ITS Applications in Transit Operations and Planning

Rudolf Kolaja, P.E., T.E., PTOE

INTRODUCTION

The substantial development of the Automatic Vehicle Monitoring and the Automatic Passenger Counting on mass transit vehicles provides an excellent opportunity for much more attractive and economical transit services. There is an abundance of the technological advances available to transit industry today.

The very first comprehensive systems was developed by the General Motors Transportation Systems Division at its Urban Transportation Laboratory in Cincinnati, Ohio in the mid 1970's. Since that time a lot has been presented on monitoring of transit buses on individual transit routes, automatic passenger counting, and providing real time information to the traveling public.

These systems can automatically collect and analyze transit operational data such as transit vehicle location, passenger volumes, running time, schedule adherence data, and a host of other information. Actual use of this data in transit service management is still to be developed in most of these systems.

The principal use of this data is in:

1) **Transit route service analysis**
2) **Transit system planning**
3) **Federal government reporting**
4) **Real time data information to the traveling public**
5) **Real time vehicle performance monitoring by transit dispatcher (mechanical as well as operational performance)**

Due to the limited time available to me I will concentrate only on the use of the transit operational data in the transit route service analysis. In this context, the data is used to optimize the transit service; that is to provide the desired level of service at the lowest possible cost.

The most important element of this process is the automation of the data collection and of the analytical functions used for the transit schedule development.

The route service schedules often undergo frequent revisions due to the fluctuation of the passenger demand, traffic conditions, and route changes. The data used for these revisions used to be collected manually; a method which is labor intensive, time consuming, and expensive. The quantity of data acquired by manual methods is usually inadequate for satisfactory decision making.

In these automated systems, the coach location and the passenger load data is stored on board the vehicle and transmitted periodically to a central control computer. This raw data is then processed into a data base from which operating information can be extracted.

OPTIMUM NUMBER OF DATA SAMPLES

In order to determine the optimum transit service arrangement it is important to obtain the representative information in the form of passenger volume profiles typical of passenger demand and the corresponding running time along the route. Furthermore, the passenger demand variation needs to be within certain limits so that the transit service capacity of the particular route would never be exceeded or unduly underutilized. These are the important reasons that the transit route data is collected in accordance with the significant variation characteristics.

The manual data collection does not provide that opportunity to demonstrate the exhaustive picture of the variation.

PASSENGER VOLUME DATA – APC SYSTEM

Route utilization characteristics can be best described by on-board passenger volumes per period of time at critical locations along the route. The automatic passenger counting is the excellent tool to provide this information.

The passenger volume data is calculated from changes in the on and off passenger counts. This data is correlated with the time of day and the coach location producing passenger load profiles along the route.

These profiles are then summarized to provide the on-board passenger volumes for any desired location and time period.

The advantage of the automated data collection is that the computer can compile the passenger volume data at any given profile on a route in each direction of travel.

The computer is also able to identify the actual maximum load points and the corresponding maximum passenger loads in each direction of travel, by individual route segments, and desired period of time. This information provides reliable utilization characteristics of the route.

This graphical presentation demonstrates the passenger volume data aggregation by period of time; ¼ -hour & 1 hour periods by route segment

The summary of maximum passenger loads by time period, and by route segment derived automatically is the most important passenger volume data summary for the transit management decisions:

a) Number of buses required to provide adequate service
b) Frequency of service (headways)
c) Short runs at very specific time periods and sections of routes

The automated data collection also enables the transit analysis aggregate the data for several routes in the comment route segments and coordinate the individual transit route services for the maximum efficiency.

RUNNING TIME AND LAYOVER TIME OPTIMIZATION

The running time information at various times of the day is another prerequisite for optimization of bus and manpower utilization. The deviations from the transit vehicle schedule collected over longer periods of time can serve for determination of optimum running time for various operating periods of a day.

The automatic vehicle monitoring data collection provides an excellent opportunity for the development of a process for running time optimization by the route segment and total round trip as well. This is one of the major benefits of the AVM system which was never available before.

The automated data collection provides the precise time of day that each boarding and alighting event occurs throughout the bus service tour. Therefore, the running time among the individual stops and route segments for unlimited number of samples is available for analysis. The optimum running time derived from a huge amount of data which is automatically analyzed, provides an excellent means of developing a reliable and achievable schedule.

Optimum running time of transit buses secures optimum utilization of buses and manpower requirements. More importantly, transit reliability requires sufficient running time to permit the transit schedule to operate under varying traffic and weather conditions within acceptable limits of on-time performance. It is a definite need to optimize running time of individual trips in such a way that scheduled bus performance will be, on average, simulated by the scheduled running time.

At this point the objective is to determine the true average running time for each trip as closely as possible and to compare it with the successive one. As the running time data is assumed to have a normal distribution, a statistical test for comparison of the means of two normal distributions can be applied.

As the hypothesis is tested the mean running time of the second trip can be larger or smaller than the mean running time of the first trip. When the test is completed, another test follows using the same process comparing the means of the running time of the second trip with the mean running time of the third trip and so on.

This series of tests for all the scheduled trips during the day will then optimize the running time for each trip. The result will be an updated optimum running timetable for schedule development purposes.

The test is based on assumption of equal variances. The calculated variances for each sample are further used in determining an optimum layover time for each trip or the period of day.

It is not possible to go through the analytical procedure in detail during this presentation. However, it is my intent to provide the fundamental analytical approach to statistical analysis of the running time data which I have successfully tested. I am also assuming the user's intimate knowledge of the statistical analysis as well as of the transit schedule development, which I am referring to.

LAYOVER TIME OPTIMIZATION

The problem of bus deviations from a fixed schedule at each stop is well known to bus riders and fleet operators. Despite the effort to start buses at uniform times or spacing at each end of the route and the check-points along the route, the given bus may be late or early with respect to the schedule.

Layover time analysis logically follows the running time optimization and utilizes the same data set. The greater the running time fluctuations, the greater the protection factor that must be built into a schedule. This is being accomplished through determination of the minimum layover time for each transit vehicle at one or both terminals to guarantee a reasonable on-time performance of the transit service.

The length of the layover time for each transit trip or group of successive trips is determined using the standard deviation calculated at the time of running time optimization. It is suggested that layover time would be determined using two standard deviations providing 97.7 percent of the cases a guarantee of adequate time for buses to start trips in opposite direction on time. This is an important input at the beginning of the scheduling process as the layover time is an indivisible part of total round trip time.

The layover time is then a strategy used by transit operators for aiding buses in schedule adherence.

TRANSIT SCHEDULE DEVELOPMENT USING THE AUTOMATICALLY COLLECTED & ANALYZED DATA

These operating characteristics (passenger volume, running time, and layover time data) are automatically created by the AVM system and are used in calculating the basic route service parameters. These values are the vital input for determination of the number trips/hour, frequency of service, number of buses needed and passenger capacity.

This automating process eliminates much of the time and expense involved in transit service data collection, as well as hours of tedious and exacting analytical

work. It provides very accurate and optimum data which complements transit vehicle scheduling and run-cutting practices.

All of this data by individual route segments and direction of travel establishes route capacity requirements which set the lower limits for the transit route service during each operating period of the day.

The transit route schedule, which represents the final product of these analysis, creates a well refined transit vehicle performance, closely satisfying the travel demand, the best possible schedule performance, and the minimum operating cost.

SUMMARY

The introduction of the automatic vehicle monitoring and passenger counting provides a comprehensive amount of transit service data available for a far more advanced analysis that leads to an optimum transit service arrangement. It provides the opportunity to fully investigate the variation characteristics of route service performance. It is possible to acquire unlimited amount of data, and therefore, to analyze and determine the performance variation characteristics at a high level of confidence.

According to my experience this is the most effective benefit of the automatic vehicle monitoring and passenger counting system. It has a direct impact on operating and capital costs of transit service operations. As such, it actually creates the most powerful tool for effective transit service management.

The most important point I want to make is that this entire process is applicable only in transit system operations which are properly design with adequate transit travel demand. That was a subject of my presentation on "Design of Effective Transit Systems" in Anchorage, Alaska in the year of 2011.