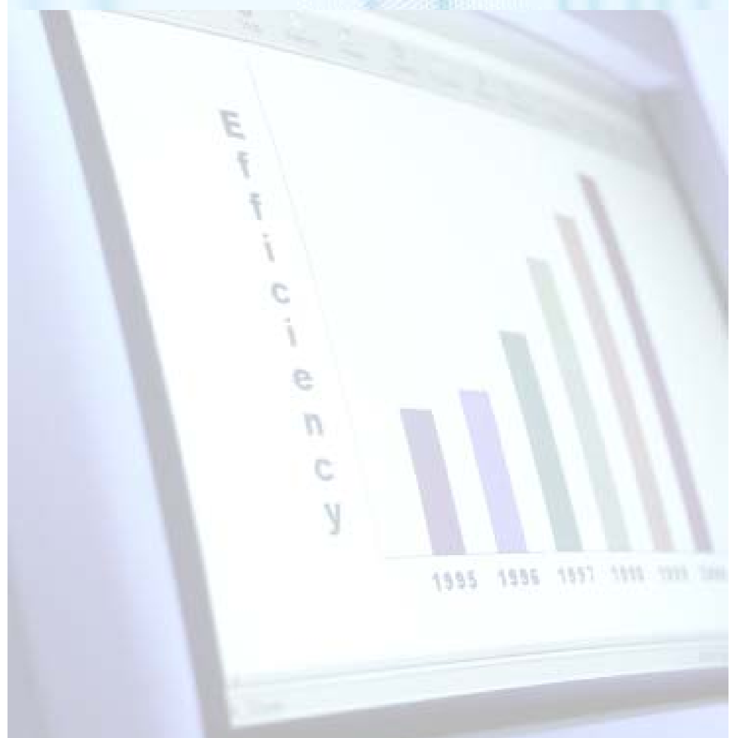
# Handbook of Automated Data Collection Methods for the National Transit Database

October 2003




FDOT BC137-40

**TECHNICAL REPORT STANDARD TITLE PAGE**

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| NCTR - 473 - 11<br>FDOT BC137-40 | | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Handbook of Automated Data Collection Methods for the National Transit Database | October 2003 |
| | 6. Performing Organization Code |
| 7. Author(s)<br>Perk, Victoria; and Kamp, Nilgün | 8. Performing Organization Report No. |
| 9. Performing Organization Name and Address<br>National Center For Transit Research (NCTR)<br>University of South Florida CUT 100<br>4202 East Fowler Avenue, Tampa, FL 33620 | 10. Work Unit No.<br><br>11. Contract or Grant No.<br>DTRS98-G-0032 |
| 12. Sponsoring Agency Name and Address<br>Office of Research and Special Programs (RSPA)<br>U.S. Department of Transportation, Washington, D.C. 20590<br><br>Florida Department of Transportation<br>605 Suwannee Street, MS 26, Tallahassee, FL 32399 | 13. Type of Report and Period Covered<br><br>14. Sponsoring Agency Code |

15. Supplementary Notes

Supported by a Grant from the USDOT Research and Special Programs Administration, and the Florida Department of Transportation

16. Abstract

In recent years, with the increasing sophistication and capabilities of information processing technologies, there has been a renewed interest on the part of transit systems to tap the rich information potential of the NTD for the purpose of improving transit operations. Because the NTD contains the only standardized collection of performance data for urban transit providers in the nation, it has become an important transit evaluation tool. In many cases, however, there have been concerns about the accuracy of the NTD information, even after final Federal Transit Administration (FTA) validation. Many of the errors found in the NTD are often related to data collection problems experienced by transit agencies and many of these agencies have expressed difficulties in collecting some elements of the NTD data. Hence, they are requesting help with collecting data from the correct sources, ease of obtaining the NTD data, determining operational procedure guidelines to collect data more efficiently, and gathering data from their contractors. This document provides examples of the capabilities of automated methods available for collecting and compiling data for the NTD. However, automated methods included in this document have capabilities beyond collecting the data necessary for the NTD, which in fact may be the primary reason for agencies to acquire these tools in the first place.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| public transit, NTD, data collection, software, APC, mobile data terminals | Available to the public through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22161, (703) 487-4650, http://www.ntis.gov/, and through the NCTR web site at http://www.nctr.usf.edu/. |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 60 | |

Form DOT F 1700.7

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# HANDBOOK OF AUTOMATED DATA COLLECTION METHODS FOR THE NATIONAL TRANSIT DATABASE

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# List of Exhibits

# I. INTRODUCTION

As part of its National Center for Transit Research (NCTR) Program, the Center for Urban Transportation Research (CUTR) has been working with the Florida Department of Transportation (FDOT) to conduct research that will assist transit agencies in their collection of the non-financial data for the National Transit Database (NTD). This handbook documents the findings of that research in a format that is designed to make it a useful reference for transit systems in their collection and application of NTD data.

In recent years, with the increasing sophistication and capabilities of information processing technologies, there has been a renewed interest on the part of transit systems to tap the rich information potential of the NTD for the purpose of improving transit operations. Because the NTD contains the only standardized collection of performance data for urban transit providers in the nation, it has become an important transit evaluation tool. In many cases, however, there have been concerns about the accuracy of the NTD information, even after final Federal Transit Administration (FTA) validation. Many of the errors found in the NTD are often related to data collection problems experienced by transit agencies and many of these agencies have expressed difficulties in collecting some elements of the NTD data. Hence, they are requesting help with collecting data from the correct sources, ease of obtaining the NTD data, determining operational procedure guidelines to collect data more efficiently, and gathering data from their contractors.

In the course of this study, CUTR conducted interviews with Florida transit agencies to understand existing methods of collecting data and current issues/problems faced in doing so. Results of these interviews are included in Appendix A. In addition, CUTR conducted research on available automated methods that have the capability to increase ease of data collection and accuracy, findings of which are included in Appendix B. The results of the transit agency interviews and research on available technologies provide a focus for the illustrative examples shown in this handbook.

Interviews with representatives of the transit agencies and the review of NTD Detail Review Letters (DRL), and the 2001 Performance Reporting Investigation (PRI) [1] findings suggested that the following areas were most challenging for agencies in collecting and reporting the NTD information:

- <u>Service Area Population and Service Area Square Miles:</u> Data for service area population and service area square miles often do not reflect the correct statistics. Figures tend to

[1] PRI reports compare NTD statistics submitted by transit agencies to the same statistics published in local newspaper advertisements in accordance with Florida Statutes, Section 341.071(3). The published data are compared with data from the agencies' individual NTD reports to determine if any differences existed and to discuss potential explanations for these differences.

be overestimated if agencies do not use route network buffers to accurately reflect service area, or underestimated if agencies do not update the information regularly.

- Information from Subcontractors: Obtaining the necessary and accurate information from subcontractors, such as the correct number of vehicle inventory and accurate sampling figures used to estimate the number of passenger miles and passengers were cited as the primary areas where agencies experienced difficulties.

- Estimating Passenger Miles: Agencies that were interviewed stated that sampling for the purpose of estimating passenger miles, is a highly time-consuming and expensive process. As mentioned previously, this also was one of the most challenging statistics to obtain accurately from contractors. In addition, this statistic was among those that raised most of the questions in DRLs.

- Other statistics that raised the most questions in the DRLs and/or PRIs included the following:
  - Total actual vehicle hours;
  - Total actual vehicle revenue hours;
  - Total actual vehicle miles;
  - Total actual vehicle revenue miles; and
  - Unlinked passenger trips.

  Specific issues related to these statistics included:
  - Unusually high/low average speed during deadheading or while vehicles are in revenue service;
  - Large variations from figures reported in previous years;
  - Inconsistent changes from previous years (e.g., declining number of total actual vehicle revenue hours with increasing total actual revenue miles, etc.); and
  - Inconsistencies between data reported for average weekday/Saturday/Sunday service and data reported for annual service.

The remainder of this handbook provides examples of automated methods available in collecting data for the above-identified areas. This handbook focuses on the capabilities of these tools in collecting the NTD data. However, automated methods included in the handbook have capabilities beyond collecting the data necessary for the NTD, which in fact may be the primary reason for agencies to acquire these tools in the first place. An overview of these capabilities is provided in Appendix B.

All of the "problem" areas discussed above are included either in the Basic Information Module or the Transit Agency Service Module of the NTD reporting system. The handbook is organized in the order of NTD modules, followed by specific problem areas in each module.

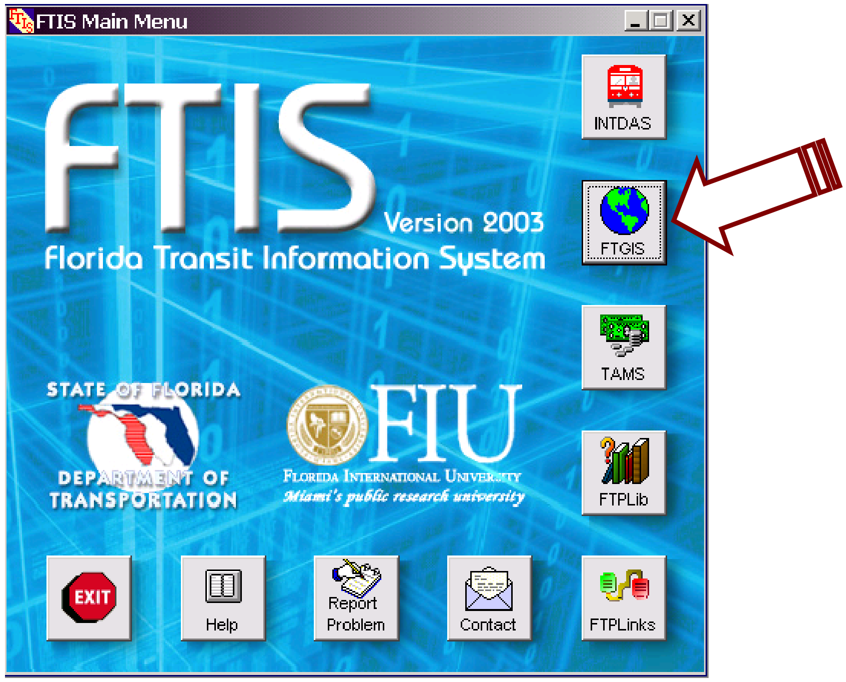
# II. BASIC INFORMATION MODULE

In the Basic Information Module, service area geographic size and service area population are two variables where accuracy problems are often experienced. Primarily, the problems result from a failure to use buffers around route networks when calculating this information as well as failing to update the information on a regular basis.

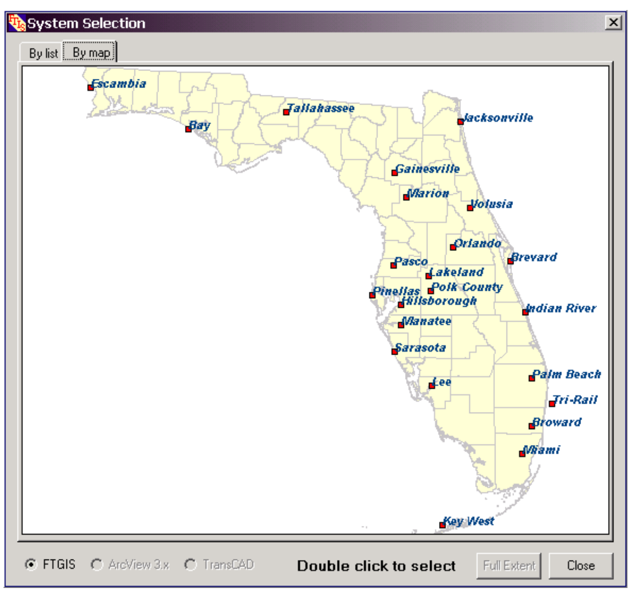
The two variables of service area size and population can be obtained accurately by using Geographic Information Systems (GIS), which integrate data and spatial information to allow for various forms of analyses. GIS data are stored in layers of information that can identify trends and patterns not easily recognizable from data in typical tabular or spreadsheet formats. By adding a geo-spatial element to the data (i.e., by identifying elements' geometry/shape as well as relevant location on earth/geography), users are able to recognize patterns in the data such as proximity, clustering, and adjacency of data units such as Census tracts/blocks or traffic analysis zones (TAZs), among others. More advanced uses of geo-spatial data would include calculating proportional area values, such as the service area of a particular transit route or route network, in square miles (e.g., calculating the size and/or population of an area within ¾-mile of a route or routes). By capturing the most fundamental parts of a transit system in GIS, such as the routes and stops/stations, a transit agency will establish the foundation for a useful, robust GIS system. Such a foundation will allow the agency to conduct a wide range of analyses, including the automation of many of its NTD reporting requirements, as well as other in-house data monitoring functions. Using GIS, agencies can calculate their service area populations according to the latest Census data available and update these figures regularly using population growth estimates available through local universities, metropolitan planning organizations (MPOs), or other similar organizations.

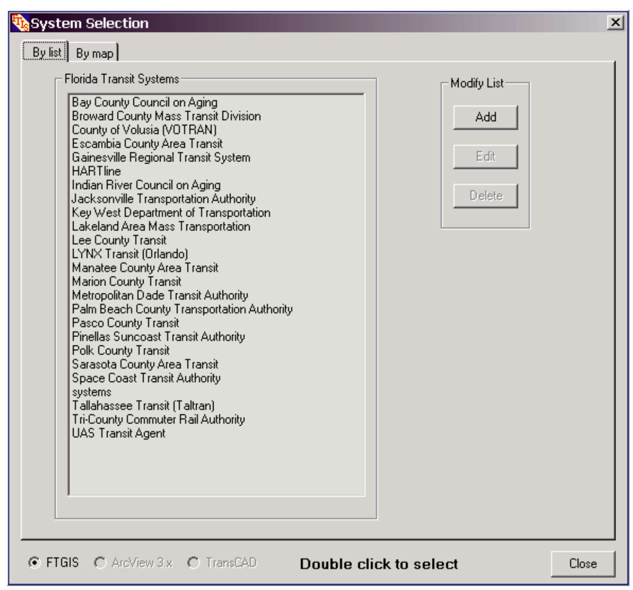
An example of a database using GIS and available to transit agencies through FDOT is the Florida Transit Information System (FTIS) database. This database includes NTD statistics for most U.S. transit agencies and is available on CD or through http://www.eng.fiu.edu/LCTR/Ftis/ftis.htm. Extensive instruction on how to use FTIS is provided on the website and also in the application. As explained in Appendix B, this database has GIS capabilities to provide service area population and size figures for most of the Florida agencies. It should be noted that the latest data used in the FTIS database include 2000 Census population figures and 2001 route information. The following instructions and screen shots provide a step-by-step illustration of how this tool is used for computing service area population and geographic size.

1. Once the FTIS program is opened, the following screen will appear. The user should select the FTGIS icon for service area size and population information.

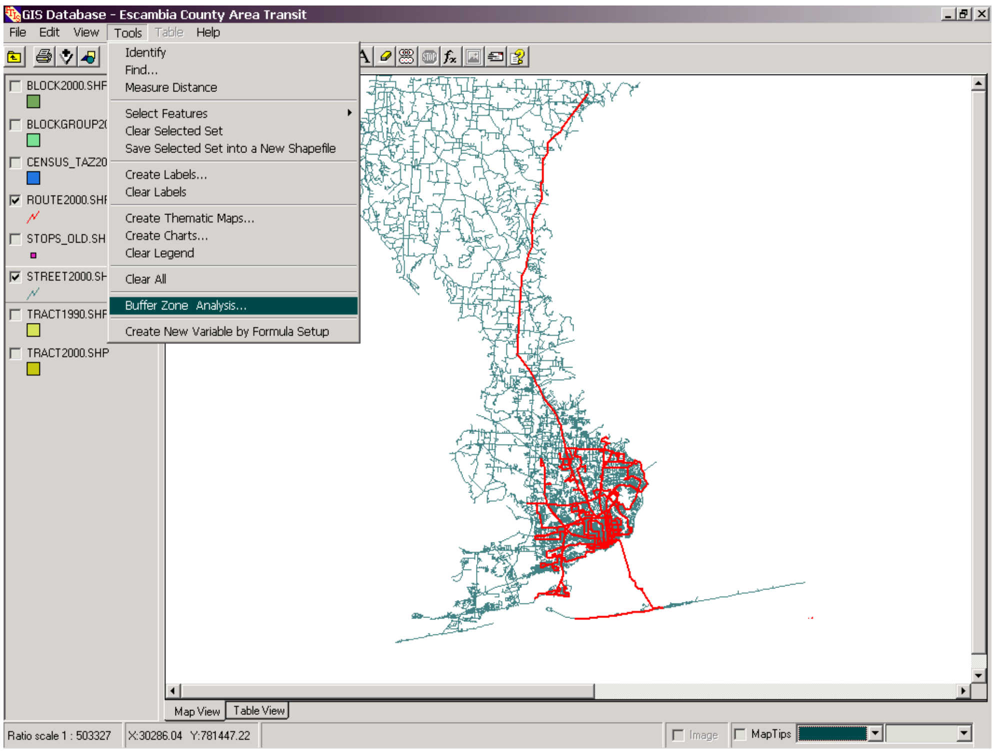



2. The list of agencies will appear either as a list or on a map as shown in the following two pictures. Select the desired agency from either format by double-clicking on the name.

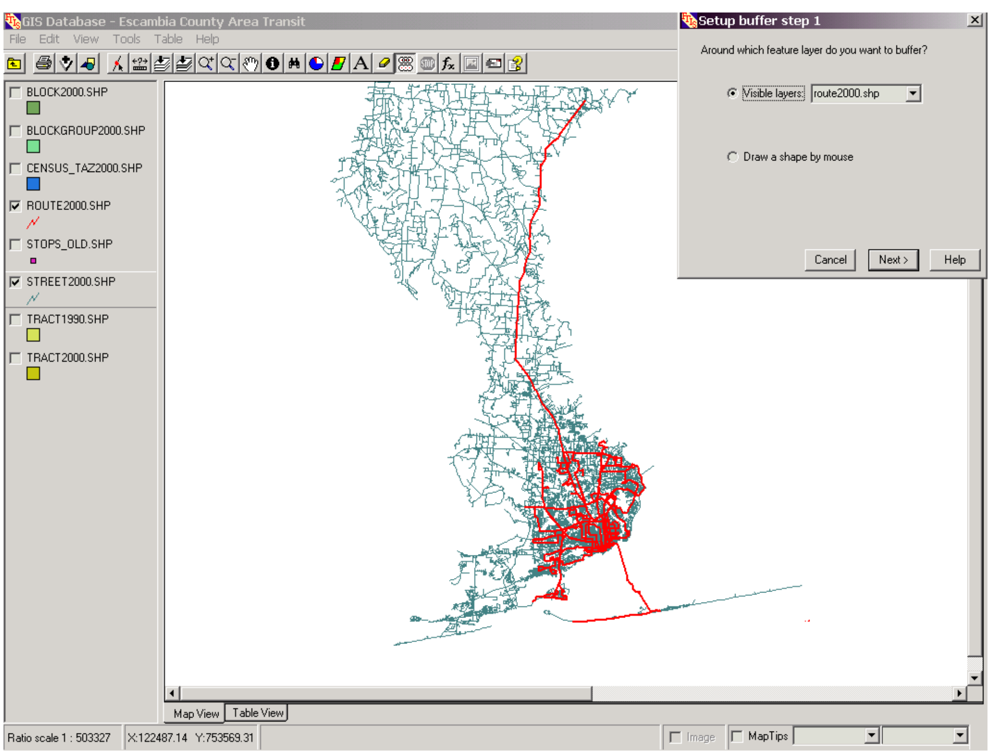


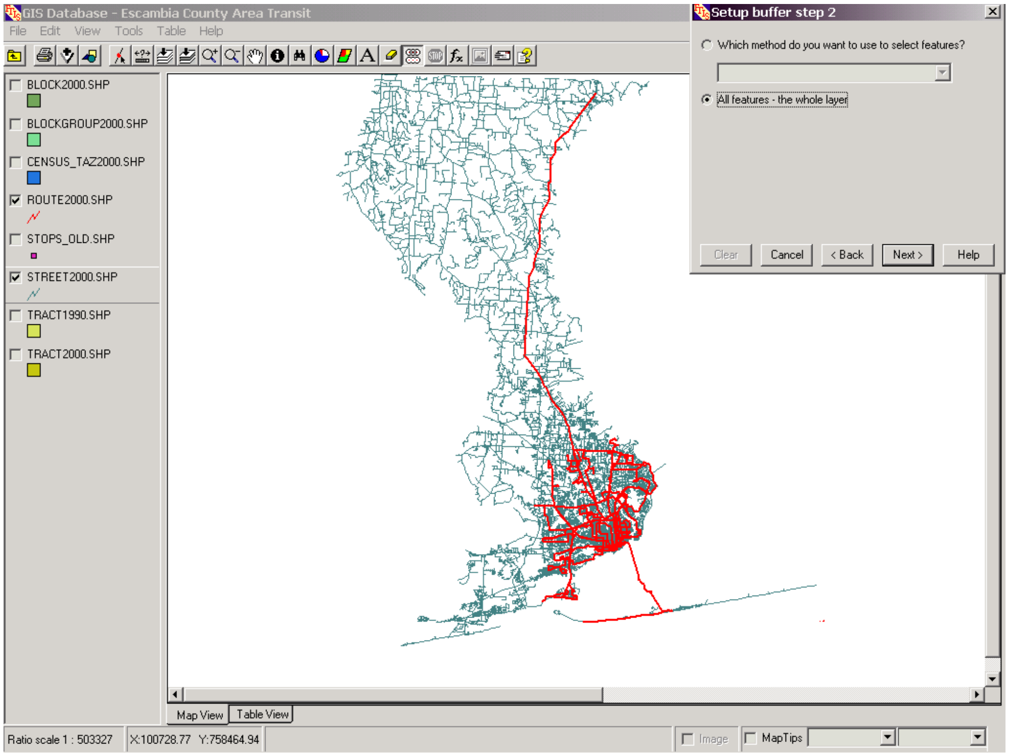
3. Selecting Escambia County Transit brings up the system's route map. Once the route map screen appears, go under **Tools** and select **Buffer Zone Analysis.**



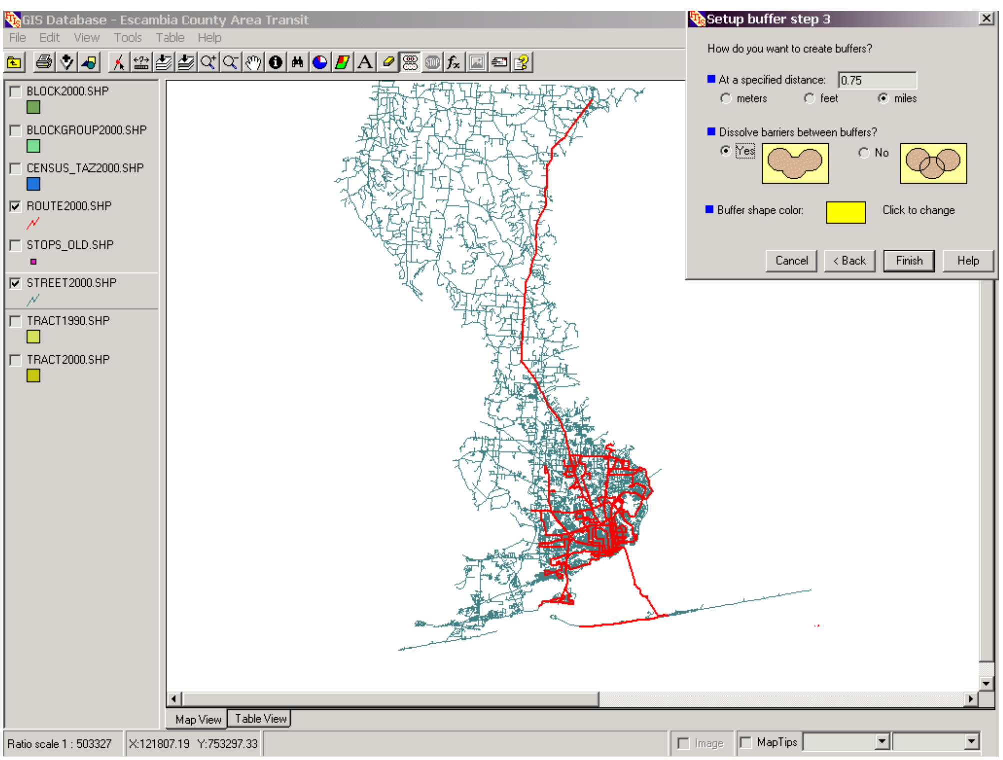

4. Select **Visible Layers** for **Route2000**. Then click on **Next**.



5. Select **All Features** and click on **Next.**

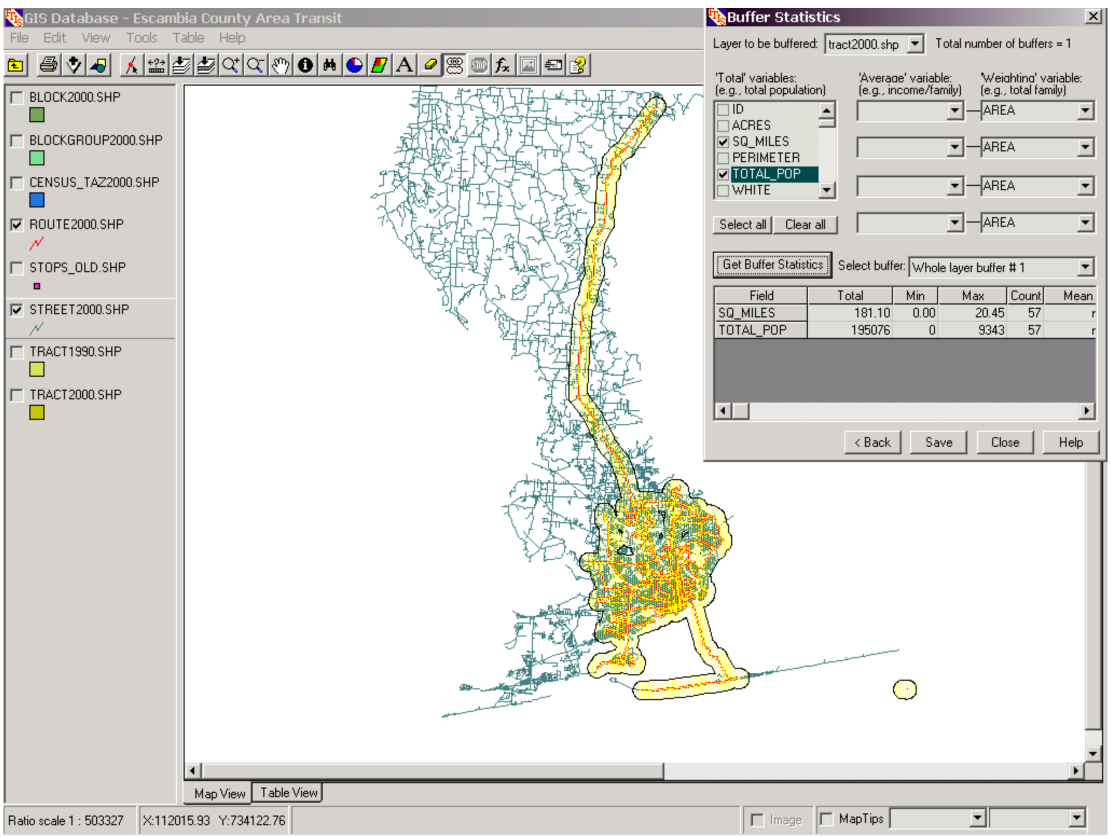



6. Specify the distance (e.g., 0.75 miles for ¾-mile boundary) and select **Yes** for dissolving barriers and hit **Finish**.



7. Select the desired layer to be buffered (tract, block, etc.) and variables for which statistics are required. In the example below, square miles and total population are selected. Click on **Get Buffer Statistics** and the database will provide requested statistics in a spreadsheet. In addition, it is possible to view the selected area on a map.

As shown in the screen capture below, using 2000 Census data, Escambia County Transit's fixed-route service area population is 195,076 and the service area size within a three-quarter-mile buffer around the fixed routes is 181.10 square miles.



As mentioned previously, the FTIS currently includes 2001 route information. Changes to agencies' routes should be considered prior to using figures from FTIS. In addition, 2000 population figures should be updated using population growth rate estimates obtained from local universities, MPOs, City/County Economic Development departments, and other similar organizations.

In addition to FTIS, CUTR is in the process of developing a database that will include Census 2000 data and system information of Florida agencies. The database will provide interactive maps at the system, route, and stop levels. A CD version of the database is expected to be available to the agencies in May 2003.

In addition to these tools available to Florida agencies, transit agencies or Departments of Transportations in other states may have developed similar tools for performing the same functions.

# III. TRANSIT AGENCY SERVICE MODULE

Within this module, the following statistics were identified to be the most challenging:

- Passenger miles;
- Total actual vehicle hours;
- Total actual vehicle revenue hours;
- Total actual vehicle miles;
- Total actual vehicle revenue miles; and
- Unlinked passenger trips.

## Data Compilation for *Passenger Miles*

Unlike all other data reported in the NTD, passenger miles may be an estimate based on a sampling procedure that meets FTA requirements for confidence (95 percent) and precision (10 percent) levels. FTA has developed acceptable passenger mile sampling procedures for fixed route and demand response services. These techniques are described in FTA Circular 2710.1A for fixed route and FTA Circular 2710.2A for demand responses. These two circulars are available through the NTD's home page by selecting "Publications", then "Reference Material." (CUTR is currently conducting a study that will explore options to reduce sample size for the FTA approved method as well as the viability of alternative methods that require smaller sample sizes.). Agencies have to sample or collect 100-percent counts of passenger miles in mandatory years. The mandatory years are fixed in one-year, three-year, or five-year cycles based on urbanized area population, number of vehicles operated in annual maximum service, and type of service.

There are several methods/automated tools available that can be used by transit agencies during the data collection and/or estimation phases based on these sampling procedures, including:

- Spreadsheets;
- Handheld units;
- Automatic passenger counting (APC) units; and
- Mobile Data Terminals (MDTs).

### *Spreadsheet Tools*

This section presents examples of Excel worksheets to keep track of the data upon collection by checkers for the purpose of estimating passenger miles. The sample Excel worksheets presented here focus primarily on the statistics required by the NTD. However, if transit agencies would like to track additional information for their internal purposes, these worksheets can be modified to include those variables. Similarly, agencies can use other spreadsheet programs such as Lotus or Quattro Pro.

***Fixed Route Spreadsheets***

Information collected during each sampled trip can be entered into an Excel spreadsheet in the format presented in Exhibit III-1 on the following page. Cells that are highlighted are those that need to be filled by surveyors for each trip. The non-highlighted cells contain formulas or pre-filled information. Of these, the column titled "Load" simply calculates the number of passengers on board by taking the load from the previous stop, adding the number of passengers who got on at the next stop and subtracting the number of people who got off. Figures under the column titled "Psgr miles," which refers to passenger miles, are calculated by multiplying the load and the distance between two stops. (Please note that numbers shown in the Exhibits in this section do not represent actual trips. They are used for illustrative purposes only.).

It is possible to prepare a template for each route with the distance between stops prior to entering any other data. As routes are selected for sampling, the appropriate template would be used to insert passenger information. Of course, any changes to the routes should be reflected by adding/deleting rows and adjusting the distance calculations between stops.

## EXHIBIT III-1: Fixed-Route Passenger Miles Spreadsheet Example (For Service with Designated Stops)

### Passenger Miles Worksheet

| | |
|---|---|
| **Date:** | 26-Mar-03 |
| **Day of the Week:** | Th |
| **Scheduled Time:** | 6:30A-7:10 A |
| **Trip Number:** | 201 |
| **Route Number:** | 1 |
| **Vehicle Number:** | 5 |

| Stop | Stop Description | Distance | Ons | Offs | Load | Psgr Miles | Ons | Offs | Load | Psgr Miles |
|---|---|---|---|---|---|---|---|---|---|---|
| **1** | **First Stop (Name/Description)** | 0.00 | 5 | | 5 | 0.00 | | | | |
| 2 | Stop Name/Description | 0.18 | 2 | 1 | 6 | 0.90 | | | | |
| 3 | Stop Name/Description | 0.39 | | 3 | 3 | 2.34 | | | | |
| 4 | Stop Name/Description | 0.11 | 6 | | 9 | 0.33 | | | | |
| 5 | Stop Name/Description | 0.15 | 8 | | 17 | 1.35 | | | | |
| 6 | Stop Name/Description | 0.30 | | 2 | 15 | 5.10 | | | | |
| 7 | Stop Name/Description | 0.10 | | 6 | 9 | 1.50 | | | | |
| 8 | Stop Name/Description | 0.34 | 5 | | 14 | 3.06 | | | | |
| 9 | Stop Name/Description | 0.18 | 4 | 3 | 15 | 2.52 | | | | |
| 10 | Stop Name/Description | 0.47 | 3 | 2 | 16 | 7.05 | | | | |
| 11 | Stop Name/Description | 0.16 | | | 16 | 2.56 | | | | |
| 12 | Stop Name/Description | 0.76 | 4 | | 20 | 12.16 | | | | |
| 13 | Stop Name/Description | 0.09 | | 8 | 12 | 1.80 | | | | |
| 14 | Stop Name/Description | 0.15 | | | 12 | 1.80 | | | | |
| 15 | **Last Stop (Name/Description)** | 0.45 | | 12 | 0 | 5.40 | | | | |
| | Trip Totals | **3.83** | | | | | **37** | **37** | | **47.87** |

| | |
|---|---|
| **Date:** | 14-Apr-03 |
| **Day of the Week:** | M |
| **Scheduled Time:** | 5:30A-5:55A |
| **Trip Number:** | 204 |
| **Route Number:** | 2 |
| **Vehicle Number:** | 8 |

| Stop | Stop Description | Distance | Ons | Offs | Load | Psgr Miles | Ons | Offs | Load | Psgr Miles |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **First Stop (Name/Description)** | 0.00 | 5 | | 5 | 0.00 | | | | |
| 2 | Stop Name/Description | 0.20 | | | 5 | 1.00 | | | | |
| 3 | Stop Name/Description | 0.52 | | | 5 | 2.60 | | | | |
| 4 | Stop Name/Description | 0.40 | 3 | 2 | 6 | 2.00 | | | | |
| 5 | Stop Name/Description | 0.31 | | | 6 | 1.86 | | | | |
| 6 | Stop Name/Description | 0.19 | 3 | | 9 | 1.14 | | | | |
| 7 | Stop Name/Description | 0.17 | | 2 | 7 | 1.53 | | | | |
| 8 | Stop Name/Description | 0.36 | | | 7 | 2.52 | | | | |
| 9 | Stop Name/Description | 0.11 | 4 | 3 | 8 | 0.77 | | | | |
| 10 | Stop Name/Description | 0.14 | | | 8 | 1.12 | | | | |
| 11 | Stop Name/Description | 0.20 | 8 | | 16 | 1.60 | | | | |
| 12 | Stop Name/Description | 0.14 | | 1 | 15 | 2.24 | | | | |
| 13 | **Last Stop (Name/Description)** | 0.22 | | 15 | 0 | 3.30 | | | | |
| | Trip Totals | **2.96** | | | | | **23** | **23** | | **21.68** |

| | |
|---|---|
| **Total Passengers** | **60** |
| **Total Passenger Miles** | **70** |
| **Total Trips** | **2** |

An alternative format for fixed route service without designated bus stops (i.e., using flagging system) can be the following example in Exhibit III-2:

**EXHIBIT III-2: Alternate Fixed-Route Passenger Miles Spreadsheet Example (For Service with Flag Stops)**

**PASSENGER MILES WORKSHEET**

| Day of Week | Beg. Time | Trip # | Route # | Veh. # | | Odometer | # of Psgrs On | Off | Difference (Miles) | Difference (Psgrs on Board) | Psgr Miles |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Wednesday | 6:15 AM | 101 | 2 | 1 | Beg of Trip | 3,000 | 2 | | N/A | 2.0 | N/A |
| | | | | | Stop 1 | 3,002 | 3 | 1 | 2.0 | 4.0 | 4.0 |
| | | | | | Stop 2 | 3,003 | 1 | | 1.0 | 5.0 | 4.0 |
| | | | | | Stop 3 | 3,006 | | 2 | 3.0 | 3.0 | 15.0 |
| | | | | | Stop 4 | 3,007 | 4 | 1 | 1.0 | 6.0 | 3.0 |
| | | | | | Stop 5 | 3,009 | | 2 | 2.0 | 4.0 | 12.0 |
| | | | | | Stop 6 | 3,010 | 3 | 1 | 1.0 | 6.0 | 4.0 |
| | | | | | Stop 7 | 3,011 | 2 | 3 | 1.0 | 5.0 | 6.0 |
| | | | | | Stop 8 | 3,014 | 4 | | 3.0 | 9.0 | 15.0 |
| | | | | | End of Trip | 3,017 | | 9 | 3.0 | 0.0 | 27.0 |
| Friday | 6:30 AM | 203 | 1 | 3 | Beg of Trip | 3,000 | 2 | | N/A | 2.0 | N/A |
| | | | | | Stop 1 | 3,002 | 3 | 1 | 2.0 | 4.0 | 4.0 |
| | | | | | Stop 2 | 3,003 | 1 | | 1.0 | 5.0 | 4.0 |
| | | | | | Stop 3 | 3,006 | | 2 | 3.0 | 3.0 | 15.0 |
| | | | | | End of Trip | 3,007 | | 3 | 1.0 | 0.0 | 3.0 |
| | | | | | ***Totals*** | | **25** | | | | **116** |

In this second format, shown above in Exhibit III-2, surveyors need to record odometer readings each time the bus stops to pick-up or drop-off a passenger. This information is used to calculate mileage between stops, which in turn is needed to calculate passenger miles.

Information obtained from either format in Exhibits III-1 and III-2 could be summarized by annual weekday, Saturday, and Sunday totals on a summary sheet in the same Excel file. In the case of mandatory sampling years, the summary and expansion could be in the format shown in Exhibit III-3 on the following page. Items (a), (b), and (c) would be obtained from the tables presented above. Item (d) is obtained by dividing (a) by (c) while item (e) is obtained by dividing (b) by (c). The number of actual trips, (f), is obtained from agencies' trip schedules adjusted for any missing trips.

## EXHIBIT III-3: Fixed-Route Passenger Miles Spreadsheet Summary Example

### *Summary of Statistics*

***Annual Sampling Totals:***

| | Ridership (a) | Passenger Miles (b) | Trips (c) | Avg Ridership per Trip (d) | Avg Psgr Miles per Trip (e) |
|---|---|---|---|---|---|
| Weekday | 60 | 76 | 2 | 30.0 | 37.78 |
| Saturday | 68 | 140 | 2 | 34.0 | 70.12 |
| Sunday | 58 | 156 | 2 | 29.0 | 77.98 |
| *Annual Total* | *186* | *372* | *6* | *31.0* | *61.96* |

***From 100% Counts:***

| | Ridership (f) | Trips (g) |
|---|---|---|
| Weekday | 500 | 100 |
| Saturday | 500 | 75 |
| Sunday | 400 | 70 |
| *Annual Total* | *1,400* | *245* |

***Expansion:***

**Mandatory Year:**

| | Ridership (h) | Psgr Miles (i) | Avg psgr miles (j) |
|---|---|---|---|
| Weekday | 3,000 | 3,778 | 1.26 |
| Saturday | 2,550 | 5,259 | 2.06 |
| Sunday | 2,030 | 5,458 | 2.69 |
| *Annual Total* | *7,580* | *14,495* | 1.91 |

**Intermediate Year:**

| | Ridership (k) | Psgr Miles (l) |
|---|---|---|
| Weekday | 500 | 630 |
| Saturday | 500 | 1,031 |
| Sunday | 400 | 1,076 |
| *Annual Total* | *1,400* | *2,736* |

NOTE: Figures may not add due to rounding.

Also in Exhibit III-3, during mandatory sampling years, expansion to reach the total annual ridership, (h), will be completed by multiplying (g) by (d) and the total annual passenger miles, (i), will be obtained by multiplying (g) by (e). Finally, item (j) is simply the division of (h) by (i) and will be used to estimate total passenger miles in non-mandatory years.

It should be noted that, if available, 100-percent counts for both passenger miles and unlinked passenger trips could be used instead of estimates reached through sampling and in fact the 100-percent count method is preferred to sampling as mentioned in the NTD Reporting Manual (www.ntdprogram.com ; Current Reporting Manual).

Finally, as illustrated in Exhibit III-3 on the previous page, during the intermediate years, ridership figures will be obtained through 100-percent counts while passenger miles, (l) can be obtained by multiplying ridership, (k), by average passenger miles per passenger (j).

The design of the summary can be altered to record trips by route, by day or month, etc., if the agency is interested in monitoring passenger mile and ridership information in any of these formats to achieve additional insight regarding the operations.

***Demand Response Spreadsheets***

Information collected during each sampled trip can be entered into an Excel spreadsheet in the format example presented in Exhibit III-4 on the next page. Cells that are highlighted are those that need to be filled by drivers or dispatchers for each trip. Cells that are not highlighted include formulas. Of these, “Difference (Miles)” is calculated as the difference in odometer readings between stops. The column titled “Difference (Psgrs on Board)” represents the load and is calculating by adding the passengers getting on to the load from the previous stop and subtracting passengers getting off. “Psgr Miles,” or passenger miles, is simply the multiplication of load and distance between stops.

## EXHIBIT III-4: Demand-Response Passenger Miles Spreadsheet Example

**PASSENGER MILES WORKSHEET**

| Day of Week | Beg. Time | Driver # | Veh. # | Pick/up or Drop-off Address | Odometer | # of Psgrs On | # of Psgrs Off | Difference (Miles) | Difference (Psgrs on Board) | Psgr Miles |
|---|---|---|---|---|---|---|---|---|---|---|
| Wednesday | 8:00 AM | 15 | 1 | 4202 E. Fowler | 3,000 | 2 | | N/A | 2.0 | N/A |
| | | | | 400 N. Ashley | 3,002 | | 1 | 2.0 | 1.0 | 4.0 |
| | | | | Address | 3,006 | 8 | | 4.0 | 9.0 | 4.0 |
| | | | | Address | 3,011 | | 2 | 5.0 | 7.0 | 45.0 |
| | | | | Address | 3,019 | 4 | 1 | 8.0 | 10.0 | 56.0 |
| | | | | Final Address | 3,022 | | 10 | 3.0 | 0.0 | 30.0 |
| Thursday | 9:00 AM | 12 | 3 | Beg Address | 5,012 | 5 | | N/A | 5.0 | N/A |
| | | | | Address | 5,020 | 3 | 1 | 8.0 | 7.0 | 40.0 |
| | | | | Address | 5,024 | 3 | | 4.0 | 10.0 | 28.0 |
| | | | | Address | 5,029 | | 6 | 5.0 | 4.0 | 50.0 |
| | | | | Final Address | 5,033 | | 4 | 4.0 | 0.0 | 16.0 |
| | | | | ***Totals*** | | 25 | | | | 273 |

Some of the information in highlighted cells can be filled prior to the trip. For example, pick-up/drop-off addresses and the number of passengers who are scheduled to get on and off can be prepared prior to the trip. During the actual trip the driver would confirm pre-filled information and add the remaining information. (Please note that numbers shown in the Exhibits in this section do not represent actual trips. They are used for illustrative purposes only.).

Information obtained in this format could be summarized by annual weekday, Saturday, and Sunday totals on a summary sheet in the same Excel file, as illustrated in Exhibit III-5 on the following page. Items (a), (b), and (c) were obtained from the previous tables. Item (d) is obtained by dividing the annual total figure for (b) by (c). The total number passengers, (e), is obtained through 100-percent counts. The expansion to obtain total passenger miles, (f), is completed by multiplying the average trip distance (d) with actual ridership (e). The design of the summary can be altered to record trips by day, by month, etc., if the agency is interested in monitoring passenger mile and ridership information in any of these formats to achieve additional insight on its operations.

## EXHIBIT III-5: Demand-Response Passenger Miles Spreadsheet Summary Example

### *Summary of Statistics*

***Based on Sampling:***

| | Ridership (a) | Passenger Miles (b) | Trips (c) | Average Trip Distance (d) |
|---|---|---|---|---|
| Weekday | 25 | 273 | 2 | 10.92 |
| Saturday | 25 | 240 | 2 | 9.60 |
| Sunday | 27 | 312 | 2 | 11.56 |
| *Annual Total* | *77* | *825* | *6* | *137.50* |

***Based on Actual Figures:***

| | Ridership (e) |
|---|---|
| Weekday | 500 |
| Saturday | 500 |
| Sunday | 400 |
| *Annual Total* | *1,400* |

***Expansion:***

| | Psgr Miles (f) |
|---|---|
| Weekday | 68,750 |
| Saturday | 68,750 |
| Sunday | 55,000 |
| *Annual Total* | *192,500* |

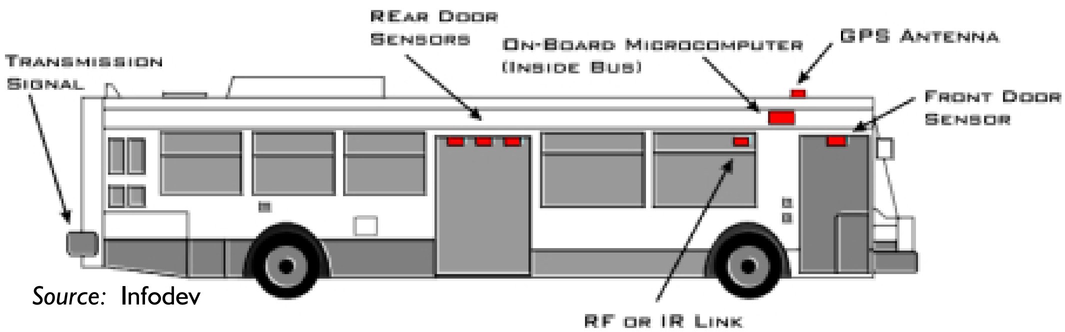
NOTE: Figures may not add due to rounding.

As also explained in Appendix B, although spreadsheets presented in this section are not as technologically sophisticated as some of the other applications that will be reviewed in the following sections, they are readily available, inexpensive, and easy to learn and use.

## *Automatic Passenger Counting Units (APCs)*

Automatic Passenger Counters (APCs) are more appropriate for use with fixed-route service. Exhibit III-6 presents various components of an APC system in a bus.

**EXHIBIT III-6:** Automatic Passenger Counting (APC) Systems




*Source:* Infodev


*Source:* PerMetrics Technologies, Inc.

A description of the primary hardware components of an APC system is presented below. (For a detailed description of various APC technologies (infrared, treadle mat, etc.) please refer to Appendix B.).

- The Passenger Counting Unit (PCU) contains the processing power for the passenger counting functions as well as the communications with the outside world. For each stop identified, the PCU will store the passenger count for each door, odometer count, arrival time, departure time, and dwell time as a bus stop record in its memory. These data represent raw passenger counting data, which then have to be matched to the appropriate route, and analyzed for passenger activity, schedule adherence or other desired information. While the raw data are available in ASCII files, for the analysis of these data various software packages can be used (such as Excel, Lotus, Access, SPSS, etc.).

- The Bus Interface Unit (BIU) functions as the link between the host vehicle and the PCU. It contains all the interface circuitry for the System Power, Engine Status, Door Switches, and Odometer Signal. The System Power circuit breaker also functions as an ON/OFF switch for system maintenance.

- Infrared Transceivers (IRTs) are used for automatic, wireless offloading of APC (or other stored data) in a garage. One transceiver is mounted on the vehicle and the other in the garage. Alternatively, the data can be offloaded manually by someone visiting the bus and removing a data card or diskette, or by plugging a notebook computer or other similar equipment into the APC equipment.

For real-time APC, data are passed to a host system where they are transmitted to a central location over the vehicle communications link. In many APC systems, data are stored on board the vehicle for later data retrieval. Data can be stored in digital memory, in a removable data card, or on a diskette. The typical capacity for storing registered data is one to four weeks depending on the number of routes the bus has driven. In the case of loss of external power, a lithium battery can maintain the time for more than two years.

To make stop-level data meaningful, the data has to have an Automated Vehicle Location (AVL) component. This AVL system may either be signpost-based or use the global positioning system (GPS). More in-depth information on these technologies is provided in Appendix B.

As mentioned previously, the output that includes the raw data is provided in ASCII format. Exhibit III-7 provides an example of APC output, which was converted to an Excel file. The file provides information on route number, stop number, time of day the data were collected, direction, block number, number of passengers getting on and off at a given stop, latitude and longitude of the stop, difference in distance between the physical stop and where the bus actually stopped, number of surveys completed, and stop name.

### EXHIBIT III-7: APC OUTPUT EXAMPLE IN EXCEL FORMAT

| Route | Stop | Stop_ID | Time | Day | Dir | Block | On | Off | Lat | Long | Delta | Surveys | Stop Name |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 101 | 3100 | 10163100 | 540 | 1 | 6 | 1 | 0 | 0 | 30.2084 | (81.6834) | 472.7500 | 4 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 640 | 2 | 6 | 1 | 2 | 0 | 30.2089 | (81.6828) | 211.8333 | 6 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 717 | 1 | 6 | 2 | 1 | 0 | 30.2089 | (81.6826) | 165.0000 | 2 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 740 | 1 | 6 | 1 | 1 | 0 | 30.2089 | (81.6827) | 193.8333 | 6 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 840 | 2 | 6 | 1 | 1 | 0 | 30.2090 | (81.6830) | 327.0000 | 7 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 920 | 1 | 6 | 2 | 0 | 0 | 30.2090 | (81.6827) | 197.5000 | 2 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 940 | 1 | 6 | 1 | 4 | 0 | 30.2089 | (81.6826) | 206.3333 | 6 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 1044 | 2 | 6 | 1 | 0 | 0 | 30.2088 | (81.6832) | 336.8333 | 6 | N.A.S. HOSPITAL NASH |
| 101 | 3100 | 10163100 | 1120 | 1 | 6 | 2 | 0 | 0 | 30.2088 | (81.6829) | 202.0000 | 2 | N.A.S. HOSPITAL NASH |

*Source:* Jacksonville Transportation Authority

A summary of other capabilities of APCs, their strengths and weaknesses, pricing, and a list of suppliers are provided in Appendix B.

## MOBILE DATA TERMINALS (MDTs)

Mobile Data Terminals (MDTs) display short text messages, replacing the voice radio communication between the driver and dispatcher except in emergency or other exceptional cases. They can automatically transmit vehicle location, passenger counts, engine performance, mileage, and other information. MDTs are used for fixed-route and demand-response services.

### ***MDTs for Demand-Response Service***

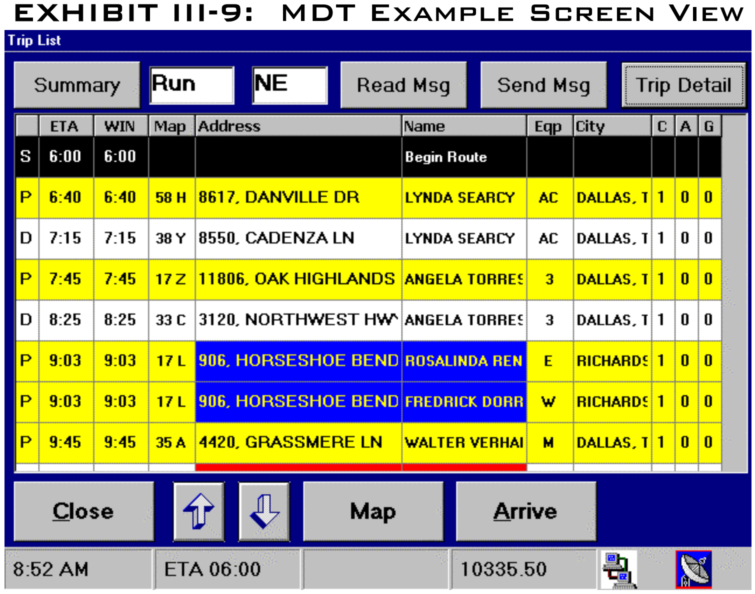
Exhibit III-8 is a picture of hardware that can be used for vans or cars used in offering demand response service.

**EXHIBIT III-8: MOBILE DATA TERMINALS (MDTs): HARDWARE**

*Source:* Greyhawk Technologies

As shown in Exhibit III-9, drivers can view trip information on the screen previously recorded by dispatchers or others. Trips are automatically removed as they are completed.

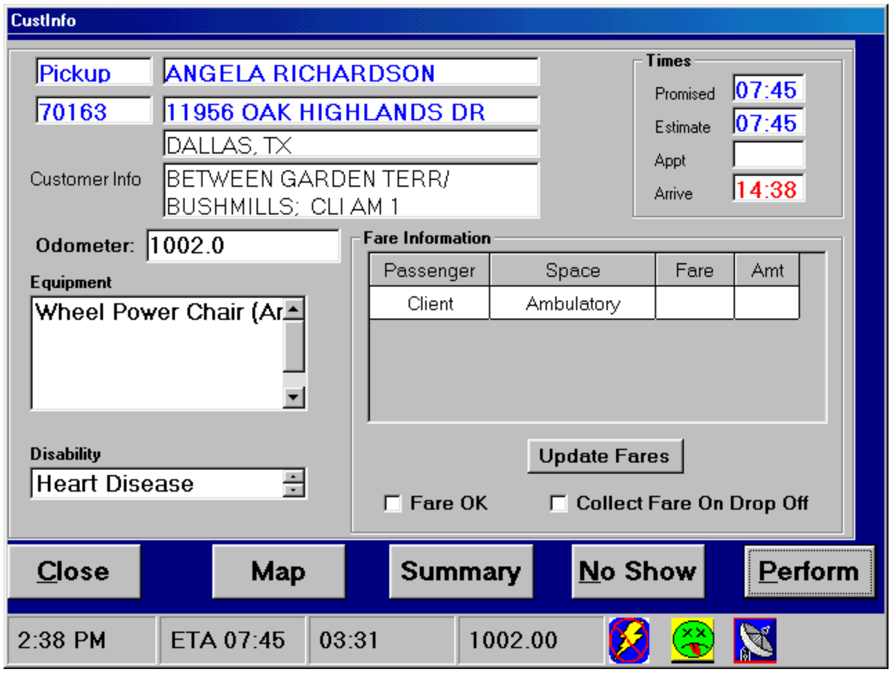
**EXHIBIT III-9: MDT EXAMPLE SCREEN VIEW**




*Source:* Greyhawk Technologies

If desired, drivers can obtain further information on a specific passenger, as in Exhibit III-10.

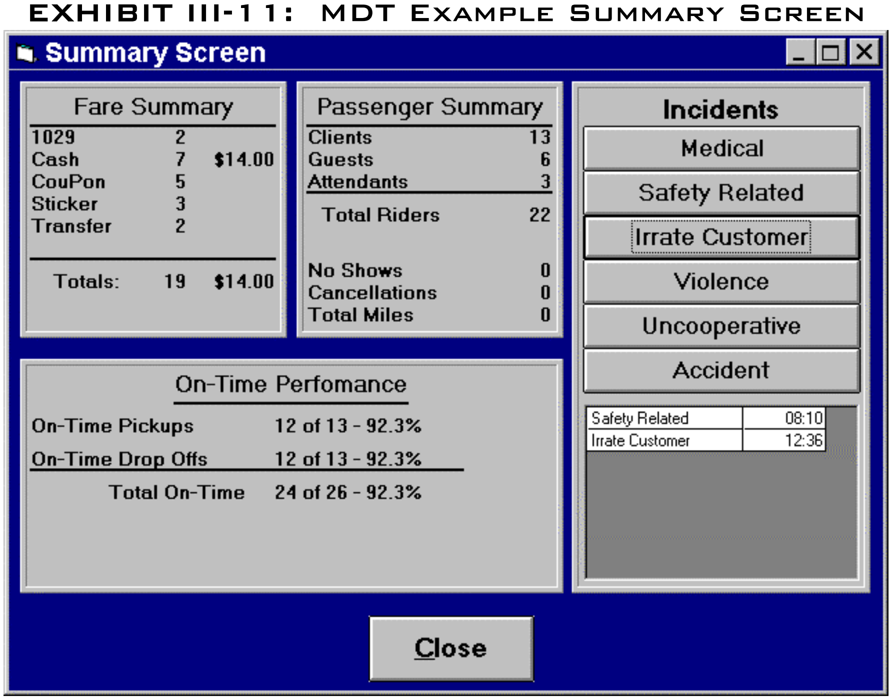
### EXHIBIT III-10: MDT Example Customer Information Screen




*Source:* Greyhawk Technologies

Summary figures are obtained in the format presented in Exhibit III-11. This information is automatically transferred to a scheduling/dispatching software and can be manipulated for NTD reporting purposes.

### EXHIBIT III-11: MDT Example Summary Screen




*Source:* Greyhawk Technologies

### *MDTs for Fixed-Route Service*

In the case of fixed-route buses, the driver screen would appear in the format shown in Exhibit III-12, and would allow drivers to send many of the standard messages without having to call in to dispatch via voice communications.

**EXHIBIT III-12: MDT EXAMPLE SCREEN FOR FIXED-ROUTE APPLICATIONS**

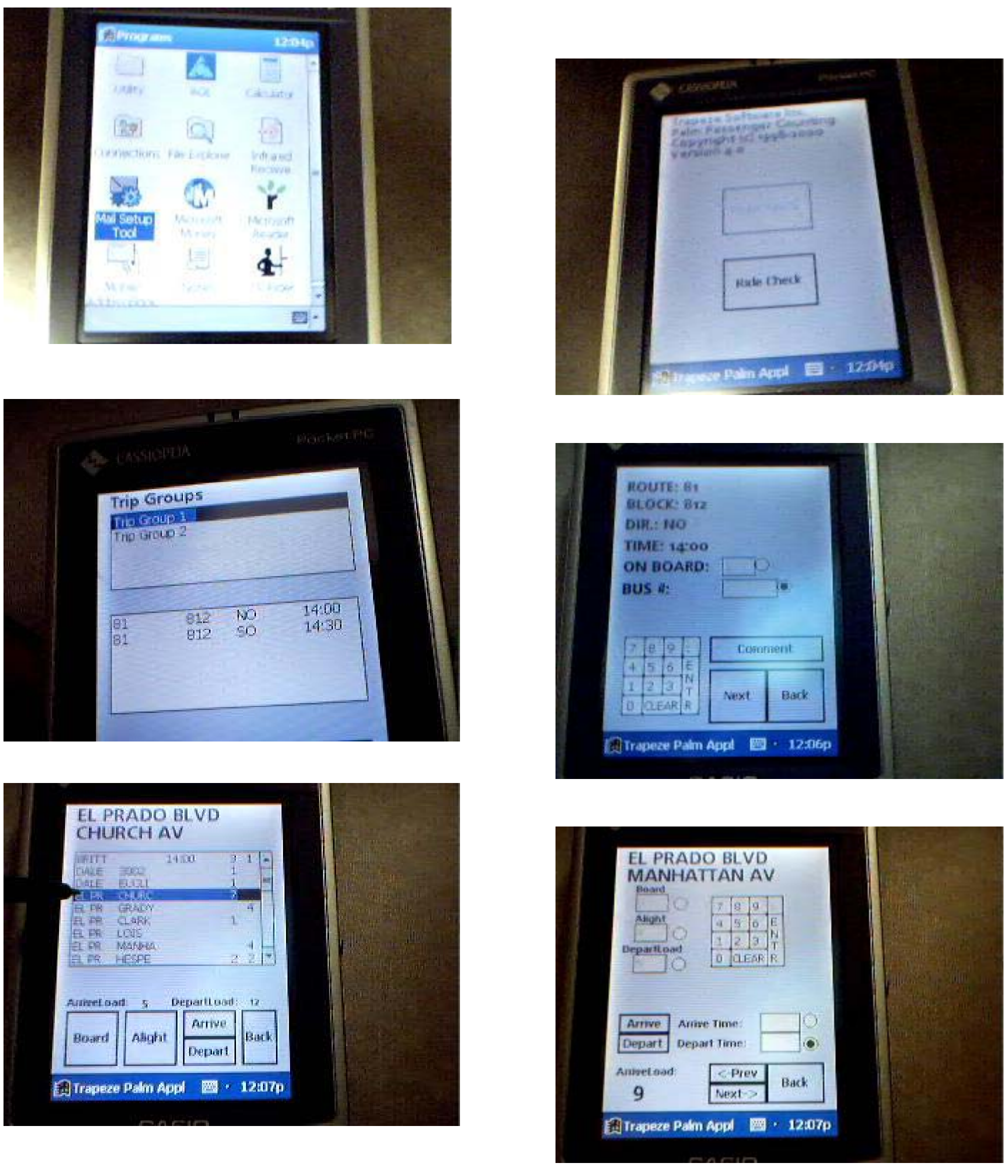

*Source:* Greyhawk Technologies

More detailed information on MDTs' capabilities, strengths and weaknesses, pricing, and a list of providers is presented in Appendix B.

### *Hand-held Units*

Hand-held units can be used during the sampling process necessary to estimate ridership and passenger miles. Information about which trips to survey can be downloaded from the main computer to the hand-held device prior to the survey. During the trips, surveyors can input the necessary information by pressing appropriate buttons on the hand-held unit. Data collected can then be downloaded directly to the main computer, eliminating the need to enter the data manually. The following pictures in Exhibit III-13 present various screens of hand-held devices used during the sampling process for estimating passenger miles.

**Exhibit III-13: Hand-Held Unit Example Screens**




*Source:* Hillsborough Area Regional Transit Authority (HARTline)

## Data Compilation for *Vehicle Miles and Hours*

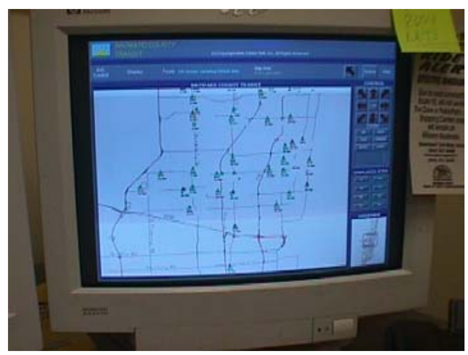
Vehicle mile and hour information can be collected using the following automated methods:

- Mobile Data Terminals (discussed in the previous section; see pages 19-21);
- Automatic Vehicle Location (AVL) Systems; and
- Spreadsheets.

### *Automatic Vehicle Location (AVL) Method*

Automatic Vehicle Location (AVL) systems provide real-time vehicle location data. At a minimum, each AVL deployment includes a specific location technology and a method of transmitting the location data from the vehicle to a central dispatch center. Many of the more recent transit applications of AVL systems have integrated the automated vehicle location component with other systems (such as communications, GIS, analysis software, dispatch/control systems, and scheduling software) to expand the use of AVL for more efficient fleet operations, on-time performance, schedule adherence, route/service data collection, security, and traveler information services. For NTD reporting purposes, AVL data can be used to track vehicle inventory and mileage (total and revenue miles) and provide information on directional route miles. Exhibit III-14 shows pictures of a radio room with the host computer.

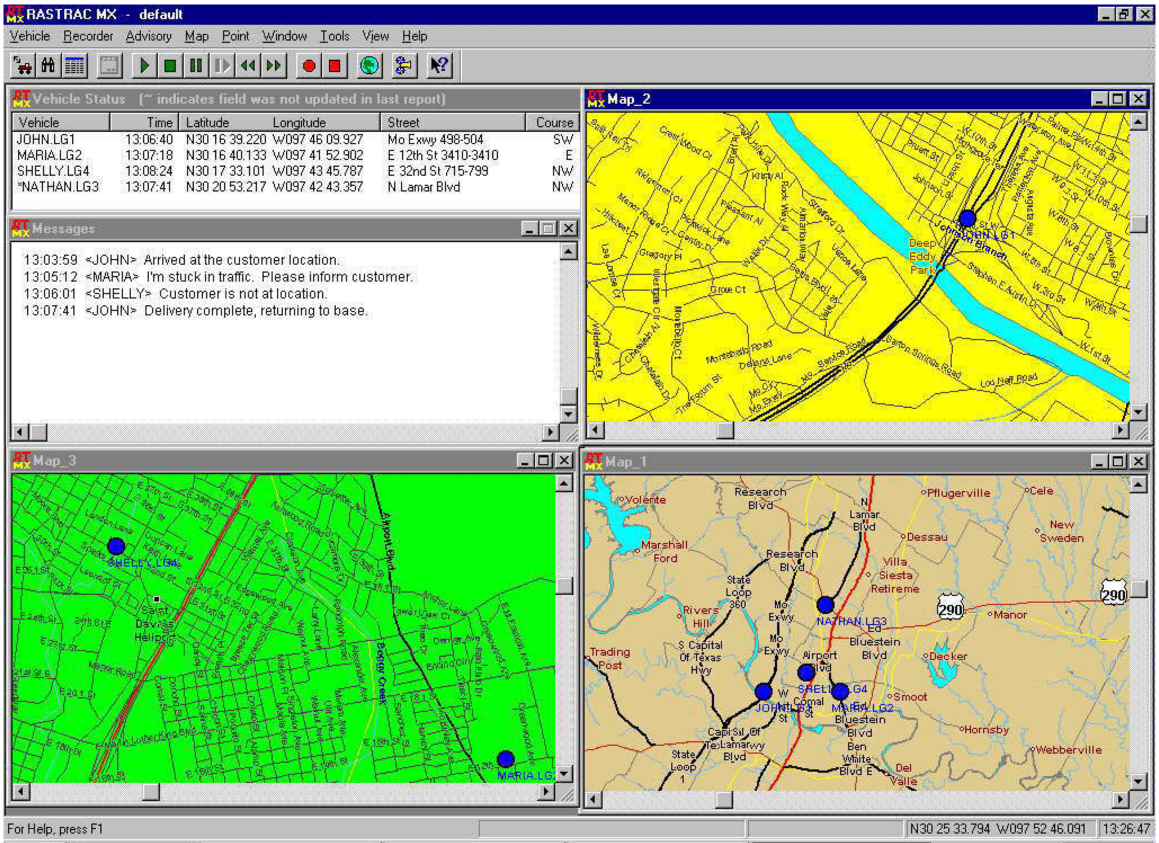
**EXHIBIT III-14: Radio Room Equipped with AVL**



*Source:* Broward County Transit

Data collected by AVL are usually displayed on a map; however, they also come in ASCII files and can be exported to various spreadsheet and database programs (e.g., Excel, Access, etc.). Exhibit III-15 presents a screen capture of how dispatchers and others can track vehicles. Information on specific vehicles are displayed both in spreadsheet and map formats.

### EXHIBIT III-15: Vehicle Tracking Using AVL




*Source:* Manning NavComp

From the information provided by an AVL system, it is possible to obtain annual total and revenue vehicle miles and hours. As mentioned previously, Appendix B includes information on other uses of AVLs, their strengths and weaknesses, pricing, and other information.

## Spreadsheet Method for Collecting Vehicle Miles, Hours

Several Florida transit agencies mentioned that they obtain vehicle miles and hours statistics from drivers' logs. This information can then be input into a spreadsheet to summarize at the end of the year. FTA's review letters suggested that some of the problems with these figures included high/low average speed during deadheading or while vehicles are in revenue service; large variations from figures reported in previous years; and inconsistent changes from previous years (e.g., declining number of total actual vehicle revenue hours with increasing total actual revenue miles, etc.). In order to minimize these problems, it is possible to build checks and balances in Excel worksheets. An example is shown below in Exhibit III-16.

**EXHIBIT III-16: Spreadsheet example for Compiling Vehicle Miles & Hours**

***Summary of Weekday Statistics***

| | TOTAL TO DATE | | |
|---|---|---|---|
| | *Current Year* | *Previous Year* | *Change* |
| Total Actual Vehicle Miles | 30,000 | 29,000 | 3.45% |
| Total Actual Vehicle Hours | 2,000 | 1,990 | 0.50% |
| Total Actual Vehicle Revenue Miles | 28,000 | 27,000 | 3.70% |
| Total Actual Vehicle Revenue Hours | 1,800 | 1,770 | 1.69% |
| | | | |
| Deadhead Mileage | 2,000 | 2,000 | 0.00% |
| Deadhead Hours | 200 | 220 | -9.09% |
| | | | |
| Average speed during deadheading | 10 | 9 | 10.00% |
| Average speed during revenue hours | 16 | 15 | 1.98% |

In the above example, weekday statistics for vehicle miles and hours are summarized for the current year and compared to the previous year (to date). Calculating the change between two figures would enable agencies to check for large variations. Agencies can also note variation in the opposite direction (e.g., decreasing vehicle miles versus increasing vehicle hours, etc.).

In addition to change from the previous year, the summary sheet also calculates deadhead mileage and hours as well as the average speed. The deadhead miles and hours are calculated as the difference between actual vehicle miles/hours and vehicle revenue miles/hours. Average speed is simply the miles divided by hours. Calculating these statistics and comparing them to the figures obtained in the previous year would give agencies an early warning regarding any data collection problems.

The same type of summary can be prepared for Saturday and Sunday totals. It is recommended to conduct this type of comparison not only at the end of the year, but regularly throughout the year to note any irregularities in a timely manner. This way, the agency would have time to correct potential problems related to the data collection process.

## Data Compilation for *Unlinked Passenger Trips*

The following automated methods are available for collecting passenger trip statistics:

- Automatic passenger counting (APC) units, which were discussed previously (see pages 17-18);
- Mobile data terminals (MDTs), which were also previously addressed (see pages 19-21) ;
- Electronic registering fareboxes (ERFs); and
- Smart Cards.

### *Electronic Registering Fareboxes (ERFs)*

ERFs are typically used in motorbuses and can provide information on the number of passengers. The following pictures in Exhibit III-17 illustrate some of the ERFs available.

**EXHIBIT III-17: Examples of Electronic Fareboxes**

*Source:* GFI Genfare

Data collected by ERFs can be retrieved in transit agencies' garages without a physcial connection or by using dynamic or periodic remote retrieval of farebox data. The following pictures in Exhibit III-18 illustrate a probing system that downloads the data from the farebox directly to the data system.

**EXHIBIT III-18: ELECTRONIC FAREBOX PROBING SYSTEM & RESULTING DATA SCREENS**

*Source:* GFI Genfare

More detailed information on electronic fareboxes is presented in Appendix B.

### *SMART CARDS*

Smart cards contain information that can be queried or supplemented by a card reader. These cards have an integrated circuit chip, a central processing unit, and an operating system like a small computer. The reader activates the card to identify the passenger, obtain stop data, determine the source and amount of fee, or other information. Smart cards can be integrated with the agencies' accounting systems, scheduling software, and AVL systems.

Typically, passengers purchase one smart card for a fixed fee and then add value to it for additional trips as long as the card lasts. The picture on the following page illustrates a printing machine that can be used to issue new cards and/or recharge previously issued cards. On the following page, Exhibit III-19 shows pictures of various Smart Cards and a Smart Card reader.

**EXHIBIT III-19: Examples of smart Cards & Smart Card Reader**


*Source:* GFI Genfare

It should be noted that in terms of collecting passenger information for NTD, this technology may be more effective for demand-response than fixed-route. In the case of fixed-route, it is important to achieve a high-level of penetration among transit users to provide any meaningful ridership data beyond the number of people who are using smart cards. Appendix B provides further information on this technology.

# IV. SUMMARY

Over the last several years, transit agencies have begun to rely more heavily on NTD data for purposes other than reporting to the Federal Transit Administration (FTA). Other uses of the data include reporting to state and local governments, as well as internal uses such as monitoring system performance. Because the NTD contains the only standardized collection of performance data for urban transit providers in the United States, it has become an important transit evaluation tool. In many cases, however, there have been concerns about the accuracy of the NTD information, even after final FTA validation. Transit agencies often experience difficulty in collecting some of the required data. As a result, they are looking for data collection methods that will assist with compiling data from the correct sources, and the ease of obtaining the NTD data. In addition, agencies would like help in determining operational procedure guidelines to collect data more efficiently, and in gathering data from contractors.

This handbook provides an overall understanding of some of the automated methods available in collecting the data for the required federal NTD reporting. A more detailed explanation of the capabilities of these tools along with examples of available sources for further information are provided in Appendix B. Upon review of this handbook, users are expected to obtain further information catered to their specific needs prior to acquiring any hardware or software discussed in this document.

# APPENDIX A: Summary of Transit Agency Surveys

As part of this research, CUTR conducted telephone surveys with Florida transit agencies to acquire an understanding of current practices in data collection for the National Transit Database (NTD) and common barriers and challenges encountered. All of the Florida transit agencies were contacted and interviews with 24 agencies were completed. The following paragraphs summarize results of these surveys.

The survey addressed each NTD reporting module in terms of existing practices and challenges in data collection. It should be noted that, because Fiscal Year 2002 was the first year the Federal Transit Administration (FTA) switched to the new NTD reporting modules from the traditional set of numbered forms, the majority of the agencies were not fully familiar with the new system. Instead, they provided feedback based on their experiences with the previous forms. One exception to this was the Safety and Security Module, which has been required to be completed on a monthly or quarterly basis beginning January 2002.

## Agency Issues with the Basic Information Module

Overall, responding agencies felt that this NTD reporting module (or former NTD Forms 001 and 002) was relatively simple to complete. The differences in reporting data or challenges reported included the following:

- In reporting service area population, approximately 60 percent of the respondents use city or county population primarily because they provide demand-response service throughout the city or county. The remaining agencies use the area within a ¾-mile buffer around their fixed service routes in compliance with the Americans with Disabilities Act (ADA) requirements. Agencies that use the ¾-mile buffer boundary tend to estimate this area using a geographic information systems (GIS) application or obtain the figure from another organization (local Metropolitan Planning Organization (MPO) or City/County Planning Office, etc.).

  Approximately 70 percent of the responding agencies use Census data for population figures while the remaining obtain their information from organizations within the City/County or from local universities. While some agencies use population figures updated annually or biannually, others update their figures only with new Census releases (every 10 years).

- In completing the Basic Information Module, the most significant challenge cited by agencies was to obtain the necessary information from their subcontractors.

Approximately 85 percent of the agencies have a contractual agreement with an outside provider and approximately half of these agencies experienced at least some difficulty in obtaining the information necessary for NTD reporting. Examples included:

- Determining the correct number of vehicle inventory dedicated to the service contracted out by the agencies (i.e., if the contracting company also provides service to others, it may have a larger inventory than what is available to a specific agency). It should be noted that as of Fiscal Year 2002, agencies are able to indicate on the Revenue Vehicle Inventory Form, A-30, whether vehicles used by contractors for purchased transportation are dedicated vehicles or not. When non-dedicated vehicles are included, the data need to be reported for a representative subset (or sample) of the vehicles and there are reduced reporting requirements in terms of data items for these vehicles;

- Vehicles provided by the subcontractor also being used for other services, which makes it difficult to determine actual vehicle and revenue vehicle miles;

- Difficulties in obtaining cooperation from contractors during the years when sampling is mandatory; and

- Contractors providing late, incomplete or incorrect information due to lack of staff and/or lack of motivation/incentive to provide these data.

Agencies that own the vehicles operated by the contractor and/or take reservations in-house (for demand-response service) tend to experience fewer difficulties in accumulating the necessary data. Agencies offered the following suggestions to minimize/eliminate difficulties in obtaining the necessary statistics from contractors:

- Include the list of statistics the contractor needs to supply in contractual agreements along with appropriate penalties if the contractor does not comply.

- Provide appropriate forms to contractors to make it easier for them to track the required information.

- Use automated methods. Automated methods mentioned ranged from providing the contractor with a spreadsheet that includes various checks and balances built in it to instantly check the reasonableness of the data to using standardized NTD forms in various programs such as Trapeze.

## Agency Issues with the Asset Module

Responding agencies stated that collecting data for this module (formerly NTD Form 408 and parts of Forms 402 and 403) was relatively simple. Most agencies input data on stations and maintenance facilities directly into the NTD form. Since transit systems generally have few of these assets, they are easy to track. In terms of collecting information on revenue vehicle inventory, agencies tend to keep an on-going list of vehicles and add/delete vehicles as they are bought and sold. While smaller agencies tend to keep the inventory manually, larger agencies use spreadsheets and other fleet management programs such as Fleet-Net, Fleetmate, Community Transit Systems Software (CTS), Transman, and other similar programs.

## Agency Issues with the Transit Agency Service Module

Overall, of the non-financial NTD data modules, this module (formerly Form 406 and part of Form 403) was the most challenging for transit agencies. The following paragraphs summarize how agencies currently collect information for various items and common challenges faced.

- Respondents stated that tracking data on the number of vehicles operated and available in maximum service and service periods was relatively easy. Typically, agencies use drivers' manifests/trip sheets or scheduling software to keep track of vehicles in maximum service. Departments that are most involved in keeping track of this information are maintenance, operations, and planning.

  Service periods are generally tracked by Scheduling/Operations and Planning Departments through schedules for fixed-route service and through drivers' manifests for demand-response.

- The dominant method of collecting data on vehicle hours and miles (total and while in revenue service) is through drivers' logs. At times, agencies utilize formulas to estimate revenue miles and use schedules for revenue hours. A few of the agencies use scheduling software to obtain some of these figures.

  In most cases, drivers' logs or dispatch reports also provide the information for missed revenue miles (the difference between the scheduled and actual revenue miles). In some cases, agencies track missed revenue miles by using a standard formula or only when they lose an entire day.

  At times, figures are tracked in spreadsheets (e.g., Excel, Lotus, Quattro Pro, etc.) and database management applications (such as Access or FoxPro), or by using scheduling software such as Trapeze, Hastus, StrataGen, Fleet-Net, G/SCHED, etc., in order to calculate annual totals.

- For the purpose of tracking statistics on the number of passengers for fixed-route service, the majority of the agencies use the 100-percent count method while, for passenger miles, they use a sampling technique. In conducting passenger counts, slightly over half of the agencies use electronic fareboxes while approximately 45 percent keep track by having drivers use clickers or record figures manually on their manifests/logs. In sampling for passenger miles, the majority uses the FTA recommended method. Agencies use one to four part-time and/or full-time checkers to complete the sampling, with an average of two full-time checkers (assuming part-time checkers work 20-hour weeks). While approximately one-third of the agencies hire dedicated checkers, others use operators and other personnel who are on light duty. There are two agencies, Lynx Transit and Jacksonville Transportation Authority, which have automatic passenger counters (APCs) in their vehicles and, therefore, do not need to use checkers.

  For demand-response, the majority uses the 100-percent count approach for both variables.

  In keeping track of passenger information required by the NTD throughout the year, approximately 60 percent of the agencies use spreadsheets (Excel, Lotus, etc.) while the remaining 40 percent uses a scheduling and validation software system (Trapeze, StrataGen, Fleet-Net, etc.).

- Responding agencies stated that sampling is a highly time-consuming and expensive process. Even when agencies use their own employees, at times, they have to pay overtime rates. Representatives of one agency estimated that conducting one survey requires two to three person-hours and, with over 500 surveys to complete, the cost rises quickly. In addition, agencies that provide service over longer periods of time mentioned that their extensive schedules make sampling even more time consuming.

- Approximately 50 percent of the responding agencies determine directional route miles for fixed-route by driving the routes either as the sole method or in conjunction with another method; 20 percent use street maps; 15 percent use mapping programs available on the Internet (e.g., Microsoft Map Point, etc.); 10 percent use GIS applications; and the remaining agencies use either APCs or scheduling software. Agencies stated that determining the figure for directional route miles was relatively simple.

## Agency Issues with the Resource Module

The Resource Module comprises the former NTD Form 404 and part of Form 403.

- The majority of agencies keep track of their employee hours through their payroll and/or finance departments. Payroll obtains the necessary information from time sheets, punch cards, or hand readers. To distribute employee hours by mode for staff that is not dedicated to a mode (e.g., administration, marketing, etc.), agencies tend to use formulas, which could be based on trip distribution, revenue-hour distribution, or other methods. The majority of the responding agencies use spreadsheets (at times in conjunction with a payroll program or another program) to keep track of this information throughout the year for NTD purposes.

- Information on revenue vehicle failures is typically obtained from drivers' manifests/logs, roadcall information, and the maintenance department/shop. One agency reported that they use a CAD/AVL (computer-aided dispatching/automatic vehicle location) system. Agencies keep track of this information through automated fleet management systems (e.g., Fleet-Net, Fleetwatch, Fleetmate, Transman, etc.) and/or spreadsheets.

- Energy consumption statistics are obtained from invoices or tickets generated when vehicles are fueled; reports from drivers or gas station attendants, automated fuel stations and, at times, from a formula based on fuel consumption per vehicle mile. Agencies tend to enter this information into an automated fleet management system to keep track for an annual figure.

- Agencies that obtain energy consumption information from records of the gas station attendants complained that at times the figures are not legible or do not make sense. They suggested that an automated fueling system would be more accurate and efficient.

## Agency Issues with the Safety and Security Module

As of 2002, FTA requires the new Safety and Security Module (previously NTD Form 405) to be completed either on a monthly or quarterly basis, depending on the population of the area served by the agency. Hence, most agencies have already been completing the new forms. Agencies with fewer than 100 vehicles operated in maximum service and no rail operations at the beginning of the calendar year are only required to report quarterly; however, they may elect to report monthly. Larger agencies are required to report monthly. Agencies with the "Nine or Fewer Vehicles Waiver" are exempt from submitting the Safety and Security Module.

While some agencies believe the increased frequency of reporting creates more work for them, others stated that the new forms are easier because the thresholds to qualify an incident or accident reportable are higher; therefore, agencies have to report fewer incidents or accidents. In addition, some agencies mentioned that, once the system is set-up, it is not difficult to report the information more frequently and doing so enables the agency to be better informed about its own safety and security statistics. The following paragraphs summarize agencies' security configurations and information collection processes.

- The majority of the agencies rely on local police for security. Approximately 25 percent of agencies do employ security personnel for their facilities, but not for the system. Only 10 percent of the responding agencies reported contracting security to an outside party. One agency placed surveillance cameras in buses to record incidents that take place inside the vehicles.

- All of the reporting agencies follow a similar process in obtaining information on incidents and accidents. When an incident occurs, operators, through dispatch or directly, inform the relevant parties (police, ambulance, fire department, etc.) and a supervisor goes to the scene to interview individuals, take pictures, and prepare a report. Written reports prepared by the driver, supervisor, police, and others are collected and information is entered into each agency's system. Then, incidents or accidents that meet the NTD thresholds are reported to FTA either directly from the written reports or from a spreadsheet application wherein the agency tracks this information. At times, agencies obtain parts of the information required for this Module from their fleet management programs since these programs track roadcalls. However, they still need to review all reports to ensure they did not omit a qualifying incident or accident that may not have required a roadcall.

Agencies stated that they do use data collected for NTD for other purposes including reporting to the State and internal evaluation of performance and operational decisions.

## Analysis of NTD Detail Review

Florida agencies were asked to share the latest NTD Detail Review Letters (DRLs) they received from FTA and 16 agencies provided these letters. An evaluation of these letters suggested that, of the non-financial data forms, former Forms 404 (Transit Agency Employee Form), 405 (Transit Agency Safety and Security Form), and 406 (Transit Agency Service Form) raised most of the questions. The following paragraphs briefly summarize specific issues related to data reported in these forms.

- In Form 404, the primary question related to the accuracy of employee hours reported for various categories.

- In terms of data reported in Form 405, the majority of FTA's inquiries related to incidents reported without any injuries, followed by incorrect reporting (reporting incidents that are below the threshold, subtotals that are greater than totals, etc.). Finally, a high degree of increases or decreases in incidents and accidents and/or arrests compared to the previous reporting year was also questioned.

- In Form 406, most of the questions were raised on data for total actual vehicle hours, total actual vehicle revenue hours, total actual vehicle miles, total actual vehicle revenue miles, unlinked passenger trips, and unlinked passenger miles. Some of the specific issues related to these variable were:

  - Unusually high/low average speed during deadheading or while vehicles are in revenue service;
  - Large variations from figures reported in previous years;
  - Inconsistent changes from previous years (e.g., declining number of total actual vehicle revenue hours with increasing total actual revenue miles, etc.); and
  - Inconsistencies between data reported for average weekday/Saturday/Sunday service and data reported for annual service.

In some cases, figures questioned were correct and agencies provided an explanation. In others, they resulted either from incorrect reporting or from typographical errors.

# APPENDIX B: EXISTING AUTOMATED TOOLS

This section of the document summarizes existing automated methods (software/hardware) that are available to transit agencies in collecting statistics for the National Transit Database (NTD). Most methods included in this appendix are generally applicable to fixed-route and demand-response service. If an application is more appropriate for one type of service over another, it is indicated.

Several considerations in selecting appropriate applications include system size, budget availability, and characteristics of the service area (large population base with high-growth versus small population base with limited growth, size of the service area, etc.). In addition, it should be noted that although these applications can be used to facilitate collection of the NTD data, this capability may not be the primary factor in deciding whether to acquire any given software or hardware. At times, the ability to collect the NTD data more efficiently is simply an ancillary benefit to the agency from implementing a certain automated method or technology.

Information provided on automated methods includes an overall description of the application and its capabilities, strengths and weaknesses, examples of suppliers (not a comprehensive list), and general price ranges. In some cases CUTR included caveats that should be noted. It should also be noted that pricing of these products ranges a great deal depending on the agency size and existing technology. In most cases, the price ranges included in this handbook were obtained directly from a sample of suppliers and are intended to give a general idea on pricing. The actual cost of these products for a given agency tends to vary significantly depending on the system's size, existing technology/equipment, the complexity/sophistication of the software and hardware, and other variables.

## Automated Data Collection Methods for the Basic Information Module

The NTD Reporting System's Basic Information Module requires information on:

- Transit Agency Identification (Form B-10)
- Transit Agency Contacts (Form B-20)
- Contractual Relationship (Form B-30)

Most of the information required in this module is standard information (name, address, contacts, etc.) that tends to remain relatively stable over time. However, information on service area demographics such as population and service area size, as well as statistics that need to be obtained from contractors tend to vary on an annual basis. Automated methods for collecting the statistics that are obtained from contractors will be discussed throughout this appendix.

### *Geographic Information Systems (GIS)*

To determine service area population and size agencies could use geographic information systems (GIS). These applications can also be used in determining directional route miles and will add mapping capabilities to other automated methods used to track inventory and estimate passenger miles, vehicle miles, and other information. The following paragraphs provide a brief description of GIS.

GIS integrate data and spatial information to allow for advanced analysis. GIS data are stored in layers of information that identify trends and patterns not recognizable from tabular data. By adding a geo-spatial element to data, users are able to recognize patterns in the data like proximity, clustering, and adjacency of data units. More advanced uses of the geo-spatial data would include calculating proportional area values, such as the service area of a route. By capturing the most fundamental parts of a transit system in GIS, like the routes and stops, an agency will establish the foundation for a robust GIS system. This foundation will allow the transit agency to automate many of its reporting requirements. Some examples include the directional route miles, one-quarter mile and three-quarter mile service area calculations, ridership by stop and route, bus stop amenities, and determining the level of Title VI and Americans with Disabilities Act (ADA) compliance.

#### ***Summary of GIS Technology***

GIS software has advanced significantly and nearly all desktop software platforms offer the same basic functions. A typical GIS application has general map production capabilities, with printing and map exporting functions, and thematic mapping (i.e., mapping data ranges for census demographics or ridership levels or identifying amenities of a bus stop inventory). All GIS platforms are able to import and read many data types. Data currently stored in MS Access, MS

Excel, Lotus, Paradox, and dBASE can be integrated with GIS easily. Additionally, GIS can export the data into other software platforms for integration into reports or presentations. A transit agency considering a GIS application should ensure that the application it purchases can easily read or import the file type in which its data are stored.

In spite of all the advances and similarities between GIS software, there are differences that should be considered. Each GIS platform utilizes its own native file format and the differences between each type should be considered prior to purchasing a GIS application. Certain GIS file types have advantages over others when it comes to transportation GIS. The GIS should easily utilize topology, an important feature for transportation GIS. Topology is the expression of the relationship between and within spatial data. For example, while GIS express the location of a feature, such as a road, topology expresses the connection of the road to the overall road network. Topology illustrates the adjacency and connectivity of GIS features. Some file formats have built in topology while others need a great deal of effort to incorporate it. Topology is important for modeling functions, such as shortest path calculations. With a complicated system to implement topology, distance calculations as well as trip planning can become quite cumbersome.

Many of the GIS software companies offer a suite of products, with a tiered system for different degrees of functionality. Agencies should consider the expansion abilities of the software for future uses. Additionally, many businesses form partnerships with GIS companies to make 'add-ons' to increase the functionality and simplify tasks. Larger GIS companies have more partners, which may weigh in a transit agency's choice of GIS platforms.

### ***GIS Caveats***

While there are great similarities in many of the GIS platforms available, transit agencies considering implementation of GIS should consider what other area agencies and municipalities are using. Because much of the beginning efforts of implementing GIS involve establishing the base data, capitalizing on data already created by other agencies is key to a quick start-up. Consequently, to ensure a quick start-up a transit agency may want to consider a GIS platform that is compatible with other area agencies' (i.e., Metropolitan Planning Organization (MPO), Regional Planning Council (RPC), and property appraisers) GIS platforms.

### ***Strengths/Weaknesses of GIS***

As mentioned previously, for NTD reporting purposes, GIS provides transit agencies with an automated tool to estimate various statistics such as the service area population, directional route miles, etc. In addition, it could enhance the capabilities of some of the other available tools such as automatic vehicle locators (AVLs), automatic passenger counters (APCs), etc.

One of the constraints of GIS is the necessary training and skill level. If transit planners are not familiar with GIS, extensive training may be necessary.

Software integration is another concern transit agencies should consider in their purchase of a GIS platform. The GIS software platform should easily integrate with scheduling, APC, and AVL systems, if an agency has them, as well as the database, spreadsheet, and word processing software currently utilized at the agency. It is important to research which file formats communicate easily with the desired AVL, APC, and scheduling software applications. By ensuring that the selected GIS application easily integrates with the existing transit applications, the implementation of GIS will be less complicated, allowing for quick deployment and opportunity to expand the use of the GIS.

Finally, as mentioned previously, a GIS application that does not support the necessary topology features will be limited in modeling calculations.

***Examples of GIS Suppliers***

ESRI (www.esri.com), which offers ArcView and ArcGIS; MapInfo (www.mapinfo.com); Caliper (www.caliper.com), which offers Maptitude and TransCAD; Intergraph (www.intergraph.com), which offers GeoMedia.

In addition, a database titled Florida Transit Information System (FTIS), was created by the Lehman Center for Transportation Research at the Florida International University (FIU) for the Florida Department of Transportation (FDOT). This database is available on CD or through a website, http://www.eng.fiu.edu/LCTR/Ftis/ftis.htm, and includes NTD statistics for all U.S. agencies that report to FTA. It also has GIS capabilities to provide population figures within desired buffer zones for Florida agencies. This component of the FTIS, titled Florida Transit Geographic Information Systems (FTGIS), includes 2001 route information for 23 Florida agencies and 2000 Census population figures.

***Examples of GIS Pricing***

There are a wide range of prices and functionality for desktop GIS applications, with prices ranging from $500 to $10,000. Agencies looking to begin implementing GIS should be able to do so for under $2,000.

## Automated Data Collection Methods for the Transit Agency Service Module

The Transit Agency Service Module contains one form, which is used to report data on the transit service supplied by the agency and the transit service consumed by passengers. In providing information for this Module, the following automated methods are used.

Vehicle information required as part of this Module includes the number of vehicles operated and available during maximum revenue service, actual vehicle hours, actual vehicle miles, actual vehicle revenue hours, actual vehicle revenue miles, and total scheduled revenue miles.

Passenger information required by the NTD includes number of riders and passenger miles.

Information on service span and days of operation for NTD is compiled by agencies using either printed schedules or their scheduling programs. These programs are also used in conjunction with other automated methods used to collect passenger and vehicle information, described below.

### *Automated Vehicle Location (AVL)*

Automated Vehicle Location (AVL) systems communicate real-time vehicle location data to other applications that need accurate and timely location information. At a minimum, each AVL deployment includes a specific location technology and a method of transmitting the location data from the vehicle to a central dispatch center. Many of the more recent transit applications of AVL systems have integrated the automated vehicle location component with other systems (such as communications, GIS, analysis software, dispatch/control systems, and scheduling software) to expand the use of AVL for more efficient fleet operations, on-time performance, schedule adherence, route/service data collection, security, and traveler information services. For NTD reporting purposes, AVL data can be used to track vehicle inventory and mileage (total and revenue miles) and provide information on directional route miles.

#### ***Summary of AVL Technology***

There are three primary methods of tracking vehicles: Signpost Technique, LORAN C Technology, and Global Positioning System (GPS). Signposts determine position via a fixed installation of electronic beacons located at various bus stops or other points on the bus routes. The signpost devices constantly emit a low-powered signal (beacon) along with a unique identification, both of which can be detected by the vehicle's transmitter or receiver. When a bus passes a signpost, vehicle data and location are instantly transmitted back to a central location. This system is also known as the Fixed Beacon system. The distance traveled between signposts can be approximated because the signpost devices also monitor electric pulses emitted by the vehicle's odometer. The advantages of this type are its low cost and considerable experience. With this method, vehicles can be tracked to within an accuracy of 500 meters (1,640 feet or 0.3 mile). This type is unsuitable for demand response vehicles and more suitable for fixed route vehicles. Signpost AVL technology has given way to GPS technology.

LORAN C technology is land based and consists of radio transmissions relayed through land connections. This provides two-way communication. Each station transmits pulses of timed signals, and a receiver mounted on the vehicle can calculate distance traveled by comparing the times it receives different signals from the different origins. Its main advantage is its flexibility, where any vehicle equipped with proper receiver can be tracked no matter what its route is. However, several sources cause signal interference, including power lines and substations, tall buildings, and fluorescent lights within the vehicles. GPS is largely replacing LORAN C.

The current state-of-the-art AVL systems for buses use GPS technology that locates the bus via satellite. GPS is a worldwide radio-navigation system consisting of 24 satellites and their ground stations. The satellites are in a geo-stationary orbit and are always looking at the same place on earth. One of GPS' benefits is its accuracy in reporting time. Some AVL systems also use Dead Reckoning (DR) to ensure the best possible location information. DR uses sensors to measure speed, distance, and direction. It uses these inputs to calculate current location from the last known position. Although either GPS or DR will provide accurate location data, they work especially well together. Both systems have their limitations and the other system compensates for those. For example, GPS sometimes provides inaccurate information around tall buildings (urban canyons) and cannot read under bridges or in tunnels. DR is not affected by these situations. However, DR needs accurate positional updates because its accuracy falls off as the distance between known positions increases. GPS provides the accurate positional updates required by DR.

Suppliers interviewed stated that in most cases including only the GPS technology is sufficient and that the DR technology is only needed in a downtown environment with high density. DR tends to increase the cost significantly and, therefore, it is important to evaluate the level of its necessity in relation to the additional cost.

Data from AVLs are usually displayed on a map. They also come in ASCII files and can be exported to various spreadsheet and database programs (such as Excel, Access, etc.). At times, these data are automatically exported to the agency's scheduling software and can be viewed in formats that software supports.

The initial implementation of an AVL system tends to take about one to six months depending on the size of the agency, area, etc.

***<u>Strengths/Weaknesses of AVL</u>***

As mentioned previously, AVL provides agencies with real-time vehicle location data and enable them to respond better to emergency situations, improve on-time performance and scheduling, and reduce fleet size (especially in the case of demand-response service since the agency has a better access to vehicle locations to fulfill requested trips), etc.

Some of AVL's limitations relate to the extent of the wireless coverage area (when using cellular technology) and quality of map data. In terms of wireless coverage area, the initial testing could be helpful in determining which areas need additional coverage. In addition, most suppliers provide an evaluation of the service area, which addresses this issue among others. Some agencies experienced problems when the map data were not accurate (e.g., addresses were incorrect or data set was incomplete, etc.).

Finally, it is important that the relevant transit agency personnel be trained appropriately on the usage of hardware and software. As mentioned in the TCRP Synthesis 24, "AVL Systems for Bus Transit," two areas of concerns that relate to the digital map database were map data accuracy and integration of routes, bus stops, and map data. Given that not all transit agencies have dedicated GIS personnel who can handle updating the digital map databases and that acquiring these skills require a certain amount of time, agencies do experience difficulties using their AVL systems to their potential. Suppliers that were interviewed by CUTR stated that training on hardware is relatively easy; however, if an agency does not have a strong Information Technology/Systems Department, training on the software could be a more extensive process. According to the TCRP Synthesis 24, while some agencies have GIS and Information Systems staff, others train internal staff, hire consultants (which can be expensive) or contract out these services.

***Examples of AVL Suppliers***

@Road (www@road.com), LOCSYS, Inc. (www.locsys.com), Manning NavComp (www.navcomp.com), McCain Traffic Supply (www.mccaintraffic.com), CompassCom (http://www.compasscom.com/index.cfm?showsecondarylinks=true&showcontentlinkID=23&primarylinkID=23), Mentor Engineering Inc. (www.mentoreng.com), Orbital Transportation Management Systems (telephone: 443-259-7125), Siemens (www.siemens.at).

***Examples of AVL Pricing***

The cost of hardware ranges from $400 to $3,000 per vehicle while software cost ranges from $2,000 to $30,000 depending on capabilities. Additional costs may include those related to the infrastructure, supplier service fees, recurring fees for the wireless network provider, etc. According to a 1996 study by Georgia State, "Assessing the Role of Advanced Public Transportation Systems in Safety and Emergency Management" and a study by the National Urban Transit Institute, AVL systems pay for themselves when they help reduce fleet size by 2.3 percent. The report also indicates that the several transit agencies reported fleet size reductions of four to nine percent, thus reaping significant savings over AVL investment.

## *Mobile Data Terminals (MDTs)*

Mobile Data Terminals (MDTs) display short text messages, replacing the voice radio communication between the driver and dispatcher except in emergencies or other exceptional cases. They can automatically send vehicle location, passenger counts, engine performance, mileage, and other information. Some information such as passenger boardings and alightings may be sent when the passengers use their smart cards as they enter or depart the vehicle or when the driver pushes function keys on the MDT. The driver can use other function keys to send pre-recorded digital messages regarding vehicle and passenger status or in response to questions or prompts displayed on the MDT screen. As a result, MDTs can virtually replace note-taking and written manifests and become an entry point for data to perform system-wide passenger counts and vehicle performance analysis.

Implementation of MDTs typically takes approximately three to six months. The necessary training is included in this time frame and takes about four to eight hours.

MDTs are used in conjunction with dispatch/scheduling software and data are reported in the format used by these software.

### ***Strengths/Weaknesses of MDTs***

MDTs can be an important tool in the full-automation of tracking passenger counts, vehicle mileage, and other information. Because the figures received will be automated, errors due to manual recording, data entry, etc. will be eliminated. The limitations of MDTs relate to the wireless coverage area. If a vehicle moves outside of the coverage area, related statistics will be lost. However, appropriate testing prior to the beginning of the installation process can minimize this risk. In addition, it is important to gain the support of the vehicle operators, who need to keep the equipment in good shape and report any problems.

### ***Examples of MDT Suppliers***

Greyhawk Technologies (www.greyhawktech.com),
Mentor Engineering (www.mentoreng.com).

### ***Examples of MDT Pricing***

Cost of the hardware ranges from $1,000 to $4,500 depending on the availability of AVL, modem capability, etc. Cost to interface with scheduling software ranges from $15,000 to $35,000.

## *Electronic Registering Fareboxes (ERFs)*

Electronic fareboxes (ERFs) can be used to count passengers in buses as they board the vehicle. ERFs allow agencies to collect ridership data in a greater detail (by route, trip, fare categories, etc.). Of the 24 agencies interviewed for this analysis, 13 use ERFs in counting passengers while the remaining agencies keep manual records. Primary manufacturers of the fareboxes used by Florida agencies are GFI and Cubic, with the majority using GFI. Agencies can retrieve the data in their garages without a physical connection or by using dynamic or periodic remote retrieval of farebox data.

### ***Summary of ERF Technology***

Electronic fareboxes can register certain type of fares automatically, such as tokens or magnetic passes (although reading magnetic passes would require additional equipment), while for others the operator has to push the appropriate button on a keypad. Examples of this second category are discounted fares and nonmagnetic passes. As explained in TCRP Synthesis 34, titled "Data Analysis for Bus Planning and Monitoring," a recent development is fareboxes that store transactional data. Instead of making a record only at the end of each trip or other segmentation point, these fareboxes create a permanent record of every boarding, or at least every fare transaction. Typically, the record includes time of day, fare category, payment medium, and identifiers such as the route number.

### ***ERF Caveats***

According to TCRP Synthesis 29, titled "Passenger Counting Technologies and Procedures," as in the case of any new technology, an initial "debugging" period is experienced by agencies that start using ERFs. This period averages almost 18 months, with a range of six weeks to six years.

### ***Strengths/Weaknesses of ERFs***

Some of the advantages of using electronic fareboxes as cited by responding agencies include increased ability to collect fares, greater accuracy of data in comparison to manual collection, and ability to group information in various forms. Disadvantages cited were the necessity of manual manipulation/entry of results, at times inaccurate data due to operator errors (e.g., pressing wrong buttons, not signing the correct run number or other relevant information, etc.), difficulties in identifying the source of the errors during validation, and not offering the capability to measure miles (vehicle miles, passenger miles, etc.). TCRP Synthesis 34 also mentions maintenance staff not probing the fareboxes each day, allowing data to be assigned to the wrong date or to be lost because of storage buffer overflow. An additional disadvantage cited in TCRP Synthesis 29 related to mechanical/equipment problems such as currency jams, aging coin mechanisms, difficulty in reading swipe cards, overloaded vaults, and reliability of time/date stamp that records when trips were made.

***Examples of ERF Suppliers***

Agent Systems, Inc. (www.agentssystems.com), C Card (www.coincard.com), Cubic Corporation (www.cubic.com), GFI Genfare (www.gfigenfare.com).

***Examples of ERF Pricing***

One supplier provided a range of $10,000 to $20,000 per farebox, including software and hardware. Another vendor stated that the hardware cost would range from $11,000 to $13,000 per box while software cost would range from $34,000 to $54,000.

### Automatic Passenger Counters (APCs)

Automatic passenger counting (APC) units are currently used by two Florida agencies and at least one other Florida agency is in the planning stages of incorporating this technology. APCs are most frequently used in buses. They count passengers as they board and alight a vehicle and record times at each stop, which allows agencies to calculate passenger miles without using checkers. APCs also provide information on directional route miles required for the NTD. Because the full APC systems include an AVL component, they can provide all of data provided by AVLs in addition to other information.

***Summary of APC Technology***

Two different technologies used by APCs include infrared sensors and treadle mats. Infrared sensors are typically mounted near the bus doors. There are two types of infrared sensor technologies: active and passive. Active infrared sensors need the reflection of objects passing through the door and dark colors do not reflect well. In addition, active infrared systems need periodic re-calibration. Passive infrared sensors can only detect "change in heat," which means if there is no movement, there cannot be any detection. Some manufacturers provide a combination of these two infrared technologies to provide more accuracy.

Treadle mats are mounted to the vehicle steps and contain switches that close as passengers step on the mat. The transitions and times between closing and opening switches determine passenger flows. According to the TCRP Synthesis 29, in certain climates treadle mats can be difficult to maintain, but most observers report no difference in accuracy between the two technologies.

To correlate the data to specific bus stops, AVL systems can be used. According to the experience of agencies interviewed as part of the TCRP Synthesis 29, availability of an AVL system reduces the cost of APC units, which no longer need to handle data storage, data transmission, and odometer interface.

Finally, agencies retrieve the data either at their garages without a physical connection, by establishing a direct downlink at the garage, or by transmitting data remotely via radio while the bus is on the street.

***Strengths/Weaknesses of APCs***

Both Florida agencies that use APCs are highly pleased with the results and believe that this technology benefited their agencies in terms of cost savings (elimination of checkers and data entry), increased accuracy of data, and additional usage of data obtained (in redesigning the system, determining routes that should be eliminated, and reallocating the resources more efficiently, etc.). One agency is now requiring new buses to be equipped with APCs so that eventually all the buses in the system will have APC units.

Overall, agencies interviewed for the TCRP Synthesis 29 were satisfied with APCs. Some of the problems experienced related to the software, including the necessity to develop/upgrade analytical programs, time-consuming data processing, and consistent maintenance requirement of databases containing schedule and bus stop information. Some of the hardware problems reported included equipment failures, maintenance problems, and the durability of APC units on the buses. For signpost-based systems, signpost detection and difficulty in coordinating signposts with bus route assignments were mentioned. Finally, it was important that APCs be accepted by all personnel of the agency and to have active management of the system.

Earlier studies found that APCs were more accurate at recording boarding activity than alighting activity and that there was a tendency for APCs to undercount passenger activity (Attanucci and Vozzola, 1983). A study completed by King County (Washington) in November and December of 2001 on demonstration coaches equipped with infrared APC technology found that the APC system had an overall accuracy of 105 percent for passenger boarding and 91 percent for passengers alighting, showing an overall tendency to overcount passenger boardings by five percent and undercount passenger alightings by nine percent. A recent study conducted by Thomas Kimpel et. al. (April 2002) evaluated the accuracy and precision of APCs by comparing APC data to data collected by video surveillance cameras. It found that although measurement error existed with APCs, the problem was relatively minor compared to error associated with manual data collection techniques.

According to the findings of the TCRP Synthesis 34, APC data are subject to five kinds of errors:

- general hardware malfunction;
- miscounting passengers;
- failing to identify the correct stop;
- incorrect data segmentation (start of new trip); and
- incorrect sign-on (route, driver) information.

Because of hardware malfunctions and location problems, agencies interviewed for TCRP Synthesis 34 reported discarding 10 to 50 percent of the data, with newer systems having generally better performance. Another challenge reported in TCRP Synthesis 34 was the trend toward low-floor buses with entries wide enough for several passengers, which makes it difficult to obtain an accurate passenger count.

***APC Caveats***

Similar to other agencies throughout the country, Florida agencies equip only a certain number of their buses with APCs in order to minimize the cost. They rotate these buses appropriately to comply with the sampling requirements of FTA.

Agencies surveyed for the TCRP Synthesis 29 reported that the break-in or debugging period for APCs averages 17 months, very similar to the electronic fareboxes.

***Examples of APC Suppliers***

Infodev (www.infodev.ca), INIT (www.initusa.com), PerMetrics Technologies, Ltd. (www.permetricstech.com), Red Pine Instruments Ltd. (telephone: 613-333-2776), Urban Transportation Associates (telephone: 513-961-0099), and Wardrop Applied Systems, Inc. (www.wardrop.com).

***Examples of APC Pricing***

If an agency already has an AVL system, the cost of adding APCs (as a sub-system) ranges from $900 to $2,000 per bus. The price to implement a full system ranges from $6,000 to $8,000 per bus. It is also possible to lease APCs, which may be feasible in some cases. The lease price depends on the number of units leased as well as the length of the lease.

### Hand-Held Units

Hand-held units can be used by checkers to record data for sampling in estimating ridership and passenger miles. This technology allows agencies to eliminate data entry and therefore tends to increase accuracy. For this purpose, it is possible to use generic computer equipment, such as laptops or personal data assistants (PDAs), which are small hand-held computers that electronically reproduce driver manifests, among serving other functions. These units tend to be directly connected to a host computer to upload and download data. Required information for each route is stored on a host computer and is downloaded to hand-held units when needed. Ridership data is uploaded when the check is completed. Changes in schedules or stop lists are made in a single location (on the host computer).

For demand-response services, drivers can pick up PDAs that are loaded with a day's worth of trip data in the morning and return them to the office at the end of the day. Each day's data are downloaded and the PDA is recharged. It accomplishes the combined job of a scheduling and dispatching software as well as a MDT system but with less capital cost and more driver effort.

### ***Strengths/Weaknesses of Hand-Held Units***

Because the data entry is eliminated, hand-held units tend to increase the accuracy of the data. At the same time, some agencies mentioned that they lost the valuable written comments they used to receive from checkers/drivers, which were instrumental in understanding the sources of/reasons for irregularities. One Florida agency that started using hand-held units recently reported that although the agency still has the same number of checkers (and therefore no obvious labor cost savings), they are able to complete twice as many surveys (increased accuracy of estimates). This agency also felt that the accuracy of the data has improved since error prone data entry process was eliminated. One problem the agency faced was having to download and upload the data only in the host computer, which required checkers to coordinate with each other and transport all of the data to the central office.

In comparison to MDTs, PDAs tend to be more affordable. One of the concerns about PDA units relates to life of the hardware (i.e., may not be very sturdy), which is increased with industrial grade units. Another concern is that these units could be stolen/lost relatively easy due to their multiple functions and small size.

### ***Examples of Hand-Held Unit Suppliers***

Casio (www.casio.com), Compaq (www.compaq.com), Dell (www.dell.com), Handspring (www.handspring.com), HP (http://products.hp-at-home.com), Microsoft (www.microsoft.com), Palm (www.palm.com), Sharp (www.sharp-usa.com), Sony (www.sonystyle.com), Toshiba (www.toshiba.com).

### ***Examples of Hand-Held Unit Pricing***

Depending on memory and other features, the price range for these products is $200 to $1,000 per unit.

## SMART CARDS

Smart cards contain information that can be queried or supplemented by a card reader. These cards have an integrated circuit chip, a central processing unit, and an operating system like a small computer. The reader activates the card to identify the passenger, obtain stop data, determine the source and amount of fee, or other information. Smart cards can be integrated with the agencies' accounting systems, scheduling software, and AVL systems.

Depending on the complexity of the project, the implementation of smart cards can require six to 24 months, which includes a training period of up to two months.

The use of smart cards by transit agencies is still limited and none of the Florida agencies interviewed reported using smart card technology for NTD purposes.

***Smart Card Caveats***

It should be noted that in terms of collecting passenger information for NTD, this technology may be more effective for demand-response than fixed-route. In the case of fixed-route, it is important to achieve a high-level of penetration among transit users to provide any meaningful ridership data beyond the number of people who are using smart cards.

***Strengths/Weaknesses of Smart Cards***

According to TCRP Synthesis 29, agencies that have tested smart cards are positive about their experiences and the potential of this technology. According to the same source, problems identified in demonstration projects included a lack of integration with the farebox and other on-board equipment and software, software bugs, data retrieval (particularly the need for training), and hardware problems. The time commitment for training personnel in the implementation of smart card, retrieving and formatting data, etc. can be extensive. The Maintenance Department's support for installation and maintenance of additional equipment strongly influences the transition to smart cards. Operators also need to be informed of the value of smart cards. Agencies without ERFs would require operator intervention to record cash fares in a smart card system, and operators tend to be the ones who must deal with passenger complaints regarding smart card malfunctions.

***Examples of Smart Card Suppliers***

ASK SA (www.ask.fr), Cubic Transportation Systems (www.cubic.com/cts/index.html), DataCard Group (www.datacard.com), ERG Group (www.erg.com.au/transit/index.htm), SchlumbergerSema (www.smartcards.net/transit/index.html).

***Examples of Smart Card Pricing***

Suppliers were unable to provide a unit price and explained that the cost of implementing smart cards depends on many factors including type of fare collected, existing back-office operations, level of usage (how extensive, how many modes, etc.), and other variables. According to one supplier, implementing a complete smart card system in a larger urban area can range from $20 million to $100 million.

### Scheduling Software

Depending on the level of automation, scheduling and validation software have capabilities to provide integrated databases for routes, riders, vehicles, and facilities, etc. These programs tend to interface with APC and AVL systems, MDTs, PDAs, and advanced fare collection technology, which eliminates the need of data entry and/or achieves a higher level of automated data integration. In the case of MDTs and PDAs, the scheduling software sends/uploads the scheduled trips prior to the beginning of the service. At the end of the service, output from these units are downloaded to the software for data manipulation. Some of these programs have sampling capabilities to be used in the estimation of passenger miles and ridership statistics.

Implementation of this type of software takes about 5 to 12 months while the necessary training ranges from one to 20 days, depending on the complexity of the program.

***Examples of Scheduling Software Suppliers***

Community Transit Systems Software, Inc. (www.cts-software.com, demand-response only), Fleet-Net (www.signature.net/dealers/fleetnet), Giro (www.giro.ca), StrataGen (www.stratagen.com, demand-response only), Trapeze Software Group (www.trapezesoftware.com), RideCheck (www.rsmservices.com, automated data entry, manipulation and reporting program, not scheduling software).

***Examples of Scheduling Software Pricing***

The cost of scheduling software varies significantly depending on the complexity and the level of automation. Based on information provided in a 1999 report prepared by North Carolina State University, "Small Urban and Rural Advanced Public Transportation Systems," the software cost for fully-automated scheduling programs ranges from $4,000 to $2 million. Discussions with transit agencies also indicated a large range. Agencies who recently acquired scheduling software stated that a part of the reason for such a large range relates to how suppliers bundle their products. Scheduling software is sold in modules with each module providing different services. If an agency can limit its purchase only to the needed module, the cost is relatively lower. However, at times, the agency's existing technology may not be compatible with the new program and some of the other software/hardware may need to be upgraded as well, which increases the cost.

## Automated Data Collection Methods for the Resource Module

The Resource Module contains three forms:

- Employees (Form R-10)
- Maintenance Performance (Form R-20)
- Energy Consumption (Form R-30)

Employee information required includes the number of transit agency employees (person count) and their total work hours by labor category and by mode. These statistics are typically tracked by accounting/payroll systems, which fall under the automated methods used for financial information and are beyond the scope of this study.

Statistics required in the maintenance area include revenue vehicle system failures and hours spent on inspection and maintenance by the transit agency's service personnel for directly operated modes. In terms of energy consumption, agencies are requested to report vehicle fuel consumption for directly operated service only.

### *Fleet Management Programs*

Fleet management programs provide transit agencies with an automated tool to track vehicle inventory, fuel purchases, vehicle mileage, and maintenance information, among other capabilities. They contain vehicle fleet information with each vehicle's history, current status including mileage, and scheduled maintenance. Agencies can use this list to provide some of the statistics required in the Asset Module as well as those required in the Resource Module.

These programs track fuels and other fluids used by vehicles by individual vehicles. With electronic fuel interface (EFI) capabilities, information from automated fueling systems can be transferred to fleet management programs without requiring manual data entry.

Fleet management programs document planned and unplanned maintenance work completed on each vehicle, which provides the agency with a list of revenue vehicle system failures.

In addition, some of the programs allow agencies to specify certain checks and balances and give warnings for figures that appear abnormal. Fleet management programs provide data in ASCII files, which can be exported to spreadsheets, databases, or other software. In addition, these programs tend to offer report generation option, which allows users to generate a variety of reports.

### ***Strengths/Weaknesses of Fleet Management Programs***

These applications significantly reduce or eliminate data entry. Although accuracy of the data increases, it is still important to validate the data. Operating a program with built-in checks and balances makes it easier to do so.

### ***Examples of Fleet Management Program Suppliers***

Dossier (www.truckfleet.com), FleetMaint (www.dpsi-cmms.com/fleetmaint), Fleetman (www.fleetman.com), Fleetmate (http://biznet.maximizer.com/dcooper/msg4.html), Fleet-Net (www.signature.net/dealers/fleetnet), RTA Fleet Management Software (www.rtafleet.com), Transman (www.tmtsoftware.com), and, for other fleet maintenance software packages along with free demonstrations, see www.plant-maintenance.com/maintenance_software_FM.shtml .

### ***Examples of Fleet Management Program Pricing***

Depending on the inventory size and complexity of the program, the cost for these programs can range from $2,000 to $200,000.

## Fuel Dispensing/Management Applications

Fuel dispensing and management applications are necessary in the full-automation of data collection on fuel purchases. Pumps equipped by these systems allow access through several methods including simpler methods such as keying in the vehicle number as well as more automated methods such as magnetic stripe cards, smart read/write keys with embedded chips, and intelligent vehicle modules which allow direct communication to the vehicle without driver interaction. At times, these applications also provide information on vehicle number and life-to-date mileage each time a vehicle is serviced.

Output from these applications can be imported to fleet management programs or are directly provided in several formats. Depending on the suppliers, these formats include ASCII files (comma-delimited or comma-separated), spreadsheets (Excel, Lotus, etc), databases (Access, FoxPro, dBASE), and HTML.

Depending on the complexity of the system, installation/implementation can range from four days to three weeks. Required training takes one to three days.

***Strengths/Weaknesses of Fuel Dispensing/Management Applications***

Agencies that use automated fluid dispensing methods believe that the information they obtain is more accurate. Florida agencies that are currently tracking energy consumption manually reported difficulties in obtaining accurate figures, reading gas station attendants' handwriting, etc. They believe that automated methods would simplify the process and increase accuracy.

***Examples of Fuel Dispensing/Management Application Suppliers***

Gasboy (www.gasboy.com), Petrovend (www.petrovend.com), Fleetwatch (www.fleetwatch.com).

***Examples of Fuel Dispensing/Management Application Pricing***

Depending on the size and complexity of the system, the cost for these products can range from $15,000 to $100,000.

## Automated Data Collection Methods for the Asset Module

The Asset Module includes the following forms:

- Station and Maintenance Facilities (Form A-10)
- Transit Way Mileage (Form A-20)
- Revenue Vehicle Inventory (Form A-30)

In many cases, agencies have a small number of stations and maintenance facilities and can fill NTD forms by memory. Revenue vehicle inventory can be tracked by using AVL systems or fleet management programs, both discussed previously. In addition, it is possible to input and track station and maintenance facility information in fleet management programs.

## Automated Data Collection Methods for the Safety and Security Module

The Safety and Security Module requires the completion of the following forms:

- Informational forms, which consist of:
  - Incident Mode Service (Form S&S-10)
  - Ridership Activity (Form S&S-20)
  - Security Configuration (Form S&S-30)

- Incident Reporting forms, which include:
  - Major Incident Reporting (Form S&S-40)
  - Non-Major Incident Reporting (Form S&S-50)

Figures for the Ridership Activity form can be obtained by using automated methods to collect ridership information, as discussed previously in this appendix. The remaining forms are typically completed based on paper reports prepared or by using information tracked in a spreadsheet. Agencies tend to not need automated methods specific to this Module.

## Other/General Use:

In addition to above mentioned automated methods and applications, most agencies use spreadsheets like Excel, Lotus or Quattro Pro and some agencies use database applications such as Access and FoxPro. Florida agencies use these applications either by themselves or in conjunction with other software to track a variety of variables including vehicle inventory, vehicle/revenue hours and miles, annual passenger data, vehicle system failures, fuel purchases, employee hours, directional route miles, safety/security information, and other statistics. In addition, some of the agencies provide their contractors spreadsheets that have hidden formulas and checks and balances built in for contractors to enter their data. This facilitates tracking the necessary statistics for contractors and gives them an indication of possible errors.

***Strengths/Weaknesses of Spreadsheets/Databases***

Although these applications are not as sophisticated as some of the other methods described previously in this appendix, they are readily available, inexpensive, easy to use, and do not require extensive training. Although they facilitate calculations and monitoring of the data, because they are not fully automated, agencies need to enter data unless they are using spreadsheets/databases in conjunction with other software. At times, they may be customized to fit an agency's specific needs. Usually a local programmer performs the work based on the needs. A few responding Florida agencies reported using customized spreadsheet/database applications for various purposes.

***Examples of Spreadsheet/Database Suppliers***

Microsoft (www.microsoft.com), FoxPro (http://msdn.Microsoft.com/vfoxpro), IBM (www.lotus.com).

***Examples of Spreadsheet/Database Pricing***

Price for spreadsheets and databases range from $100 to $600 (without customization). Some products may come "bundled" with new computers. In addition, if other departments of the City/County governments already own a copy, getting the right to install an additional copy may be quite inexpensive.

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This appendix provides a broad overview of automated methods available to transit agencies in collecting and compiling required NTD data. As mentioned previously, in most cases these applications offer capabilities and functions beyond what is needed for collecting NTD data. Hence, agencies' overall needs in the related area should be considered in deciding to acquire various software and hardware.

# BIBLIOGRAPHY


Attanucci, J. & Vozzolo, D. (1983). Assessment of operational effectiveness, accuracy, and costs of automated passenger counters. Transportation Research Record, 947, 15-23.

Baltes, M. & Rey, J. (1998). Use of automatic passenger counters assessed for Central Florida's Lynx. Center for Urban Transportation Research.

Boyle, D. B. (1998). Passenger counting technologies and procedures. TCRP Synthesis of Transit Practice 29. Washington, DC: Transportation Research Board.

Friedman, T. (1993). The Evolution of Automatic Passenger Counters. Seattle Metro.

Furth, P. (2000). Data Analysis for Bus Planning and Monitoring. TCRP Synthesis of Transit Practice 34. Washington, DC: Transportation Research Board.

Kimpel, T., Strathman, J., Griffin, D., Callas, S., & Gerhart, R. (2002). Automatic passenger counter evaluation: Implications for National Transit Database reporting. Center for Urban Studies, Portland State University and Tri-Met.

King County, Metro Programs – Automatic passenger counter. http://transit.metrokc.gov/prog/smartbus

Kittelson & Associates, Inc., Urbitran, Inc., LKC Consulting Services, Inc., MORPACE International, Inc. Queensland University of Technology, and Yuko Nakanishi (2003). A Guidebook for Developing a Transit Performance-Measurement System. TCRP Report 88. Washington, DC: Transportation Research Board.

Los Angeles County Metropolitan Transportation Authority. ATMS Project. www.mta.net/other_info/ATMS/automatic_passenger_counting.htm.

North Carolina State University Department of Civil Engineering (1999). Small Urban and Rural Advanced Public Transportation Systems. The Federal Transit Administration.

Okunieff, P. A. (1997). AVL Systems for Bus Transit. TCRP Synthesis of Transit Practice 24. Washington, DC: Transportation Research Board.

Volpe National Transportation Systems Center (2000). Benefits Assessments of Advanced Public Transportation System Technologies Update 2000.

Websites of various programs, most of which are listed in the report.