Timetable Adjustments in the Wellington Region Using Real-Time Information

Aim:

To research methodology used to rectify timetable inaccuracies using Real-Time information and recommend methodology for application in the Wellington region.

Summary of research:

RTI has the potential to provide an enormous amount of data that provides the potential to significantly improve bus timetables by making them more achievable and improving their accuracy. This report focuses on how to analyse RTI data to improve timetables.

"Traditional scheduling methods, created in an era of expensive manual data collection, are based on mean observed running times, which are estimates from small sample sizes. Now, however, AVL (Automatic Vehicle Location) data offers the possibility of using extreme values such as 85- and 95-percentile running times as a basis for scheduling. Extreme values are important to passengers, who care less about mean schedule deviation than about avoiding extreme deviations such as buses that are early or very late. Extreme values are also important to planning, because a goal of cycle time selection (sum of scheduled running time and scheduled layover) is to limit the probability that a bus finishes one trip so late that its next trip starts late." (1)

Because extreme values can only be estimated reliably from a large sample size, the RTI data available to GWRC and operators offers new opportunities for analysis.

Research papers suggest advantages of focusing on extreme values in the context of refining timetables. Two of the suggested advantages of focusing on extreme values are:

1) "**Recovery time** is put into the schedule to limit the probability that a bus finishes one trip so late that its next trip starts late. Therefore, logically, scheduled half-cycle times (scheduled running time plus recovery time) should be based on an extreme value such as the 95^{th}-percentile running time….. Yet, some route-period combinations need more than this standard, and others less, because they do not have the same running time variability. AVL data allows an agency to actually measure 95^{th}-percentile running times and use that to set recovery times." (1).
2) "**Passenger waiting time** is an important measure of service quality. Studies show that customers are more affected by their 95^{th}-percentile waiting time – for a daily traveller, roughly the largest amount they had to wait in the previous month – than their mean waiting time, because 95^{th}-percentile waiting time is what passengers have to budget in their travel plans to be reasonably certain of arriving on time.", indicating that a shift toward customer-oriented measures goes hand in hand with the ability to measure extreme values (1).

Scheduling Philosophy:

There are a few different ways of scheduling the timetable effectively. The method chosen depends upon the scheduling and operating philosophy of the transit agency and operators.

Trip Running Time – including Allowed time, Half-Cycle Time and Recovery Time

When looking at how to adjust the timetable, some schedulers choose to focus on running times for the whole trip/journey. In doing so some schedulers choose to base schedules on mean running time while others prefer to intentionally put in slack, as a fraction of mean running time, into the schedule (for this approach to be successful it needs to be coupled with a practice of holding at timepoints). The research suggests that a more "scientific, data-driven approach is to use a percentile value, or feasibility criterion". For example, a feasibility criterion of 85% means setting the allowed time to 85^{th}-percentile observed running time so that the schedule can be completed on time 85% of the time.

An alternative method is to use the 'half-cycle time approach'. Half cycle time is the sum of running time and recovery time. It is, in effect, the time from a bus's departure at one terminal to its next departure in the reverse direction. Because the purpose of recovery time is to limit the likelihood that delays encountered in one trip will propagate to the next, half-cycle time is based logically on a high-percentile value of running time.

Using the half-cycle approach combined with feasibility criterion is one option of creating more suitable timetables. An example of such an approach is as follows: The chief engineer for operations analysis at Brussels' transit agency has recently been working with a scheduling software vendor to develop reports to support statistically based schedules. Their approach uses three parameters, as explained in this example: If the three parameters are 95%, 80%, and 5 min, then half-cycle time is set equal to 95th-percentile running time, and allowed time is set equal to 5 min less than 80th-percentile running time. That way, there will be an 80% chance that a trip finishes no more than 5 min late, and a 95% chance that the next trip can start on time (1).

Herbert Levinson (Transportation Consultant and Professor Emeritus of Transportation) referred to in a paper by Kimpel and Strathman (2) suggests that the scheduled run time should be set at the mean or median run time in order to ensure that the majority of operators do not have to 'kill' time in order to maintain schedule adherence. Levinson also contends that an optimal amount of recovery time for a given bus trip is the 95^{th} percentile run times minus the scheduled run time. A study for TriMet (Transit Agency of Oregon) found that basing recovery times on 95^{th}-percentile running times could lead to an average reduction in recovery time of 7.3 minutes per trip and an estimated reduction in operating costs of $7.1 million (2).

Segment Running Time

Scheduling running time on segments, or equivalently setting departure (or arrival) times at timepoints relative to the trip start time, can either precede or follow scheduling route times.

Two suggestions for calculating running times at the segment level are discussed.

If the transit agency and operators are favourable to holding at timepoint then the 'Passing Moments' method, developed by The Delft University of Technology, may be considered. Applied at several Dutch transit agencies, the Passing Moments method bases timepoint schedules on f-percentile completion time from each timepoint to the end of the line, where completion time is running time from a point to the end of the line, and f is the feasibility criterion (the transit agency in Eindhoven, for example, utilize the 85^{th}-percentile (3)). Segment running times are determined by working backwards from the end of the line, without ever explicitly analyzing observed running time on timepoint-to-timepoint segments. This approach was designed to overcome operators' resistance to holding, which is the key to good schedule adherence. If a schedule is written based on mean running time, operators know that, if they hold at a timepoint, they will have a 50% chance of finishing the trip late and thereby getting a shortened break; therefore, they are reluctant to hold. With 85th-percentile allowed times between each timepoint and the end of the line, operators know that even if they hold, they have a high chance of finishing on time. The Passing Moments method has two advantages compared to setting slack time simply proportional to mean running time. First, it is sensitive to where on the route delays and running time variability occurs. Second, it tends to put less slack in the early part of the route and more in the later part of the route, which is a better way to distribute slack than simply applying it proportionately throughout. It results in holding buses less in the early part of the route because they may need that time later in the route.

If the transit agency and operators are not favourable to holding at timepoints then it may be better to use a low feasibility criterion and (i.e. percentile value lower than the median) because running early is more harmful to passengers than running late. TCRP Report 113 (1) states that "a statistically based approach for segment-level scheduling might be to base departure time at a timepoint on 40th-percentile observed cumulative running time (i.e., from the start of the line to a point). That way, there will be only a 40% chance of a bus departing early, and those that depart early should not be very far ahead of schedule". TriMet uses the 40^{th} percentile of running times to set the timetable schedule (3).

<u>Homogenous Periods:</u>

A challenge of analysing the running times using the preceding methods can be choosing the boundaries of running time periods within which allowed time is constant or homogenous. A trade-off is required between short periods within which scheduled running times match the data well versus longer periods of constant allowed time but greater variability. TCRP Report 113 (1) provides a logical method in resolving the trade-off: First determine, for each scheduled trip, an ideal allowed time and then to make running time periods as long as possible subject to the restriction that no more than a certain percentage of the scheduled trips in that period have an ideal running time that deviates by more than given tolerance from the suggested running time for that period.

<u>Scheduling Tools:</u>

Some agencies, including King County Metro and Eindhoven, have software tools that suggest scheduled running time, in combination with a parallel tool for establishing scheduling periods, i.e. periods of homogeneous running time for which a common running time can be assigned. Users supply a criterion such as "find as long a period as possible for which a common scheduled running time is within 2 minutes of the 75-percentile observed running time for at least 90% of the scheduled trips in that period." (3).

At King County Metro, schedules are built beginning at the segment level, so running time analysis is done at the segment level. In Eindhoven, schedules are first made at the route level, with running time later allocated over segments, so analysis is first done at the route level, followed by another tool that suggest segment running times.

Chapter 5 of the TCRP Report 113 (1) discusses a scheduling tool called TriTAPT, developed by the Delft University of Technology. The TriTAPT program provides the ability to perform two integrated analyses: the first divides the day into running time periods and establishes route running times for each period, and the second allocates running time over a route's segment.

This program is still available by contacting Peter Knoppers (p.knoppers@tudelft.nl).

Perhaps the program MiniTab, used by GWRC, has the capability of performing statistical and trade-off analyses similar to what is described in Chapter 5 of TCRP Report 113 (1). Further research into MiniTab's capabilities may be required if the decision is to use the methods suggested.

Stop Level or Timepoint Level Detail?

While timepoint data is all that is needed for traditional scheduling, there is the issue of End-of-line problems with timepoint data. Agencies with only timepoint records generally find data for the first and last segments of the line to be unreliable because of unpredictable operator behaviour at the end of the line (3). With stop data, operations near the end of the line are better tracked and far less information about the final segment is lost. This could have some application in the Wellington area. Perhaps using stops close to the end-of-line instead of end-of-line data could remove the effect of unpredictable behaviour at the end-of-line (e.g. finishing a trip early because there are no passengers on board or logging into the trip early).

References

1. Furth, P.G., Hemily, B.J., Muller, T.H.J., & Strathman, J.G. (2006). Using Archived AVL-APC Data to Improve Transit Performance and Management (TCRP Report 113). Washington, DC: Transportation Research Board.

2. Kimpel, T.J., & Strathman, J.G. (2004). Improving Scheduling Through Performance Monitoring Using AVL/APC Data. Portland, OR, Centre for Urban Studies.

3. Furth, P.G., Hemily, B.J., Muller, T.H.J., & Strathman, J.G. (2003). Uses of Archived AVL-APC Data to Improve Transit Performance and Management: Review and Potential (TCRP Web Document H-28). Washington, DC: Transportation Research Board.