<u>Analyzing Transit-Route Performance using AVL/APC Information with GIS</u>

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Abstract

We describe some of the ways in which archived AVL (Automatic Vehicle Location) and APC (Automatic Passenger Counter) information were used to analyze the performance of a bus route that was known to experience regular delays. GIS was used to understand the observed schedule deviations and passenger counts along the route, their relationship to one another, and how they varied with different trips and time periods. A tabular representation of the deviations or passenger flow is certainly not an appropriate method when a large number of stops are involved. A graphical representation can show a general trend; however, exporting this information to a GIS and adding street layers enabled displaying the numbers along the route while making it possible to comprehend and analyze different types of information simultaneously.

1. Introduction

Automatic Vehicle Location (AVL) systems and Automatic Passenger Counters (APC) are increasingly being deployed by transit agencies in USA. Most of the agencies are using these systems primarily for managing operations in real time (1). However, with the availability of systems that allow archiving of the bus location and passenger data, many operators are realizing novel ways of using the information for performance analysis and planning purposes. "Preparing and evaluating over long periods and in close correlation to practical activities allows transport companies to draw up the bases for economic viability considerations or operational planning. Strengths and weaknesses can be detected, analyzed and operating procedures corrected and optimized" (2).

In Champaign and Urbana, Illinois, USA, the Champaign-Urbana Mass Transit District (CUMTD) uses CAD-AVL (CAD: Computer Aided Dispatch) and APC systems developed by

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INIT inc. Most of the CUMTD's fleet is equipped with this technology. Detailed stop level data is archived on a daily basis including the actual and scheduled departure and arrival times, number of people getting on and off and the bus load for all routes and buses. MobileStatistics, a data administration and evaluation system is used to query the archived AVL and APC data. Various types of queries are possible such as Passenger Flow Per Stop, Schedule Deviation Average, Schedule Deviation On Time, Passenger Flow Per Trip, Running times, etc.

Having such detailed information is not of much use if not condensed into an easily understandable form. Especially for planning purposes, one needs to look at the data for an extended period of time. This paper aims to describe how Geographic Information System (GIS) was used to comprehend and analyze the performance of a bus route which was known to experience regular delays.

The rest of the paper is organized as follows. Section 2 describes the methodology involved in querying and extracting AVL/APC data and classifying and visualizing it using ArcView. Section 3 summarizes the observations and section 4 concludes the paper.

2. Methodology

2.1. Querying and Extracting Data

Delays in 9A Brown route and 9B Brown route service were reported quite often. These are weekday daytime community routes. 9A Brown runs in the clockwise direction and 9B Brown runs in the counterclockwise direction (Figure 1).
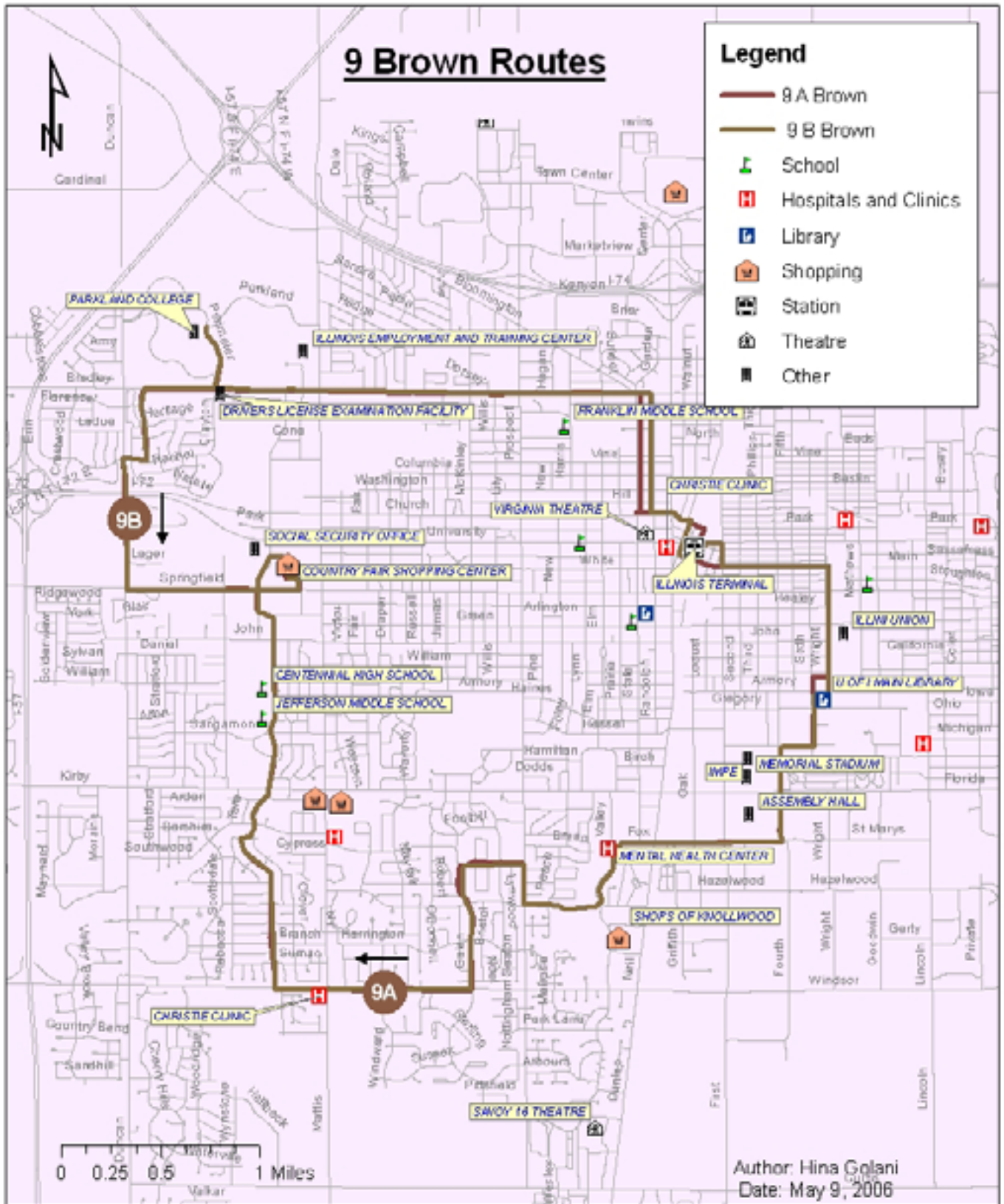
Figure 1: 9A Brown and 9B Brown routes

To find the causes of the problem along with the problem areas along the route, the archived APC and AVL data had to be extracted. We used two types of MobileStatistics queries to extract the data for 9 Brown bus routes: Passenger Flow Per Stop and Schedule Deviation Average. A number of parameters can be specified in the queries. The parameters include type of query, name of route, range of dates, time period, stop set, block number and trip patterns. In our case, the different parameters specified were:

- Type of query: Schedule Deviation Average, Passenger Flow Per Stop
- Name of route: 9A Brown, 9B Brown
- Range of dates: 14 March 2005 to 30 April 2005
- Time period:
    - Individual trips: 1:15 pm to 2:13 pm (for a trip that begins at 1:15 pm and ends at 2:13 pm) etc
    - Morning, day and evening time periods: 7 am to 10 am, 10 am to 3 pm, 3 pm to 6 pm
    - All (to include trips throughout the day)
- Stop set: Parkland college to Parkland college (all stops for this clockwise/anti-clockwise route)
- Block number: Block 131, 156, 160 etc.
- Trip set: 9A and 9B trip patterns which are subsets of the complete trip starting and ending at Parkland College.

The Schedule Deviation Average is the difference between actual and scheduled departing time at a stop which we averaged over a one and a half month period. This was displayed for all the stops since we included all possible stops in the stop set. A block is a set of trips completed by one bus. For instance, for the schedule displayed in Figure 2, the trips indicated by the arrows correspond to block 131 and are serviced using same bus.

Figure 2: Blocks for route 9A Brown

All the results are obtained in a table form, which can be exported to excel or GIS. For this route, while there are certain stops called timepoints where a bus must stop , each intersection is potentially a stop if there is a passenger who wishes to get on or off at an intersection. A tabular representation of the deviations or passenger flow is certainly not an appropriate method when such a large number of stops are involved. A graphical representation can show a general trend, however exporting it to GIS and adding streets layers would enable displaying the numbers along the route while making it possible to simultaneously analyze different types of information.

2.2. Classifying and Visualizing the information using GIS

Two shapefiles were obtained from the export of Passenger Flow per Stop and Schedule
Deviation queries. These were imported into an ArcView Map having a layer of streets and a
layer of the 9A (or 9B) route. Passenger Flow per Stop shapefile has fields with information
regarding stop name and position, total number of people getting on and off the bus at a stop,
total load, average on and off per trip, daily boardings, wheelchair activity and number of trips.
Average Schedule Deviation shapefile has fields with information regarding stop name and
position, average deviation from schedule, standard deviation from the average, minimum and
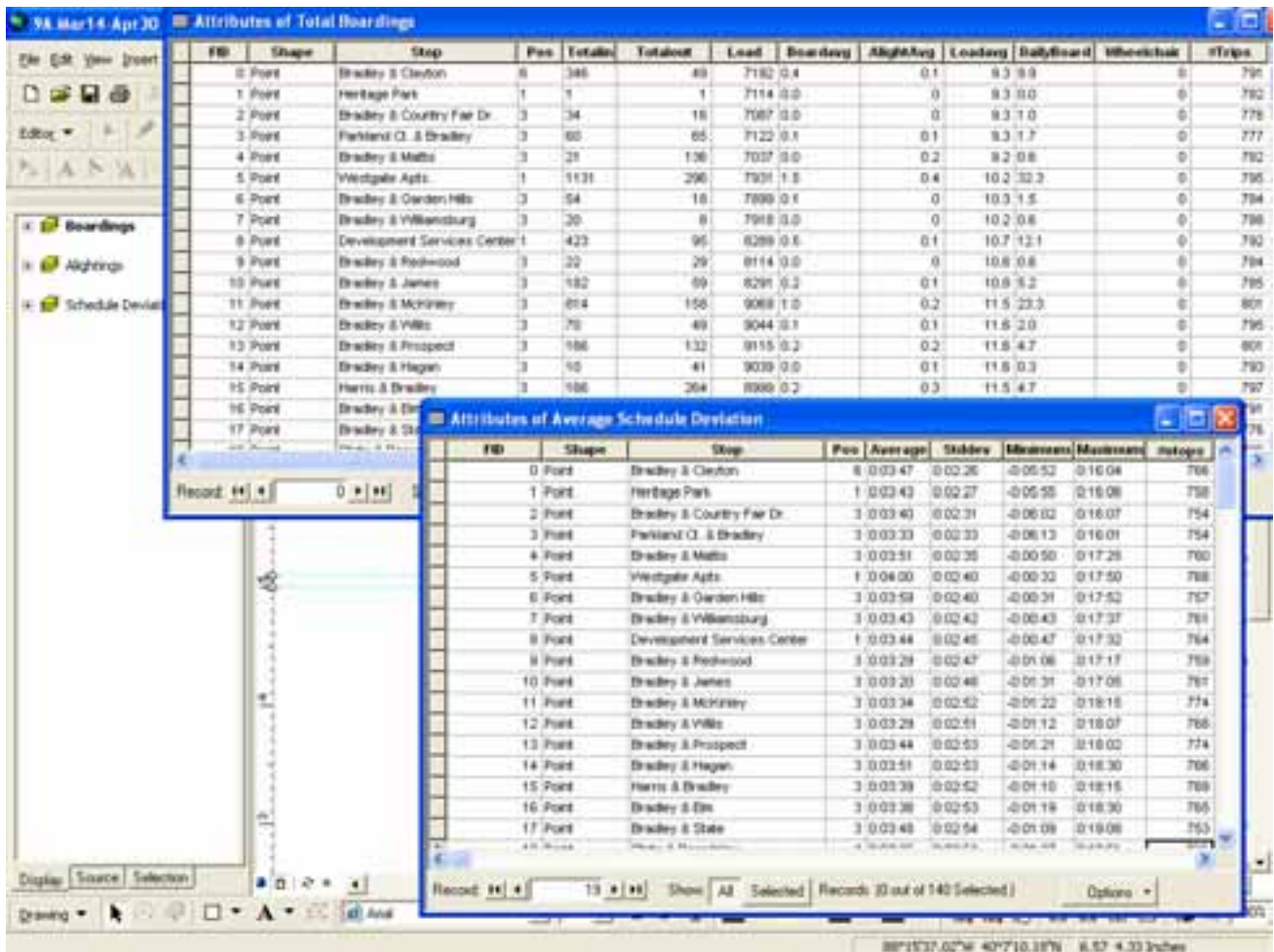maximum values of deviation (Figure 3).

Figure 3: Attributes of Passenger Flow per Stop and Average Schedule Deviation

The average schedule deviation was classified in ArcView so that different colors and sizes of symbols represent different delay intervals of 1 to 2 minutes, 2 to 3 minutes, 3 to 4 minutes and so on (Figure 4). Total number of boardings and alightings for a one and a half month period (Figure 4) and average number of boardings and alightings per trip for the same period were plotted along the route to find if the schedule deviation patterns corresponded to an increase and decrease in the number of people boarding and alighting. The next step was to plot the three types of statistics for all blocks of route (Figure 5). This helped in visualizing and identifying the problem blocks. For example, blocks 156 and 160 were identified as two of the problem blocks with average schedule deviations being 8 to 9 minutes at some of the stops. Further extracting the schedule deviation and ridership data for the blocks by different time periods (Figure 6) and trips (Figure 7) and plotting it in sequence helped identify trip specific delays and determine if and how much of the delay from one trip was carried over to another trip.
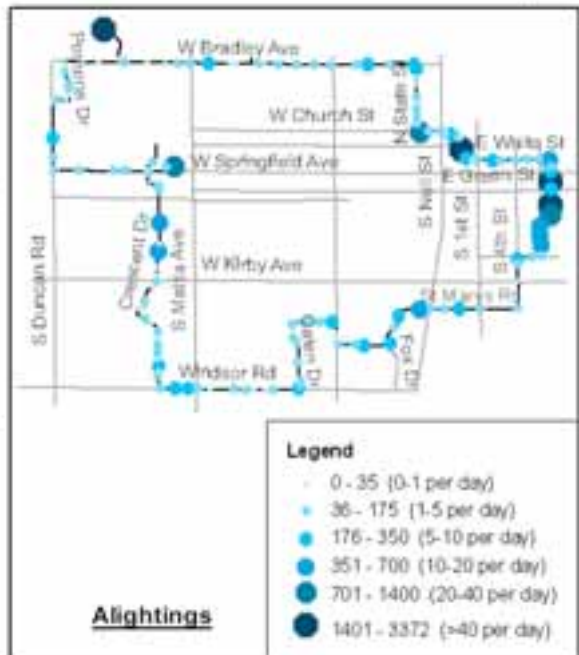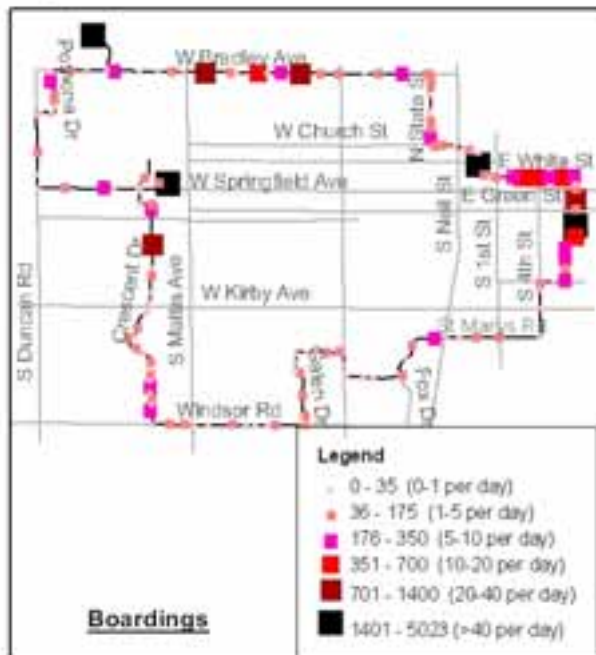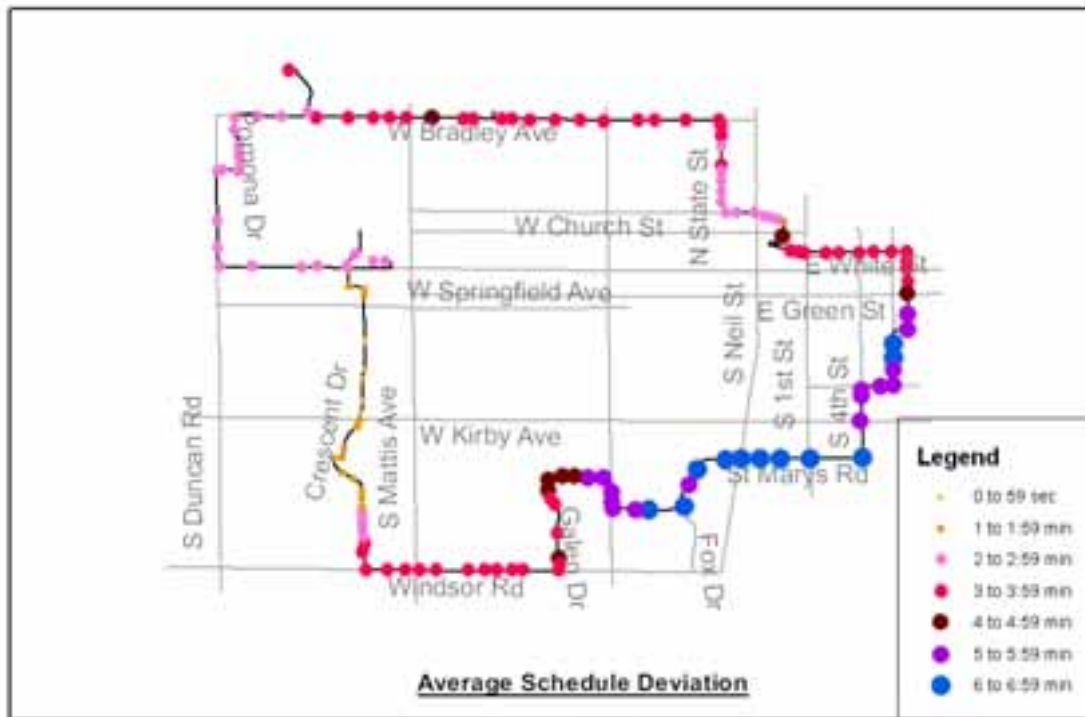
Figure 4: Schedule deviation, total boardings and total alightings for all trips

9A Brown Blocks - Average Schedule Deviation
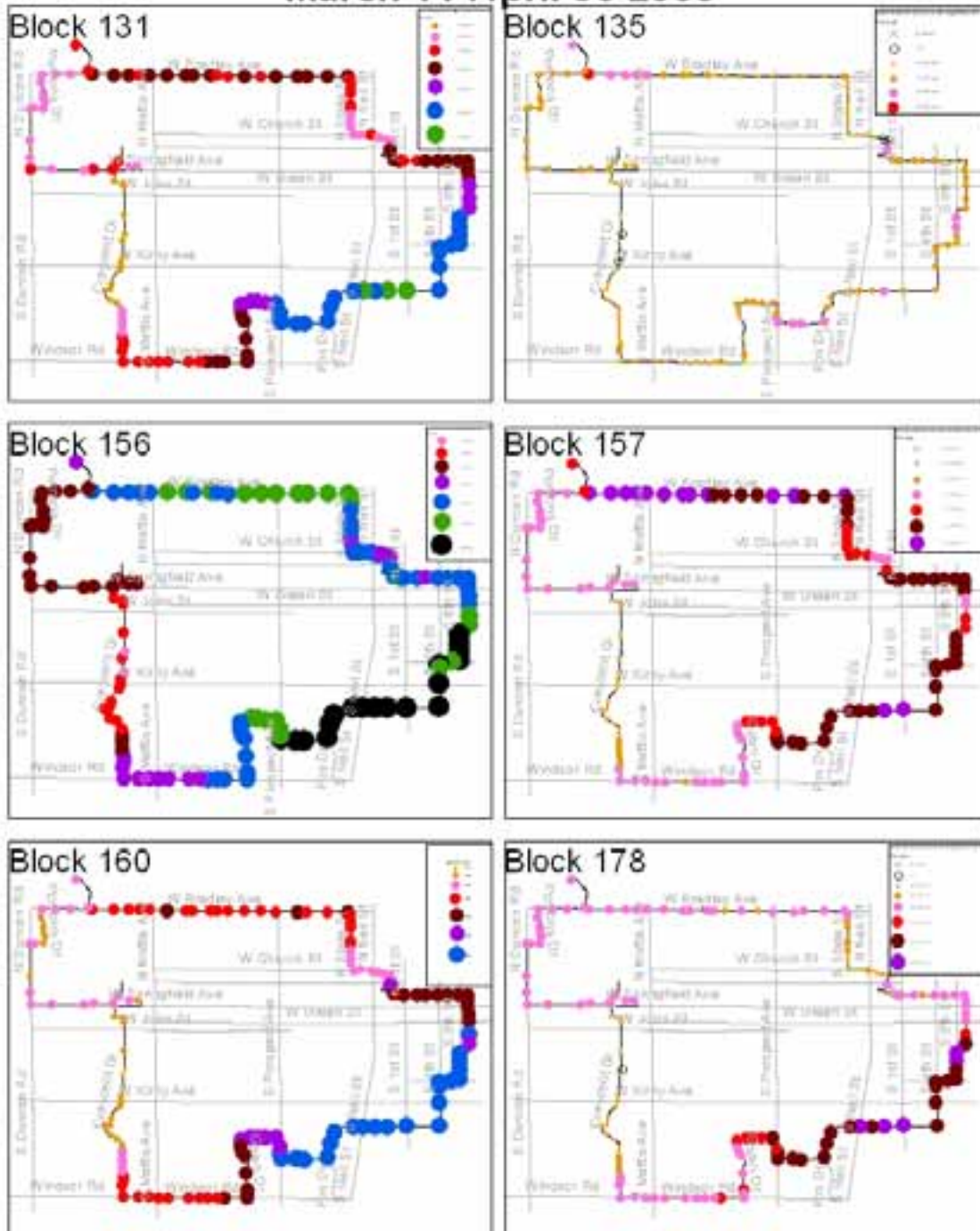## March 14-April 30 2005

Figure 5: Schedule deviation for blocks

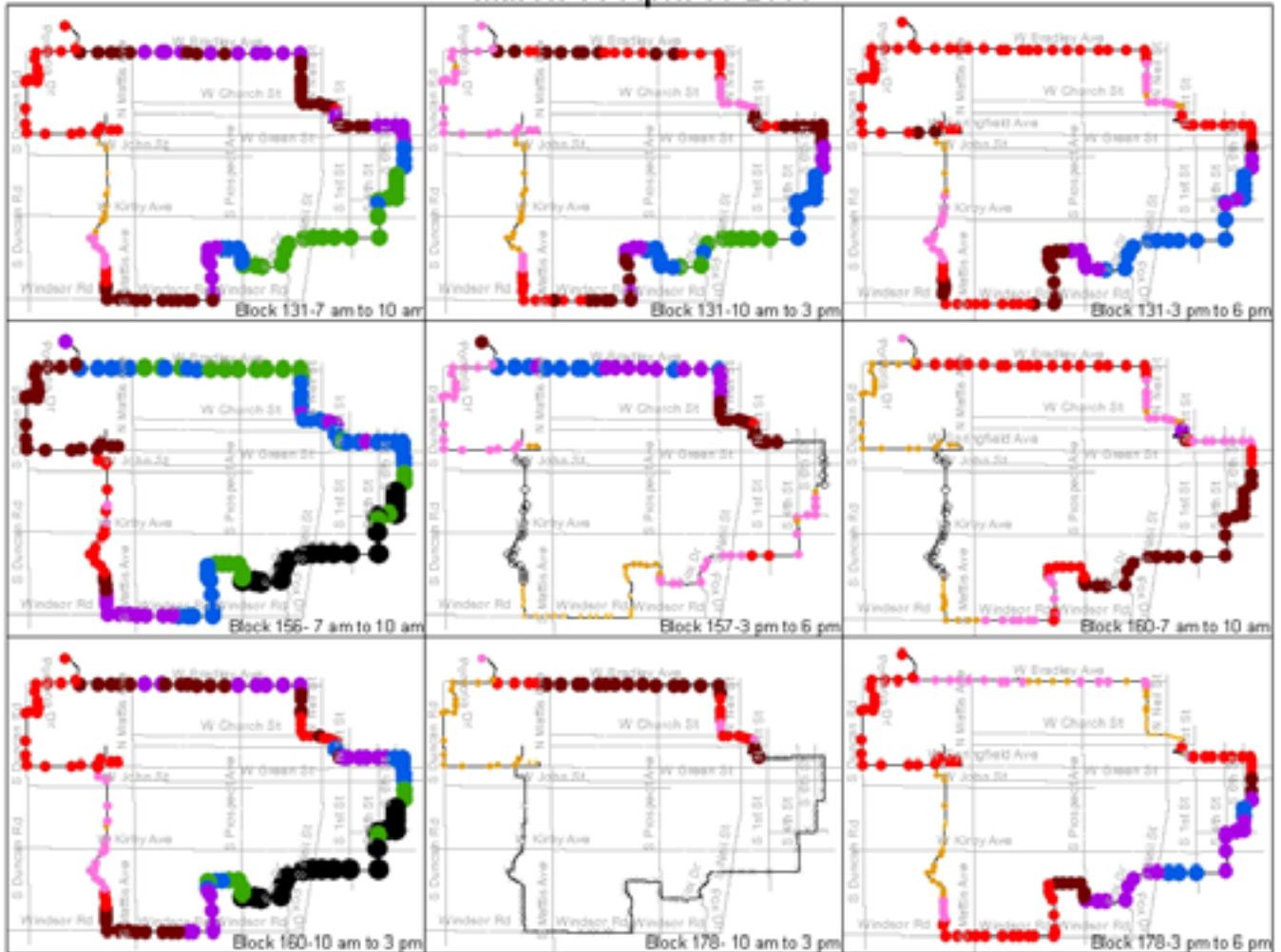**Figure 6: Schedule deviation during morning, noon and evening time periods for all problem blocks**
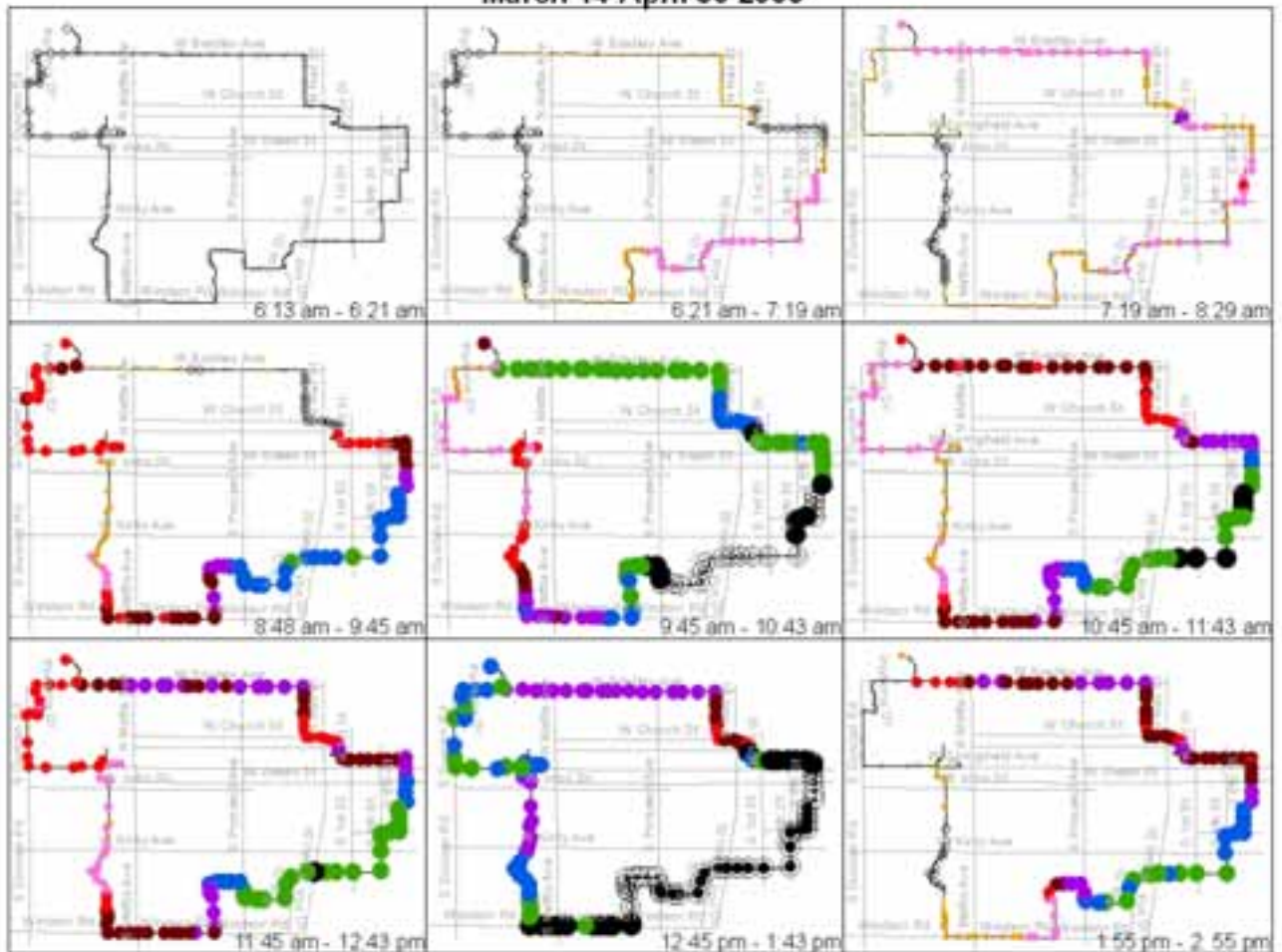
Figure 7: Schedule deviation for individual trips for a problem block

3. Observations:

We summarize the observations for the 9A route here. The general pattern shows worst delays[3] in the south east part of the route typically starting to appear at Illinois Terminal and continuing through St. Mary's road, while recovering a little after Prospect Ave. There are principally 4 or 5

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[3] The query Schedule Deviation Average also calculates the standard deviation from the average of the difference in scheduled and actual departure times. This is typically observed to be around 2 or 3 minutes. A stop with an average delay of 8 minutes and a standard deviation of 2 minutes would by the definition of standard deviation imply that 68% of times, the delay would be between 8+-2 minutes (8+-1 standard deviations), i.e., between 6 and 10 minutes and 95% of times, between 8+-4 minutes (8+-2 standard deviations), i.e., between 4 and 12 minutes.

stops where there is largest increase in deviation as compared to previous stop. This could be mostly related to the number of passengers boarding or alighting at those stops. One particular stop at a point of time in afternoon was seen to trigger delay, while the same stop did not have significant delay during the other trips. This could be traced back to an increased traffic and school kids boarding the bus at that stop at the end of the school. However, one of the interesting observations was that at many stops and time points, the increased delay coincided with operator relief stops and times. It can be seen from Figure 7 with trips plotted in sequence that delays are typically carried over from one trip to another suggesting that the layover times at the end of the cycle are not sufficient. One way to work around this is to combine its block/bus assignments with another route 7 Grey which has the same start/end stop (Parkland College) as 9 Brown. In order to revise the schedule, it will also be beneficial to compare the average times taken to complete the trip versus the scheduled running times.

4. Conclusion:

Vast amounts of data about the performance of transit routes are now available from AVL and APC systems. ArcView offers a simple, yet efficient way of visualizing and comprehending this enormous database. We have developed an easy to understand classification symbology to classify and visualize schedule deviation and passenger counts data for a route with schedule adherence problems. Patterns in schedule deviation and ridership could be easily identified along with the problem blocks, trips, stops and times.

References:
1. Furth, Peter G., Hemily, Brendon J., Muller, Theo H.J., Strathman, James G., "Uses of Archived AVL-APC Data to Improve Transit Performance and Management: Review and Potential", 2003
2. http://www.initusa.com/en_products/t_mobilestatistic.php, Accessed May 1, 2006

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