus number will be indicated. For the security door and cashbox alarms, the report will also indicate the amount of revenue that was in the cashbox at the time the alarm was generated.

2.3.7 Editing Data

It will be possible to edit data in the data system in restricted ways. Only operator entries (route, run, driver and trip numbers) can be changed to preserve the security of the data system.

2.3.8 Transaction Log

A Transaction Log will be maintained in the data system computer. The Transaction Log will maintain a record of all uses of passwords to access reports, the reports accessed, the time of log on and log off, etc. In particular, all editing of data in the system will be recorded in the Transaction Log. The Transaction Log will maintain this information for a minimum of 60 days. It will not be subject to editing by users through any Contractor data system software.

APPENDIX C
Cubic Information[3]

1.1 Introduction

Cubic® Transportation Systems, Inc. is another provider of automated fare collection systems for public transport including bus, bus rapid transit, light rail, commuter rail, heavy rail, ferry and parking. Cubic's solutions and services include system design, central computer systems, equipment design and manufacturing, device-level software, integration, test, installation, warranty, maintenance, computer hosting services, call centre services, card management and distribution services, financial clearing and settlement, multi-application support and outsourcing services.

Every year, nearly 10 billion rides are taken worldwide using Cubic fare collection systems. Cubic has delivered over 400 projects in 40 major markets on five continents. Active projects include London; New York / New Jersey region; Washington, D.C. / Baltimore / Virginia region; Los Angeles region; San Diego region; San Francisco; Minneapolis/St. Paul; Chicago; Atlanta; Miami; Vancouver and Edmonton, Canada; Brisbane, Australia; and Scandinavia.

1.2 System Introduction and Diagram

Cubic's successful track record over the past 30 years in the fare collection business is built upon our reputation and commitment to delivering quality, reliability, innovation and customer focused solutions.

Their complete line of fare collection equipment for rail, bus and other transport modes utilizes common engineering platforms that enable us to leverage our proven technology to achieve lower development costs and faster delivery schedules for our customers while preserving flexibility for agency customizations.

[3] From official cubic company website: http://www.cubic.com/. Accessed in April, 2010

1.3 Automated Fare Collection Systems and Services Provider to Major Transportation Markets

London/PRESTIGE/Oyster Card
Largest smart card fare collection contract ever awarded
Cubic's contract value awarded under the PRESTIGE contract is now in excess of $1.2 billion since 1998

Sweden
$33 million in contracts awarded since 2005

New York/New Jersey Region
$525 million in contracts awarded since 1991

Washington D.C./Baltimore/Virginia Region
$186 million in contracts awarded since 2000

$402 million in contracts awarded since 1975

Los Angeles Region
$208 million in contracts awarded since 2002

San Diego Region
$29 million in contracts awarded since 2002

San Francisco Bay Area
$93 million in contracts awarded since 1999

Minneapolis/St. Paul
$22 million in contracts awarded since 2002

Chicago
$111 million in contracts awarded since 1993

Atlanta
$96 million in contracts awarded since 2002

Brisbane, Australia
$145 million in contracts awarded since 2003

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