# Automatic Transit Schedule Updating Using AVL/APC System Data

by

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## Authors Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

# Abstract

Observing and fixing transit vehicle's schedule adherence problems have always been one of the main priorities of a transit agency, and different approaches have been developed over time to help reflect transit vehicle's performance and where the improvements should be focuses. Unlike traditional performance analysis that generates reports of the bus's performance based on some performance measures such as 'on-time percentage' at each timepoint, in this study, a methodology is developed that uses the on-time performance of individual transit vehicles on each segment of the route to identify systemic problems with the transit schedule and then make recommended adjustments to the schedule for the next schedule period.

The output of the proposed methodology in this research study consists of:

1. On-time performance measures for each segment of the route of interest;
2. Recommended changes to the transit schedule. These recommendations can be made under two different assumptions related to transit agency resources. The "Resource unconstrained" approach assumes that there is no constrain on the amount of time that can be added to the schedule. The "Resource constrained" approach assumes that time can be reallocated within the schedule, but the route traversal time must not be extended.

The proposed method provides transit agencies with a mechanism to effectively adjust bus schedules to improve on-time performance.

An application of the proposed methodology is conducted and tested on Automatic Vehicle Location (AVL) and Automatic Passenger Counting (APC) system records from Grand River Transit which is located in Waterloo Region of Ontario, Canada.

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## List of Symbols

$i$ = Timepoint i (from 1 to N)

$j$ = Trip j (from 1 to M)

$N$ = Total number of timepoints on the selected direction of the chosen route

$M_i$ = Total number of trips recorded at timepoint i within the study period

$T_i$ = Total number of trips recorded for segment $i$ within the study period

$A_{a_{i,j}}$ = Actual arrival time of the bus at timepoint i on trip j

$A_{d_{i,j}}$ = Actual departure time of the bus at timepoint i on trip j

$A_{dti,j}$ = Actual dwell time of the bus at timepoint i on trip j

$A_{tti,j}$ = Actual traversal time of the bus to traverse the segment between timepoint i and timepoint i on trip j

$S_{a_{i,j}}$ = Scheduled arrival time of the bus at timepoint i on trip j

$S_{d_{i,j}}$ = Scheduled departure time of the bus at timepoint i on trip j

$S_{dti,j}$ = Scheduled dwell time of the bus at timepoint i on trip j

$S_{tti,j}$ = Scheduled traversal time of the bus to traverse the segment between timepoint i and timepoint i on trip j

$D_{a_{i,j}}$ = Scheduled deviation of the bus's arrival time at timepoint i on trip j

$D_{d_{i,j}}$ = Scheduled deviation of the bus's departure time at timepoint i on trip j

$E_a$ = threshold of a bus's early arrival at any timepoint

$E_d$ = threshold of a bus's early departure from any timepoint

$L_a$ = threshold of a bus's late arrival at any timepoint

$L_d$ = threshold of a bus's late departure from any timepoint

$TD_{i,j}$ = True schedule adherence difference of the bus to finish segment between stop i-1 to stop i on trip j

$DTD_{i,j}$ = Schedule adherence difference of the bus's dwell time at stop i-1 on trip j

$TTD_{i,j}$ = Schedule adherence difference of the bus from departing at stop i-1 to arriving at stop i on trip j

$TDR_i$ = The median value of schedule deviation over the segment between stop i-1 to stop i on all tirps

$DTR_i$ = The median value of schedule deviation of dwell time at bus stop i-1 on all trips

$TTR_i$ = The median value of schedule deviation of traversal time from departing from stop i-1 to arriving at stop i on all trips

$+TD\%_i$ = percentage of trips that have a positive 'TD' value over the segment between stop i-1 to stop i

$-TD\%_i$ = percentage of trips that have a negative 'TD' value over the segment between stop i-1 to stop i

# Chapter 1: Introduction

## 1.1 Background

When planning a transportation system, several factors need to be considered by planners such as mobility, public accessibility, mode choice, and environmental and economic impacts. With transit system playing a significant role in the broad transportation system, it is transit agencies' responsibilities to make sure that the transit system meets the goals of attracting passengers, providing economic benefits to the public and also operating efficiently. To meet those goals, in the phase of route and schedule planning for a route, different proposals are evaluated to achieve the best overall system performance. Once a route has been developed and operated, its performance will be consistently assessed and improved over time.

The performance of a transit system can be evaluated using different criteria such as economics, ridership, reliability, accessibility and etc. Evaluating any of these criteria needs the collected data of the buses' performance. However, the collection process of the data used to be done manually due to the lack of technology, which results in fairly low economic efficiency for the agency and limited dataset to work with.

With the development of Automatic Vehicle Location (AVL) system and Automatic Passenger Counting (APC) system in recent years, many transit agencies have started adopting them on their bus fleet to collect data automatically and also more efficiently. Furth, Hemily, Muller and Strathman (2003) illustrated that AVL system was originally developed aiming to provide 'location-at-time' information to show the location of bus at a given time to assess its adherence to the schedule, and because this information does not aid to off-line analysis where 'time-at-location' information is needed, the traditional AVL system is not capable of generating useful archived data for off-line analysis and is mainly used for emergency responses. In contrast, APC system has always been built to generate archived data for performance analysis since it provides both 'time-at-location' data and passenger boarding and alighting at every stop.

When using the combination of both systems, the data would not only be useful for real-time operation but also helpful for off-line analysis. When the transit system is operating, the automatically collected data is fed back to the agency in real-time so the agency is able to discover and react correspondingly to any abnormal activities. When the buses return to the terminal, the onboard archived data could be uploaded to the cloud and be utilized by the agency to analyze and improve the system's operational plan such as scheduling and ridership. With the support of those two components, the transit system's operational plan and service quality control can be improved to have a better performance and higher ridership.

Since the AVL/APC system provides a large dataset to the agency, several data quality assurance approaches have also been published over time to make sure that the data comes with good quality for further analysis.

## 1.2 Motivation

Traditionally, transit system's performance has been evaluated by visualizing the transit data which is usually manually collected, so when it comes to the data with a much larger scale, this method is not applicable anymore.

To use the data collected by AVL/APC system to its full potential, some performance measurements have been developed such as 'on-time percentage' to summarize the data at an aggregated level so that the agency know where the system is not performing as expected so that they know where to make the improvements. In addition to that, the data can also be used to indicate the causes of poor performance. Combining both the location and the poor performance causes will make it more efficient for the agency's decision making.

However, after the location and the causes for poor performance are identified, how to fix the problem seems to be problematic. To illustrate, consider a hypothetical example. Table 1, 2 and 3 provide the archived scheduled and actual arrival times for 4 consecutive timepoints for a trip along a route for three different scenarios. A timepoint usually has a lot of passenger activities and it is assigned with a scheduled arrival time and scheduled departure time for the bus. Assuming that if the agency needs to make improvements to the schedule just based on this record, the following analysis will be conducted using the previous on-time performance measure used in the study of Mandelzys and Hellinga (2010) where a bus is considered on-time if arrives at a timepoint less than 3 minutes late and departs from a timepoint less than 30 seconds early.

For Scenario 1(Table 1), the bus arrives late at every stop and in most cases, it arrives more than 3 minutes late. So, if using the previous measurement performance and the cause identification method (Mandelzys and Hellinga 2010), every stop will be identified as 'problematic' and one of the causes for arriving late at each stop will be that it arrives late at the previous stop. But if investigated further, it is easy to find that the bus takes 3 minutes to travel from stop *N* to stop *N+1* where the traversal time is scheduled to be 4 minutes, so the bus's performance at this segment (roadway between stop *N* and stop *N+1*) is exceeding the expectation by 1 minute whereas for the segment between stop *N+1* and stop *N+2*, the bus takes 3 minutes more than the scheduled time to traverse it. Lastly, the bus spends the same amount of time as scheduled to traverse the last segment (from stop *N+2* to stop *N+3*). Thus, the conclusion should be that the bus arrives late at all the stops, but the reasons for this poor performance are (1), the bus does not perform well on the route before stop *N*. (2), the time scheduled for the bus to traverse the segment between stop *N+1* and stop *N+2* is not sufficient. To fix the problem, adjustments to the schedule need to be made to the route before stop *N*. For the stops listed in the table, the time scheduled for segment between stop *N* and stop *N+1* is sufficient and the extra 1 minute may be taken out and added to other segments. For the segment between stop *N+1* and stop *N+2,* 3 more minutes should be schedule. In terms of scheduled dwell time at each stop, it is easy to observe that 1 more minute should be added to the scheduled dwell time at stop *N+3*.

Table 1: 'Dummy' Record 1

| **Stop ID** | N | N+1 | N+2 | N+3 |
|---|---|---|---|---|
| **Scheduled Arrival Time** | 6:05 | 6:10 | 6:20 | 6:25 |
| **Actual Arrival Time** | 6:09 | 6:13 | 6:26 | 6:31 |
| **Scheduled Departure Time** | 6:06 | 6:13 | 6:21 | 6:27 |
| **Actual Departure Time** | 6:10 | 6:16 | 6:27 | 6:34 |

The second Scenario (Table 2) consists of a bus that takes 2 minutes more than the scheduled time to traverse each segment, so the lateness builds up along the route and the bus's on-time performance at stops gets worse over the route. In this case, using the previous approach (Mandelzys and Hellinga 2010) will lead to conclusions that the stops at downstream have the worst on-time performance and causes for this are because the bus arrives late at previous stops. However, problem is not associated with some specific timepoints, instead, it is due to insufficient scheduled time for each segment. To fix this problem, 2 more minutes should be assigned to the scheduled traversal time for every segment. As for scheduled dwell time, no adjustment is needed.

Table 2: 'Dummy' Record 2

| **Stop ID** | N | N+1 | N+2 | N+3 |
|---|---|---|---|---|
| **Scheduled Arrival Time** | 6:05 | 6:10 | 6:20 | 6:25 |
| **Actual Arrival Time** | 6:07 | 6:14 | 6:26 | 6:33 |
| **Scheduled Departure Time** | 6:06 | 6:13 | 6:21 | 6:27 |
| **Actual Departure Time** | 6:08 | 6:17 | 6:27 | 6:35 |

In the third Scenario(Table 3), based on the traditional approach, the bus arrives late at stop *N+1* and its performance is good at the other stops, but it is easy to find that the bus takes 4 minutes longer than the scheduled time to traverse from stop *N* to stop *N+1*, yet it takes 4 minutes less than the scheduled time to traverse the segment between stop *N+1* and stop *N+2*, so to achieve a better performance, 4 minutes should be taken out from the scheduled traversal time for the segment between stop *N+1* and stop *N+2*, and put that amount of time to the scheduled traversal time for the first segment(stop N to stop N+1). In the meantime, no adjustment is needed for scheduled dwell time at each stop.

Table 3: ‘Dummy’ Record 3

| **Stop ID** | N | N+1 | N+2 | N+3 |
|---|---|---|---|---|
| **Scheduled Arrival Time** | 6:05 | 6:10 | 6:20 | 6:25 |
| **Actual Arrival Time** | 6:05 | 6:14 | 6:20 | 6:25 |
| **Scheduled Departure Time** | 6:06 | 6:13 | 6:21 | 6:27 |
| **Actual Departure Time** | 6:06 | 6:17 | 6:21 | 6:27 |

As discussed above, using the approach from the study of Mandelzys and Hellinga (2010) may not be able to capture the real causes for the bus’s bad performance and result in the agency spending unnecessary resources to find out where exactly to fix the problem. Thus, new approaches are needed to not only identify where the problems lie within the system but also to automatically make recommendations for schedule changes that will improve schedule adherence.

## 1.3 Objectives and Assumptions

The objectives of this research are:

1. Develop a set of measures that reliably reflect the performance of transit vehicles on each segment on the basis of archived AVL/APC data;
2. Utilize these measures to identify systematic deficiencies in the transit schedule;
3. Propose a method that automatically make recommendations to adjust the existing schedule to achieve better on-time performance for the next schedule period;
4. Calibrate and validate the proposed method using field data from Grand River Transit system in Waterloo, Ontario.

When developing the proposed methodology, some assumptions are made:

1. The transit vehicles mentioned in this study are buses;
2. Buses are equipped with AVL/APC systems and the recorded data is archived;
3. Routes are operated based on their schedule instead of being headway controlled;
4. There may exist several schedule periods within a year (typically Winter, Summer and Fall period);

5. Only changes to schedules are considered, other factors such as route alignment adjustments, intersection control changes, and transit priority measure implementations etc. are not considered.

## 1.4 Thesis Structure

This thesis is composed with five chapters, and a brief summary of each chapter is listed below:

- Chapter 2 reviews previous work of how performance measures of schedule adherence were developed and how date generated by AVL/APC system is utilized to assure data quality and evaluate transit system's service quality;
- Chapter 3 develops the proposed methodology for identifying the systematic deficiencies in the transit schedule and automatically recommending adjustments to the schedule to improve on-time performance;
- Chapter 4 demonstrates a case study where the proposed methodology is applied to Route 31 and Route 200 in Grand River Transit (GRT) system, Waterloo, and discusses findings and decisions made during the analysis;
- Chapter 5 presents the conclusions of this study and recommendations for the future research and application opportunities.

# Chapter 2: Literature Review

## 2.1 Introduction

In this chapter, previous work of developing performance measures of schedule adherence and how data generated by AVL and APC system was utilized in terms of quality assurance and evaluating schedule adherence are reviewed. It is known that schedule adherence performance measures help understand how well a transit system performs compared to its designed schedule, so that the transit agency knows where the attention and improvements should be placed. For example, by evaluating the performance measures of each timepoint, it is easy to recognize at which timepoints the buses are not performing well based on the results of performance measures such as 'on-time percentage' etc.

AVL/APC system has been adopted to provide data in a more efficient way to examine schedule adherence by a number of agencies in the past decade. In section 2.1, an overview of how traditional schedule adherence performance measures are developed in previous work is presented. Section 2.2 presents how data from AVL/APC system is quality-assured and how it is used to estimate schedule adherence.

## 2.2 Traditional Performance Measurements for Schedule Adherence

Transit agencies traditionally use 'on-time' performance to measure how a transit system performs, and this process is done by defining an on-time threshold first and then evaluating the percentage of trips that are on-time at a timepoint. However, the definition of a transit vehicle being on-time, according to Transit Capacity and Quality of Service Manual or TCQSM, 3rd Edition (Kittelson et al. 2013), is highly dissimilar among different agencies. This publication references a survey that was done among American transit agencies in 1990s, in which approximately 42% of the responding agencies considered a transit bus as on-time even if it arrives more than 5 minutes late while 24% of the agencies considered buses that depart early to be on-time. A survey conducted among 17 Canadian transit agencies shows a relatively stricter definition of a bus being on-time (Canadian Urban Transit Association 2001). Among those transit agencies, 11 of them indicated that a bus is considered as not on-time if it arrives more than 3 or 4 minutes late while the remaining survey respondents considered 5 minutes to be the threshold for arriving late. More importantly, departing early was not considered as on-time by 15 of the 17 responding agencies. In the updated service standard report edited by Toronto Transit Commission, when defining a transit bus's on-time performance, it must depart from the origin terminal in the interval of 1 minute before the scheduled departure time and 5 minutes after the scheduled departure time and the bus must have arrived at a timepoint in the interval from 1 minute prior to the scheduled arrival time and 5 minutes after the scheduled arrival time. (Toronto Transit Commission 2017).

TCQSM (Kittelson et al. 2013) also identified the significance of how departing early is assessed when defining on-time thresholds. In a passenger's view, an early departure of a transit bus may cause the passenger to wait until the next bus which is as long as another headway. On the other hand, early departures when no more passengers wish to board may be helpful for the bus to catch up with the schedule if the bus is running late. In order to help the industry to reach a standardized definition of on-time for a transit bus, TCQSM (Kittelson et al. 2013) specified that a transit vehicle is on-time if it departs less than 1 minute (60 seconds) early or arrives less than 5 minutes (300 seconds) late at a timepoint. The following equations are adopted from the study of Mandelzys and Hellinga (2010) which show the mathematical representation of the definition:

$$D_{a_{i,j}} = A_{a_{i,j}} - S_{a_{i,j}} \quad (1)$$

$$D_{d_{i,j}} = A_{d_{i,j}} - S_{d_{i,j}} \quad (2)$$

A bus is on-time at timepoint $i$ if $D_{a_{i,j}}$ < 300seconds AND $D_{d_{i,j}}$ > - 60 seconds

where $i$ = Timepoint i (from 1 to N)

$j$ = Trip j (from 1 to M)

$A_{a_{i,j}}$ = Actual arrival time of the bus at timepoint i on trip j

$A_{d_{i,j}}$ = Actual departure time of the bus at timepoint i on trip j

$S_{a_{i,j}}$ = Scheduled arrival time of the bus at timepoint i on trip j

$S_{d_{i,j}}$ = Scheduled departure time of the bus at timepoint i on trip j

$D_{a_{i,j}}$ = Scheduled deviation of the bus's arrival time at timepoint i on trip j

$D_{d_{i,j}}$ = Scheduled deviation of the bus's departure time at timepoint i on trip j

## 2.3 Utilization of AVL/APC System Data

A thorough analysis on how the archived AVL/APL data can be utilized to help transit system improve its system's performance was performed in 2003(Furth et al. 2003). In the study, it was identified that the data generated by AVL and APC has a significant potential in refining the transit system plan in terms of improving its schedule adherence performance if the data is generated, stored and used correctly. With a better-quality control on the AVL/APC data, the system can be beneficial for the transit agencies in the following perspectives: service monitoring, scheduling adherence analysis, demand and utility analysis, decision support and so on, along with which some opportunities for further research are also listed such as system design, organizational issue and better analysis and decision support tools.

AVL/APC data along with some disaggregated data obtained from surveys of travel behaviors were used to pick the stops and also assess the running time for a new bus service (limited-stop) in Montreal, Canada (Tétreault and El-Geneidy 2010). After development and evaluation of different scenarios, it was concluded that the whole transit system would significantly benefit from the new service. In 2006, the data generated by AVL/APC system to assess the performance of the transit system in Boston was tested (Cham 2006). In this study, the reliability of the transit system was measured, the causes of unreliable service were identified, and recommendations were made on how to improve service reliability.

Recently, AVL/APC system has been used to not only assess a transit system's performance, but also to identify problems and make changes to the schedule to achieve a better overall performance. In Portland regions, AVL/APC system was used to identify how often buses bunch at some locations within a chosen time period. After the problems were identified, a methodology was also developed to point out the causes of bus bunching (Feng and Figliozzi, 2011). The scheduled adherence information that AVL system provides was used to improve on-time performance by Cevallos, Wang, Chen and Gan (2011). They performed a simulation after making changes to the schedule based on the distribution of the scheduled adherence of each timepoint to test the improvement of the on-time performance.

The following two sections present two of the previous research studies. The first study illustrates a methodology for AVL/APC data quality assurance and the second study introduces how a transit system's performance is assessed and how the causes are identified.

### 2.3.1 AVL/APC System Data Quality Assurance

AVL/APC system has been employed in many cities due to its potentials in real-time command and control and real-time information system. Even though AVL/APC system brings benefits compared to the previous environment where the data source is usually poor, if the data is not captured and stored correctly, the errors that are brought during the data generation and data process may result in errors in the analysis results and/or incorrect conclusions. Several studies have been done in order to evaluate the level of accuracy of AVL/APC data. For example, loop detector data is used to evaluate the reliability of travel time estimation generated from AVL/APC system by Coifman and Kim (2009). Regards of passenger counting accuracy, Strathman, Kimpel and Callas (2005) used records that are manually generalized to evaluate the results derived from AVL/APC system, which leads to the conclusion that the system tends to undercount passenger boarding while over-counting alighting activities. Similar study was also carried out in 2003 by using video surveillance as the external source (Strathman et al. 2003) which lead to the same conclusion about the passenger counting accuracy.

Because the size of the dataset only becomes larger over time, automated validation approaches start to draw more attention to the related organizations and research groups. A quality assurance method is presented to justify archived data generated by the system in a larger scale by Saavedra, Hellinga and Casello (2011) with the goal of excluding erroneous and suspect data collected by the AVL/APC system. In their methodology, first, the data is disaggregated into stop level, and then it goes through series of tests at stop level and is classified into 'non-suspect' and 'suspect' categories at trip level so that only the 'non-suspect' trip data is used for further analysis.

In their methodology, the processes are divided into three phases which are:

1. Base Checks (BC)
2. Outlier Identification (OI)
3. Valid Outlier Identification (VOI)

In Phase 1, trip data is compared to a set of thresholds associated with physical route constraints such as minimum travel time, minimum and maximum travel distance, minimum and maximum travel speed, etc. Trips for which recorded data fall outside of these constraints are labeled as 'suspect'. Trips which are not labeled as suspect in Phase 1 are passed to Phase 2.

In Phase 2, trip data, including passenger counts, schedule deviations, distance deviations and passenger count corrections are compared to route thresholds that reflect typical operating conditions. If a data of a specific trip passes all the tests, it is labeled as 'non-suspect'. Trips that do not pass these tests, have recorded data for one or more attributes that exceed the threshold and therefore are atypical. These trips are examined in Phase 3 to determine if the atypical values are an accurate reflection of the service delivered but the service was atypical for some reasons such as detour or poor weather in which case the data are labelled as 'non-suspect'. Otherwise the data for these trips are labeled as 'suspect'.

In their case study of Grand River Transit, the values of the thresholds are defined based on the characteristics of the transit buses and routes before performing the tests. The application of their proposed quality assurance process resulted in 14.3% of the sample data labeled at 'suspect' after all the tests.

Their proposed methodology makes sure that future study can be conducted on the accurate dataset without being influenced by the errors introduced by the AVL/APC system. More importantly, it also gives insights on how erroneous data is introduced into the system.

### 2.3.2 Identifying Causes for Poor On-time Performance Using AVL/APC Data

AVL/APC data has been used extensively by transit agencies to quantify transit service on-time performance (schedule adherence). The schedule adherence can be reported at the timepoint level, route level, or system level, and over a defined period of time including time of day (e.g. AM period from 6 – 9am), day of week (e.g. weekday vs weekend), as well as the span of time of the year (e.g. fall period from Sept 6 – December 15).

Regardless of the level of aggregation of the reporting, the performance is typically reported in terms of the fraction of trips that were on-time during the time periods of interests. When this on-time performance falls below the transit agencies service standards, then there is a need to identify why the poor performance occurred and what changes, if any, should be made to improve performance for the future.

Given the large amount of data, it is desirable to be able to automatically identify (a) substandard schedule adherence, (b) the causes for the poor performance, and (c) identify recommended changes to improve service delivery for future periods.

Mandelzys and Hellinga (2010) proposed a methodology in an attempt to address items (a) and (b) from the above list. Specifically, their proposed method used AVL/APC data to automatically identify the timepoints with substandard on-time performance and for these timepoints, attempted to identify the causes for the substandard schedule. The framework of their methodology is illustrated in Figure 1.

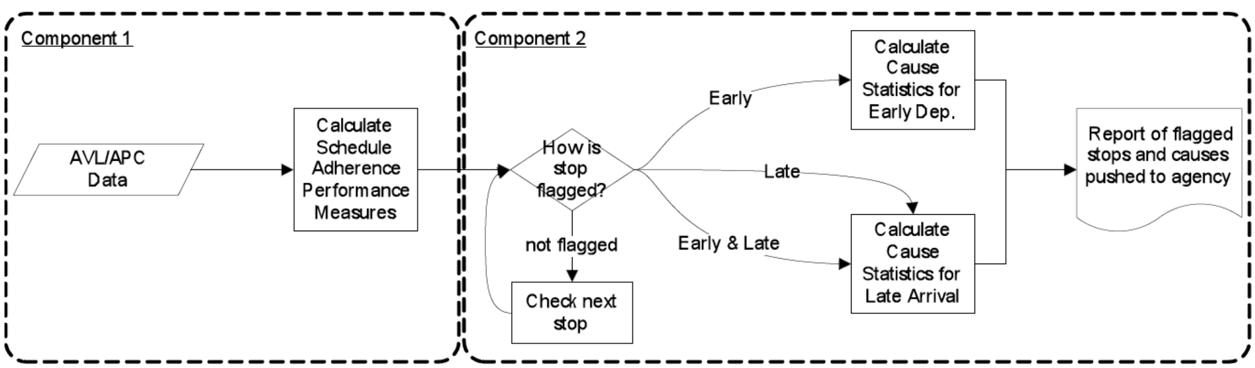


Figure 1: Framework for Automatically Identifying Transit Performance Causes
(Source: Mandelzys and Hellinga 2010)

In Component 1, the measure of performance is calculated based on the stop-level record and then analyzed. In their study, buses are not on-time if they arrive more than 3 minutes late or departing more than 30 seconds early. The arrival and departure of the bus are treated separately so the performance measure analysis is divided into two categories which are ‘arriving late’ and ‘departing early’. A service standard threshold of 85% trips on-time is assumed, and consequently up to 15% of trips can be not on-time. This is divided equally into each category so that a threshold of 7.5% is assigned to arriving late and to arriving early. Trips that exceed the threshold are further analyzed to find the causes of poor schedule adherence. Figure 2 shows the graph presentation of the processes of this component.

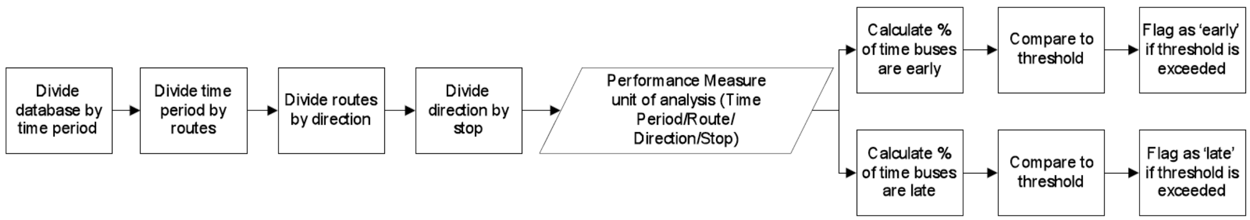


Figure 2: Processes of Calculating Schedule Adherence Measure of Performance (Source: Mandelzys and Hellinga 2010)

In Component 2, the method attempts to identify the causes of the bad performance. This is done by predefining some potential problems shown in Figure 3. Each category has a series of criteria, and any record that meets the criteria will fall into the category automatically.

| Problem | Category | Potential Causes |
|---|---|---|
| **Late Arrival** | Travel time from previous stop took longer than scheduled | • Traffic reasons (congestion, inclement weather, signal timing, etc.)<br>• High demand for intermediate (non-timepoint) stops<br>• Unscheduled stops<br>• Etc. |
| | Dwell time at previous stop was longer than scheduled | • High passenger activity (on/off)<br>• Difficulty rejoining traffic stream<br>• Lift use<br>• Etc. |
| | Arrived at previous stop late | • Upstream causes |
| **Early Departure** | Dwell time at current stop was less than scheduled | • Low passenger activity (on/off) |
| | Travel time from previous stop was lower than scheduled | • Traffic reasons (lower than expected congestion, etc.)<br>• Low demand at intermediate (non-timepoint stops)<br>• Etc. |
| | Departed previous stop early | • Upstream causes |

Figure 3: Cause Categories for 'Late Arrival' and 'Early Departure' (Source: Mandelzys and Hellinga 2010)

Figure 4 shows a sample of the findings of the study including the percentage of not on-time trips associated with each potential cause.

| *Cause Statistics* | *Charles Street Terminal* | *Courtland / Stirling* | *Ottawa / Strasbourg* | *Ottawa / Westmount* | *Williamsburg / Westmount* | *Forest Glen Plaza* |
|---|---|---|---|---|---|---|
| ***Late Arrival*** | | | | | | |
| *Travel time in prior segment longer than scheduled* | | | 60% | | 88% | 20% |
| *Dwell time at previous stop longer than scheduled* | | | 0% | | 25% | 0% |
| *Late arrival at previous stop* | | | 100% | | 100% | 100% |
| ***Early Departure*** | | | | | | |
| *Dwell time at current stop shorter than scheduled* | | | | 0% | | |
| *Travel time in prior segment less than scheduled* | | | | 100% | | |
| *Early departure from previous stop* | | | | 25% | | |

Figure 4: Sample of Cause Statistics Results

(Source: Mandelzys and Hellinga 2010)

This automatic approach reveals stops that have poor on-time performance and also identifies the causes of the poor performance.

However, there are two limitations to this proposed approach:

1. The cause statistics are not robust. The method examines each route segment independently, so the interactions between two segments are overlooked. More importantly, because the bus's schedule and routing plans change over time, for example, the same roadway between two timepoints may have different scheduled traversal time during different seasons, the conclusions from the proposed methodology may not stand during a different season;
2. The method does not make any recommendations to the transit agency on what to do about the problem. For instance, if the cause of the bus being not on-time at a timepoint falls into the category of 'Late arrival at previous stop', but the lateness could be caused by upstream stops, and what strategies the transit agency needs to implement to improve the service quality is not considered in this approach.

The literature review described in this chapter reveals the following:

- Transit agencies have a need to regularly measure and report service delivery performance;
- Many transit agencies have deployed AVL and APC technologies that permit the automatic collection of vehicle location and passenger boarding and alighting data. These

data, combined with the schedule data, permit the automated calculation of on-time performance metrics for all trips at all timepoints and across all days;

- Given that data collection and calculation of performance metrics is automated, there is also a need to automatically perform quality control methods. Methods have been proposed and described in the literature and the research in this thesis assumes that the proposed method is applied to AVL/APC data that have been subjected to a suitable quality assurance process;
- Some previous work has proposed a method to automatically identify schedule adherence performance that does not meet service standards and to identify the potential cause of this poor performance;
- Despite these advances, a gap remains because there is no automatic method to both identify causes for poor performance and to make recommendations on how to solve the problem for future trips.

This thesis presents a proposed method for automatically identifying causes of poor schedule adherence and recommending changes to the transit schedule to improve the on-time performance. The next chapter describes the proposed methodology.

# Chapter 3: Methodology

## 3.1 Introduction

In this chapter, how systemic problems with the transit schedule are identified and how adjustments are recommended in the proposed methodology are described. The input to the methodology is a database containing the historical AVL/APC data as well as schedule data. The outputs of the methodology are:

1. On-time performance measures for each segment of the route of interest;
2. Recommended changes to the transit schedule. These recommendations can be made under two different assumptions related to transit agency resources. The 'Resource unconstrained' approach assumes that there is no constrain on the amount of time that can be added to the schedule. The 'Resource constrained' approach assumes that time can be reallocated within the schedule, but the route traversal time must not be extended.

Figure 5 presents the framework of the approach.

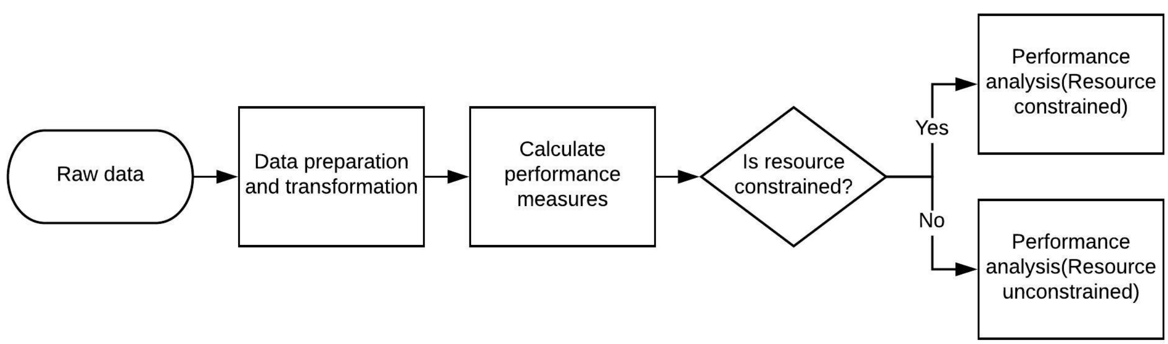


Figure 5: Methodology Framework

## 3.2 AVL/APC Data Preparation and Transformation

The approach proposed in this study is developed for quality assured AVL/APC data which means that the analysis results should not be impacted by the false data that is introduced by internal system errors and data recording. Because data quality assurance is illustrated in Chapter 2 and it is not what this study focuses on, so the process will not be included in the methodology. Before conducting any part of the methodology, it needs to be ensured that the data is already 'cleaned'.

Table 4 shows the key elements of original data structure from AVL/APC system.

Table 4: Original Stop-level Data Structure

| **Fields** | **Data type** | **Description** |
|---|---|---|
| DayOfWeek | Number | Operation day of a week:<br>1 - Sunday<br>2 - Monday<br>3 - Tuesday<br>4 - Wednesday<br>5 - Thursday<br>6 - Friday<br>7 - Saturday |
| LINE_ID | Number | Route number |
| PATTERN_DIRECTION | Number | Route direction |
| PATTERN_ID | Number | Travel pattern ID |
| PATTERN_LONG_NAME | String | Travel pattern name |
| DepDate | Date | Operation date |
| Trip_Event_No | Number | Trip event number |
| TripDepTime_Sched | Number | Scheduled departure time of the trip from starting terminal |
| TripDepTime_Actual | Number | Actual departure time of the trip from starting terminal |
| TripArrTime_Sched | Number | Scheduled arrival time of the trip at the ending terminal |
| TripArrTime_Actual | Number | Actual arrival time of the trip at the ending terminal |
| Stop_Event_No | Number | Stop event number |
| StopArrTime_Sched | Number | Scheduled arrival time(sec) at the stop or NULL if there’s none |
| StopArrTime_Actual | Number | Actual arrival time(sec) at the stop |
| StopDepTime_Sched | Number | Scheduled departure time(sec) at the stop or NULL if there’s none |
| StopDepTime_Actual | Number | Actual departure time(sec) at the stop |
| PATTERN_IDX | Number | ID number within the same trip |
| POINT_ID | Number | Internal ID of the stop |
| STOP_ID | Number | ID of the stop to the public |
| POINT_LONG_NAME | String | Name of the stop |
| PASSENGER_IN | Number | Number of passengers that get onboard |
| PASSENGER_OUT | Number | Number of passengers that get off the bus |

### 3.2.1 Data Preparation

Since AVL/APC system generates a record whenever a bus performs an action (arrival and departure), so the original data contains records for every stop of each trip. However, because schedule is only made for timepoints by the transit agency, there may exist some intermediate stops that do not have scheduled arrival and departure time. Therefore, those records would not be useful in the data analysis and should be excluded when evaluating transit vehicles' on-time performance. This process is done for the records of the chosen direction of the route of interest, and every record in the database represents the recorded information of the bus at a stop. Figure 6 shows how this process is conducted.

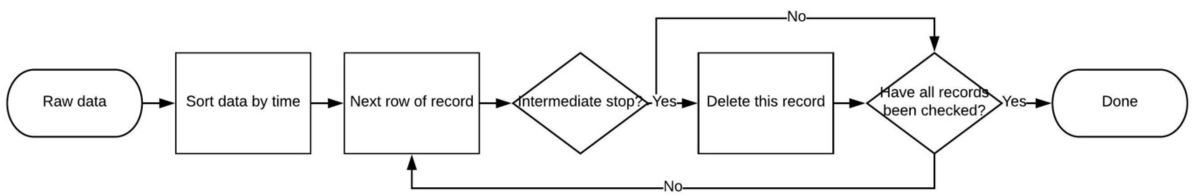


Figure 6: Data Preparation Process

### 3.2.2 Data Transformation

As it is discussed in Chapter 1, because the bus's schedule and routing plans changes over time, so if the analysis is done at stop level, the results may not be able to be applied to another time period. In this study, the methodology is developed for the AVL/APC data at segment level, so the original data is converted into the segment-level structure, and each segment represents the roadway between two consecutive timepoints, and the time for the bus to finish segment *i* starts from the arrival of a bus at starting timepoint *i* to the arrival of the bus at ending timepoint *i+1*. By doing this, when there is a change to schedule or route, the analysis results for the same segments are still applicable for the next schedule period.

Figure 7 illustrates the definition of a route segment. In this figure, segment *i* is the portion of the route from timepoint *i-1* to timepoint *i*.

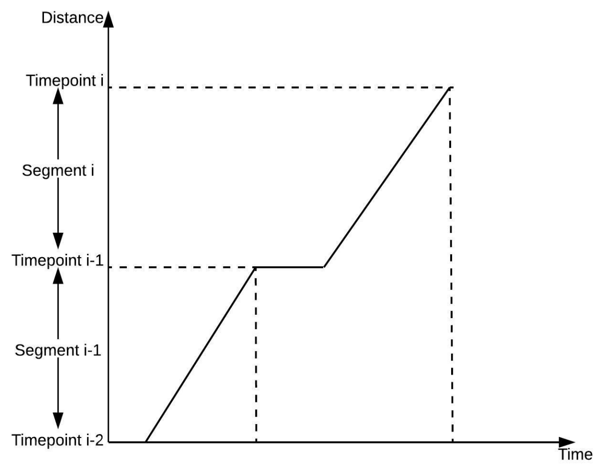


Figure 7: Segment Definition in Time-space Diagram

Figure 8 shows the process of the transformation of data structure.

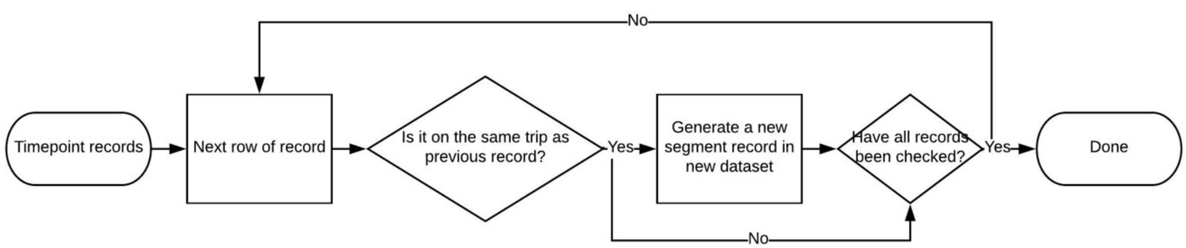


Figure 8: Data Structure Transformation Framework

Table 5 shows a list of key elements of the segment record after the transformation of data structure.

Table 5: Segment-level Data Structure

| **Fields** | **Data type** | **Description** |
|---|---|---|
| LINE_ID | Number | Route number |
| PATTERN_ID | Number | Travel pattern ID |
| DepDate | Date | Operation date |
| Trip_Event_No | Number | Trip event number |
| Startstop_ID | Number | Start stop ID of segment |

Table 5(continued): Segment-level Data Structure

| | | |
|---|---|---|
| Endstop_ID | Number | End stop ID of segment |
| Startstop_NAME | String | Start stop's name of segment |
| Endstop_NAME | String | End stop's name of segment |
| StartstopArrTime_Sched | Number | Scheduled arrival time(sec) at the start stop of segment |
| StartstopArrTime_Actual | Number | Actual arrival time(sec) at the start stop of segment |
| StartstopDepTime_Sched | Number | Scheduled departure time(sec) at the start stop of segment |
| StartstopDepTime_Actual | Number | Scheduled departure time(sec) at the start stop of segment |
| EndstopArrTime_Sched | Number | Scheduled arrival time(sec) at the end stop of segment |
| EndstopArrTime_Actual | Number | Actual arrival time(sec) at the end stop of segment |
| PASSENGER_IN | Number | Number of passengers that get onboard at start stop |
| PASSENGER_OUT | Number | Number of passengers that get off the bus at start stop |
| SegPsg_activity | Number | Passenger activity happens on the segment |

## 3.3 Performance Measures

Traditional measures of performance are helpful in reflecting a transit vehicle's performance such as on-time percentage as it discloses the percentage of time that a bus is on-time at each timepoint, so in this approach, the bus's on-time percentage is used as the measure of performance to evaluate the improvements the methodology could bring to transit system's service quality, and how the on-time percentage is calculated is illustrated below.

As discussed in Chapter 1, traditional performance measures are good at showing a bus's performance. However, they lack the ability to reveal the real causes for the poor performance and where the attention should be focussed to solve the performance problems. To achieve this, several performance measures are developed and analyzed in this study to help both identify transit schedule's systematic problems and make recommendations to adjust the transit schedule for the next schedule period. In the following sections, three categories of performance measures are introduced, where Category 2 and Category 3 are calculated based on the results of Category 1.

### 3.3.1 Traditional Performance Measure On-time Percentage

As it is discussed in Chapter 2, because the proposed methodology in this research not only attempts to address the problems of buses being late on some segments, it also attempts to identify the segments where buses are running early, so unlike the performance measure used in the study of Mandelzys and Hellinga (2010) where it only captures when the bus arrives late or departs early, in this study, the on-time percentage reflects if a bus arrives early or late and if a bus departs early or late at a timepoint. The percentage of a transit buses that were on-time at each timepoint is calculated based on both of transit vehicles' arrival and departure.

A transit bus is labelled ad 'on-time' at timepoint *i* on trip *j* if the conditions defined in Equations 3 and 4 are true.

$$E_a < D_{a_{i,j}} < L_a \quad (3)$$

$$\text{AND } E_d < D_{d_{i,j}} < L_d \quad (4)$$

where $E_a$ = threshold of a bus's early arrival at any timepoint

$E_d$ = threshold of a bus's early departure from any timepoint

$L_a$ = threshold of a bus's late arrival at any timepoint

$L_d$ = threshold of a bus's late departure from any timepoint

For each timepoint, the on-time percentage of trips is calculated using Equation 5.

$$'on-time\%'_i = \frac{\sum_{j=1}^{M_i}(if\ trip\ is\ 'on-time'\ then\ 1, else\ 0)}{M_i} \quad (5)$$

where $M_i$ = Total number of trips recorded at timepoint i within the study period

### 3.3.2 Performance Measure Category 1: 'TD', 'DTD', and 'TTD'

As part of the method proposed in this thesis, three performance measures True Difference (*TD*), Dwell Time Difference (*DTD*), and Travel Time Difference (*TTD*) are developed to reflect schedule adherence deviation of transit vehicles.

Figure 9 shows a time-space diagram of a bus's actual trajectory (black line) and trajectory associated with the transit schedule (red line) on segment *i* on one trip *j*.

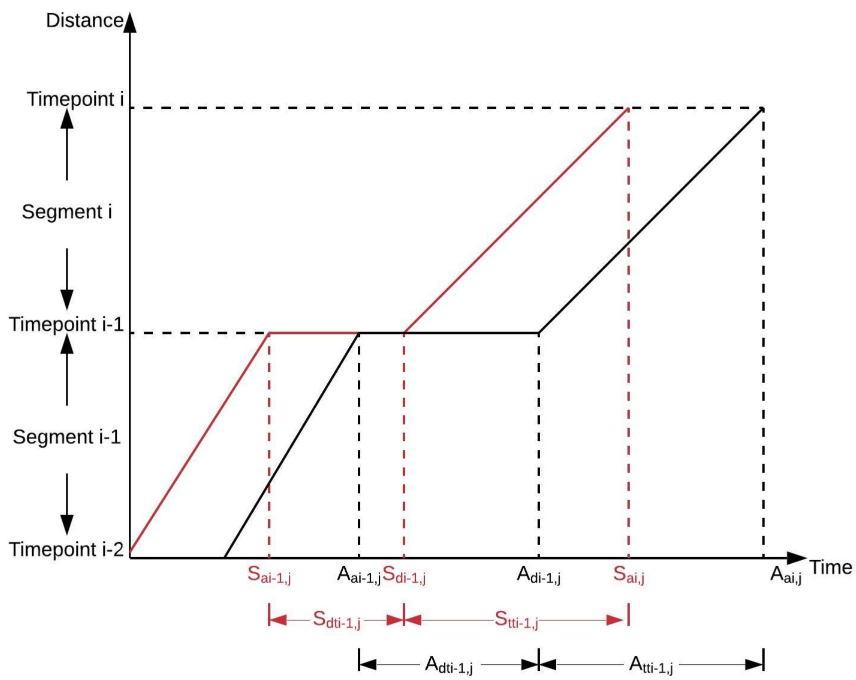


Figure 9: Time-space Diagram of Segment i

where $S_{dti-1,j}$ = Scheduled dwell time of the bus at timepoint i-1 on trip j

$S_{tti-1,j}$ = Scheduled traversal time of the bus to traverse the segment between timepoint i-1 and timepoint i on trip j

$A_{dti-1,j}$ = Actual dwell time of the bus at timepoint i-1 on trip j

$A_{tti-1,j}$ = Actual traversal time of the bus to traverse the segment between timepoint i-1 and timepoint i on trip j

*TD* represents the different between the actual time and scheduled time for the bus to traverse the segment, and it is calculated using Equation 6. For example, if $TD_{i,j}$ has a value of 10, it means that on trip *j*, from arriving at stop *i-1* to arriving at stop *i*, the bus spend 10 seconds more than the scheduled time to finish this segment.

$$TD_{i,j} = \left(A_{dt_{i-1,j}} + A_{tt_{i-1,j}}\right) - \left(S_{dt_{i-1,j}} + S_{tt_{i-1,j}}\right) \tag{6}$$

$$(i \geq 2 \ because\ there\ is\ no\ segment\ before\ timepoint\ 1)$$

where $TD_{i,j}$ = True schedule adherence difference of the bus to finish segment between stop i-1 to stop i on trip j

*DTD* and *TTD* are defined in Equations 7 and 8. $DTD_{i,j}$ and $TTD_{i,j}$ are both used to measure a bus's performance on segment *i* on trip *j* where $DTD_{i,j}$ measures the difference between the actual and scheduled dwell time at stop *i-1*, and $TTD_{i,j}$ measures the difference between the actual and scheduled time to travel segment *i* from departing at stop *i-1* to arriving at stop *i*.

$$DTD_{i,j} = A_{dt_{i-1,j}} - S_{dt_{i-1,j}} \tag{7}$$

$$TTD_{i,j} = A_{tt_{i-1,j}} - S_{tt_{i-1,j}} \tag{8}$$

$$(i \geq 2)$$

where $DTD_{i,j}$ = Schedule adherence difference of the bus's dwell time at stop i-1 on trip j

$TTD_{i,j}$ = Schedule adherence difference of the bus from departing at stop i-1 to arriving at stop i on trip j

It can be noted that the difference in segment traversal time is the sum of the difference in dwell time plus the difference in travel time (Equation 9):

$$TD_{i,j} = DTD_{i,j} + TTD_{i,j} \tag{9}$$

### 3.3.3 Performance Measure Category 2: 'TDR', 'DTR' and 'TTR'

This category of measure of performance are built based on the results of performance measure of category 1. We begin the development of Category 2 measures by considering the difference between the actual and scheduled segment traversal time (i.e. $TD_{i,j}$).

Assume, temporarily, that all trips traversing segment *i* experience the same conditions and scheduled traversal time is fixed. Then $TD_i = TD_{i,1} = TD_{i,1} = TD_{i,\mathrm{M}}$.

If $TD_i > 0$, then the transit vehicles took longer to traverse segment *i* than was scheduled and on-time performance would have been improved if the schedule had an additional $TD_i$ seconds for the traversal time for segment *i*. Conversely, if $TD_i < 0$, then the transit vehicles took less time to traverse segment *i* than was scheduled, then on-time performance would have been improved if $TD_i$ seconds had been removed from the scheduled traversal time for segment *i*.

Now consider the time-series plot of $TD_{i,j}$ from actual and scheduled trip data for a segment i of a bus route in Waterloo, Ontario, Canada. Figure 10 shows a scatter plot of *TD*. It is evident from this graph that the value of *TD* varies for different trips and that our assumption that $TD_i = TD_{i,1} = TD_{i,1} = TD_{i,\mathrm{M}}$ is clearly not valid. These variations are likely the result of differences in traffic and/or weather conditions on different days, differences in transit vehicle driver behaviour, variations in number of passengers boarding and alighting at stop *i-1* on different trips, variations in the time taken for passengers to board and alight, traffic incidents, etc.

For this set of data, distribution of *TD* is not symmetrical. The mean is 147 seconds and the median is 124 seconds. Almost all values of *TD* are positive, indicating that for most trips, the transit bus took more time to traverse the segment than scheduled. Consequently, it seems logical that on-time performance would have been improved if the scheduled traversal time was increased.

This leads to two important questions:

1. What measure from the distribution should be used to determine the recommended change to the schedule?

2. If time should be added or removed from the schedule, should the change be made to the dwell time at stop *i-1* or the travel time from stop *i-1* to *i*?

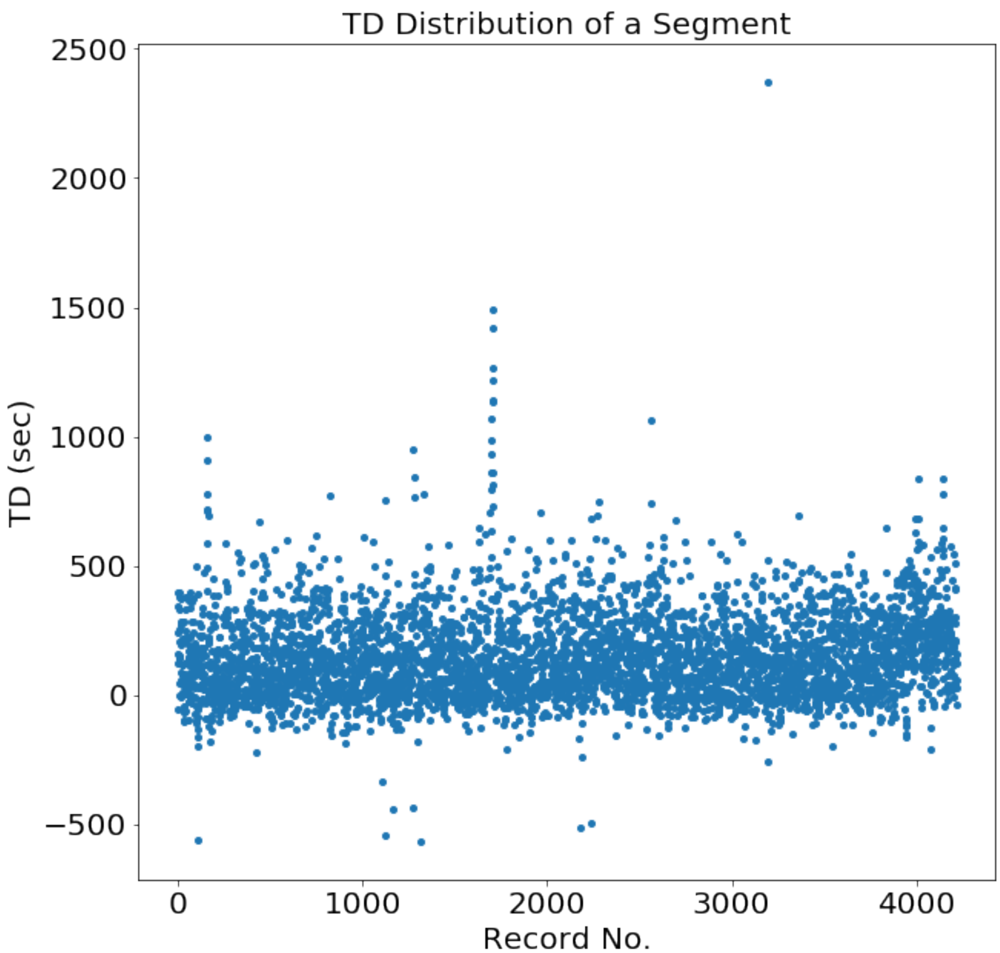


Figure 10: TD Distribution of a Segment

Thus, True Difference Recommendation (TDR), Dwell Time Recommendation (DTR) and Travel Time Recommendation (TTR) are introduced to reflect a bus's aggregated deviation of schedule adherence on each segment over the study time period.

To aggregate the *TD* value of all the records and also avoid the impacts caused by the 'outliers', the median values of *TD*, *DTD* and *TTD* of all the trips recorded for each segment are used to represent a bus's overall performance on the segment. The fact that there is no segment prior to the starting stop is also considered in this process.

Equation 10, 11 and 12 show how *TDR*, *DTR* and *TTR* are calculated.

$$TDR_i = median\ of\ TD_{i,j}\ from\ trip\ 1\ to\ T_i \tag{10}$$

$$DTR_i = median\ of\ DTD_{i,j}\ from\ trip\ 1\ to\ T_i \tag{11}$$

$$TTR_i = median\ of\ TTD_{i,j}\ from\ trip\ 1\ to\ T_i \tag{12}$$

where $TDR_i$ = The median value of schedule deviation over the segment between stop i-1 to stop i on all trips

$DTR_i$ = The median value of schedule deviation of dwell time at bus stop i-1 on all trips

$TTR_i$ = The median value of schedule deviation of traversal time from departing from stop i-1 to arriving at stop i on all trips

For example, if a bus has a result of *TDR* value as 30 seconds, *DTR* as 0 second and *TTR* as 35 seconds on a segment, it indicates that overall, the bus spends 30 seconds more than scheduled time finishing the segment which is from arriving at the starting stop to arriving at the ending stop, and there is no deviation in the dwell time the bus spends at the starting stop, and it takes 35 seconds more than the scheduled time from departing at the starting stop until arriving at the ending stop. More importantly, unlike what it shows in equation (8), because those three performance measures are calculated from the medians of the measurements mentioned above independently, the values of *DTR* and *TTR* for a segment do not necessarily add up to the *TDR* value of the same segment.

### 3.3.4 Performance Measure Category 3: '+TD%' and '-TD%'

Logically, if *TDR* for a segment *i* has a positive value, and as it becomes larger, it is expected that the fraction of *TD* at this timepoint that is positive also becomes larger, and vice versa when it has a negative value. However, hypothetically, there might be one scenario where using just *TDR* is not sufficient to reflect a bus's performance on this segment. For example, if there are 101 records recorded for one segment, 50 trips have a *TD* value of -80 seconds whereas the rest have a *TD* value of 80 seconds, and the *TDR* of this segment has a value of 80 seconds. Though this situation is not very likely to happen often, it does raise some concerns:

1. Using just *TDR* to reflect a bus's performance on a segment, in this hypothetic case, it will indicate that 80 seconds should be added to the scheduled time. However, a half of the trips on the segment are 80 seconds early, doing so is not the best solution;
2. So, there should be another set of criteria to show the fraction of the trips that indicate that time should be added to or removed from the scheduled time of a segment.

The third category of performance measures includes 'percentage of positive TD' (+TD%) and 'percentage of negative TD' (-TD%) are introduced to quantify the 'skewness' of the *TD* value of all the trips at a segment. Equation 12 and 13 show the definitions of those measures. The numerators in the equations are the number of trips on a segment that have positive or negative values of *TD* while the denominator represents the total number of trips recorded on this segment.

$$`+TD\%'_i = \frac{\sum_{j=1}^{T_i}(if\ TD_{i,j}>0\ then\ 1, else\ 0)}{T_i} \tag{12}$$

$$`-TD\%'_i = \frac{\sum_{j=1}^{T_i}(if\ TD_{i,j}\leq 0\ then\ 1, else\ 0)}{T_i} \tag{13}$$

where $T_i$ = Total number of trips recorded for segment *i* within the study period

$+TD\%_i$ = percentage of trips that have a positive *TD* value over the segment between stop i-1 to stop i

$-TD\%_i$ = percentage of trips that have a negative *TD* value over the segment between stop i-1 to stop i

Those two performance measures are used to indicate the 'skewness' of a bus's overall performance on a segment. Due to the characteristics and inherent randomness of traffic condition, it is impossible for a bus to have a perfect schedule adherence in reality for all the segments on each trip, *TD* has a value of 0. In practice, it is expected that a bus will always have schedule adherence deviations within a certain range.

It is considered that a bus has a good performance when the *+TD%* and *-TD%* values for a segment are around 50% which means that the bus's performance deviation on a segment is 'evenly' distributed which means that half of the records show that the bus run late on this segment while the other half of the records show that the bus run early on the same segment. In contrast, if a bus has a value of 80% for *+TD%* and a value of 20% for *-TD%* on a segment, it means that for 80% of the trips the bus takes more time to finish the segment than is scheduled, which is an indication of the bus being late on the segment most of the time. Thus, this segment should be highlighted for further analysis, and more time may be added to the schedule time on this segment to improve the service quality.

After performing all the calculations of performance measures in this component, the output is a performance report of on-time performance measures for each segment of the route of interest

## 3.4 Performance Analysis under Resource Unconstrained/Constrained Conditions

Traffic condition may be different during different time period of a day, so it is necessary to calculate performance measures for different time periods separately. The first step is to divide the record into the following categories of time period depending on the time of day when those records are recorded:

1. AM peak hour;
2. Mid-day;
3. PM peak hour.

Then the three categories of measure of performance are calculated for the chosen direction of the route of interest within each category of time period. In this component of the approach, the results of those measures of each segment will be further analyzed to decide if an adjustment should be recommended to improve transit system's performance. Figure 11 shows the steps of the data analysis.

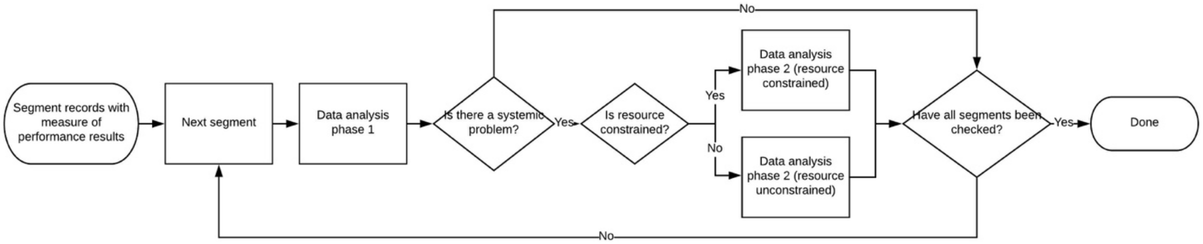


Figure 11: Data Analysis Steps

The records of each segment go through the first phase of data analysis (section 3.3.1) in which it is determined if a systemic problem with the existing transit schedule (for this segment and time period) exists. If there is a systemic problem, then depending on if resource is constrained or not, the records of this segment will go to the second phase of data analysis (section 3.3.2 and section 3.3.3) where what schedule changes should be made are decided.

### 3.4.1 Data Analysis Phase 1: Decision Making for Each Segment

Some constraints are used to decide if there is a systematic problem to the schedule, and the processes are shown in Figure 12.

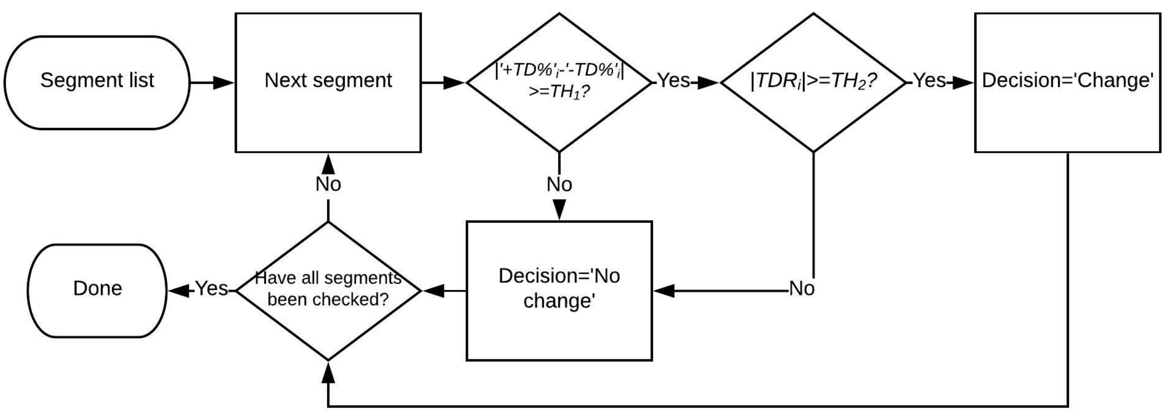


Figure 12: Phase 1 Decision Making Analysis Process

where $TH_1$ = threshold 1 for deciding if TD value's skewness is significant on each segment

$TH_2$ = threshold 2 for deciding if TDR's absolute value is significant on each segment

The reasons for using these two sets of constraints to decide if there is a systemic problem in the schedule are:

1. As it is mentioned before, the values of *+TD%* and *-TD%* are used to assess the 'skewness' of a bus's deviation of schedule adherence. For example, if *+TD%* and *-TD%* have values of 55% and 45% on a segment, it means that the percentages of time when the bus takes more and less than the scheduled time are close so that the bus is already performing well and adjusting the schedule does not seem necessary in this case;
2. In a case where a bus's performance on a segment is fairly skewed (*+TD%*: 70%; *-TD%*: 30%), but the *TDR* has a value of 10 seconds. This means that even though the bus is late on most of trips, the overall deviation of schedule adherence is 10 seconds which indicates that the time that the buses run late by is not significant, so making a change to the schedule may not be favoured by a transit agency. However, it is expected that when the bus's performance on segment is fairly 'skewed', it will also have a fairly large value for *TDR*.

### 3.4.2 Data Analysis Phase 2: Decision Application under Resource Unconstrained Condition

When resources are not constrained then the scheduled cycle time of a route does not need to remain fixed at the current value and time can be added to or removed from a segment's scheduled time without regard for the impact that this has on the route cycle time. Furthermore, the adjustments to the schedule can be done hourly instead of to the whole time period of a day, so a better improvement after applying schedule adjustments is expected. On the same day of week, traffic conditions change within the same category of time period, so a bus may have different performance within different hours within that time period. Thus, to make best recommendations that take into consideration of a bus's performance variation over time within a time period on a segment, deciding if the bus's performance is relatively consistent within a time period of a day is important so that the schedule adjustments can be developed to either the whole time period of a category (AM, Mid-day, and PM) or each hour within the time period separately.

If in the first phase of the analysis, it is decided that there is a systemic problem in the transit schedule, then this category of time period will be broken down into every one-hour period first and the bus's performance measures *(+TD%, -TD%, TDR, DTR* and *TTR*) of each one-hour period are calculated and the same analysis of phase 1 will be performed on each one-hour period. If systemic problems in the schedule are discovered, based on the results of performance measure, the decision of whether to perform an overall adjustment to the schedule for that whole time period or perform specific adjustments to each one-hour period within that time period are made. The process is illustrated in Figure 13.

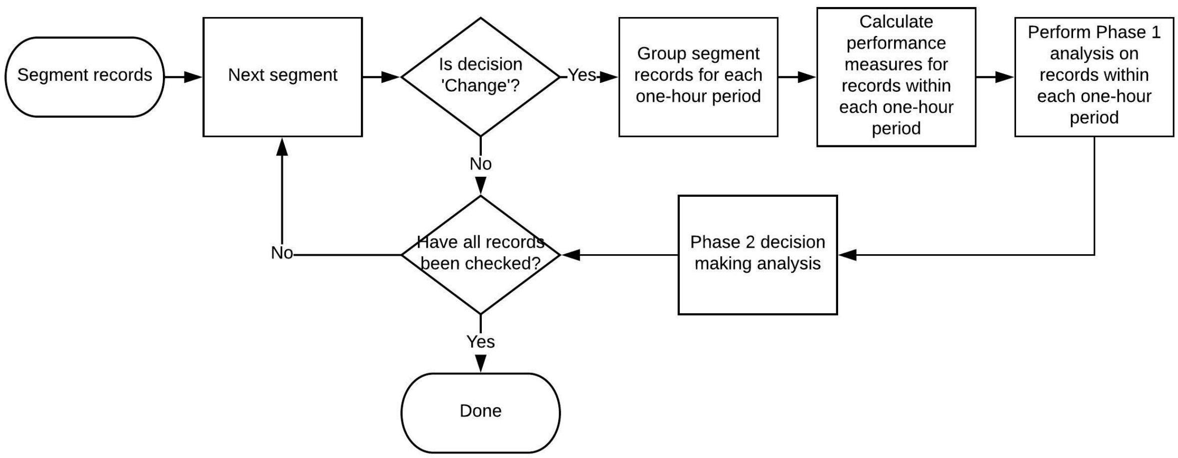


Figure 13: Decision Application Process Framework (Resource is Unconstrained)

To help illustrate this process, consider the following hypothetical example in which we apply the proposed method to the AM peak period (6-9 AM) records of a route of a chosen direction. The route consists of three segments and four timepoints. Furthermore, assume that in the first phase of analysis, the parameters $TH_1$ and $TH_2$ are set as 30% and 30 seconds, respectively.

The results are shown in Table 6 where Start_ID and End_ID represent the starting stop's ID and ending stop's ID of a segment respectively:

Table 6: Phase 1 Analysis Report

| **Start_ID** | **End_ID** | **+TD%** | **-TD%** | **TDR** | **DTR** | **TTR** | **Decision** |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 77% | 23% | 68 | 5 | 70 | Change |
| 2 | 3 | 65% | 35% | 40 | 2 | 35 | Change |
| 3 | 4 | 46% | 54% | -2 | 0 | -5 | No change |

As shown above, the first and the second segments both have a value of *TDR* that exceeds the threshold $TH_2$, and the values of *+TD%* and *-TD%* also meet the criteria listed in Figure 12. So, it is decided that a change to the original schedule should be made to them. Then the records of these segments will be grouped together within each one-hour periods (6-7 AM, 7-8 AM, and 8-9 AM), and since it is AM-peak hour, so there is only one category of time period. Next, the same set of performance measures are calculated again for each one-hour period of each segment, after which the first phase of analysis will be performed on the results of performance measures for each hour period. Table 7 shows the results of this step of analysis:

Table 7: Analysis Results of Each One-hour Period

| **Start_ID** | **End_ID** | **Time** | **+TD%** | **-TD%** | **TDR** | **DTR** | **TTR** | **Decision** |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 6AM-7AM | 80% | 20% | 70 | 10 | 59 | Change |
| 1 | 2 | 7AM-8AM | 67% | 33% | 65 | 0 | 70 | Change |
| 1 | 2 | 8AM-9AM | 60% | 40% | 45 | 5 | 45 | No change |
| 2 | 3 | 6AM-7AM | 70% | 30% | 42 | 5 | 38 | Change |
| 2 | 3 | 7AM-8AM | 68% | 32% | 39 | 0 | 42 | Change |
| 2 | 3 | 8AM-9AM | 72% | 28% | 45 | 5 | 42 | Change |

We can make two observations from the results in Table 7:

1. The decisions (i.e. 'Change' vs 'No change') for each of the individual hours with the three-hour AM period are not always the same. This is evident for segment 1 from 8 to 9 AM;
2. The magnitude of *TDR, DTR* and *TTR* can vary across the individual hours for each segment.

It is, therefore, necessary to determine whether schedule changes need to be made for a segment at the hourly level (because different changes are needed across the different hours) or the changes can be made at the period level (because the same changes are made for each hour in the time period).

This decision is made by considering two aspects of the analysis results conducted at the hourly level:

1. It is undesirable to change the schedule for a segment during a given hour if such a change is not warranted because changing the schedule will likely degrade on-time performance. Consequently, if the results of the hourly analysis (i.e. Table 7) indicates a decision of 'No change' for one or more of the hours in the period, then schedule changes need to be made separately for each hour;
2. If the decision is 'Change' for all hours in the period, it may be that the recommended schedule changes vary substantially across the different hours. If so, then these schedule changes need to make for each hour separately. We determine if the recommended schedule changes are substantially different by comparing the magnitude of *TDR* values of each one hour within that time period. In other words, as it shows in Figure 14, if a change is recommended to all one-hour periods, then an equation ($(TDR_{max}-TDR_{min})>=min(|TDR_{max}|, |TDR_{min}|)$) is used to decide if each hour should be treated separately. The following three scenarios explain how decision is made in this step:
    a. If all the *TDR* values are all positive and the maximum value of *TDR* is more than two times of the minimum value of *TDR* values, then schedule changes need to be made separately for each hour (the multiple, in this case, 2 is chosen subjectively);
    b. If all the *TDR* values are all negative and the maximum absolute value of *TDR* is more than two times of the minimum absolute value of *TDR* values, then schedule changes need to be made separately for each hour (the multiple, in this case, 2 is chosen subjectively);
    c. When some *TDR* are positive, and some are negative, then schedule changes need to be made separately for each hour.

The following diagram (Figure 14) shows the constraints in the second phase of decision making analysis to decide the final action for each segment:

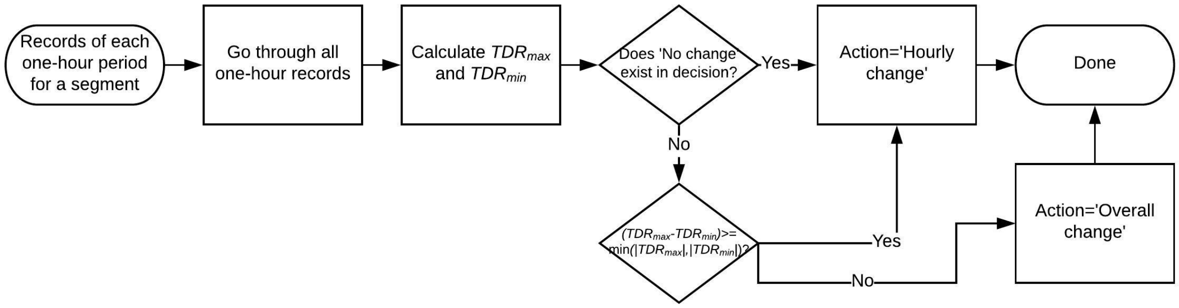


Figure 14: Phase 2 Decision Making Analysis Framework (Resource Unconstrained)

where $TDR_{max}$ = the maximum value of 'TDR' of the results within each one-hour of the same segment

$TDR_{min}$ = the minimum value of 'TDR' of the results within each one-hour of the same segment

For the hypothetical example above, on the first segment, the decision for the hour between 8AM and 9AM is 'No change', suggesting that changing the schedule for the entire 3- hour AM peak period would not be appropriate. Instead, schedule adjustments should be made for each one-hour period. For segment 2, we observe that (i) there is a 'Change' decision for each of the three separate hours, and (ii) the proposed changes are not substantially different across the three hours (i.e. the conditions listed in Figure 14 are not satisfied). Consequently, for Segment 2, an overall schedule change is recommended. The final result report is provided in Table 8.

Table 8: Final Result Report (Resource Unconstrained)

| **Start_ID** | **End_ID** | **+TD%** | **-TD%** | **TDR** | **DTR** | **TTR** | **Decision** | **Action** |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 77% | 23% | 68 | 5 | 70 | Change | Hourly change |
| 2 | 3 | 65% | 35% | 40 | 2 | 35 | Change | Overall change |
| 3 | 4 | 46% | 54% | -2 | 0 | -5 | No change | No change |

The implementations of adjustments are made based on the actions decided for each segment:

- If the action is 'Overall change', then the recommendations will be based on the report of the bus's **overall performance measure results** (Table 8), and the values of *DTR* and

*TTR* are adjusted to the scheduled dwell time at starting stop and scheduled traversal time between departing at starting stop and arriving at ending stop respectively. For example, to adjust the schedule of the second segment in the previous example, 2 seconds will be added to the scheduled time at stop 2 (in reality, this may be ignored since the value is too small and transit schedule is always in one minute resolution), and 35 seconds will be added to the scheduled traversal time from stop 2 to stop 3;

- If the action is 'Hourly change', then the recommendations will be based on the report of the bus's **performance measure results of each hour** (Table 7), and the values of *DTR* and *TTR* of each hour period will be adjusted to the scheduled dwell time at starting stop and scheduled traversal time between departing at starting stop and arriving at ending stop respectively if the scheduled time falls into this one-hour period. For instance, to improve the bus's performance on the first segment in the previous example, for the schedule between 6AM to 7AM, 10 seconds will be added to the scheduled dwell time at stop 1 and 59 seconds will be added to the scheduled traversal time from stop 2 to stop 3. Moreover, for the hour period between 7AM and 8AM, 70 seconds will be added to the scheduled traversal time. No change is needed to be made for hour period between 8AM and 9AM.

### 3.4.3 Data Analysis Phase 2: Decision Application under Resource Constrained Condition

In the previous section, we presented a model to adjust the schedule without restricting the impact that these changes can have on the route cycle time (and consequently on the transit agency's fleet size and service hour requirement). In this section, we present a model in which resources are constrained, meaning that cycle time may not be increased, or may be increased but only by a maximum amount. Because of the characteristics of resource constrained condition, it is not applicable to do hourly modification on the schedule while maintaining a fixed route cycle time, so the analysis and adjustments will be performed on the whole time period of each category.

In this phase of the analysis, there may be two scenarios and the implementations of adjustment in each scenario are different:

1. In Scenario 1, the sum of the recommended changes to the segment scheduled traversal times is less than the total additional time that can be added to the route (i.e. required schedule changes do not exceed allowable resources);
2. In Scenario 2, the sum of the recommended changes to the segment schedule traversal times is greater than the allocated time (i.e. exceeds allowable resources).

In this step of analysis when resource is constrained, *DTR* and *TTR* are used as initial inputs for the analysis ($DTR_I$ and $TTR_I$), and the initial input value $TDR_I$ is set as the sum of *DTR* and *TTR* instead of using *TDR.* To illustrate the processes, two hypothetical examples are given below. For both examples we assume that the resource constraint is that no additional time can be allocated to the route.

Table 9: Final Recommendation Report (Resource Constrained Scenario 1)

| **Start_ID** | **End_ID** | **+TD%** | **-TD%** | **$TDR_I$** | **$DTR_I$** | **$TTR_I$** | **Decision** |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 77% | 23% | 35 | 5 | 30 | Change |
| 2 | 3 | 65% | 35% | 40 | 0 | 40 | Change |
| 3 | 4 | 20% | 80% | -90 | 0 | -90 | Change |

where $TDR_I$ = Initial recommended value for TDR

In the table above (Table 9), it shows that 35 seconds needs to be added to the first segment, 40 seconds needs to be added to the second segment and 90 seconds could be taken out from the third segment. The proposed recommended schedule changes meet the resource constraint and therefore can be implemented as proposed.

Table 10 shows an example of Scenario 2, for which the net proposed schedule changes exceed the resource constraint. As the result, the proposed schedule changes cannot be implemented as computed.

Table 10: Phase 1 Result Report (Scenario 2)

| Start_ID | End_ID | +TD% | -TD% | $TDR_I$ | $DTR_I$ | $TTR_I$ | Decision |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 77% | 23% | 35 | 5 | 30 | Change |
| 2 | 3 | 65% | 35% | 40 | 0 | 40 | Change |
| 3 | 4 | 30% | 70% | -60 | 0 | -60 | Change |

Consequently, the process of implementing the adjustments is:

- For segments where time is decided to be taken out from schedule, the time will be extracted and combined with the amount of time that is allowed to be added to cycle time (in this example, 0) as spare time ($T_{neg}$) that can be utilized by other segments;
- For segments where time should be added to the schedule, the total available spare time will be distributed to the segments where time is needed based on the weight of their $TDR_I$ values, and for each segment, its assigned time will be further distributed based on their $DTR_I$ and $TTR_I$ weights.

Equations (12, 13, 14 and 15) show how to reallocate time among the segments during the process.

$$T_{neg} = \sum_{x=1}^{X} TDR_{I_x} + t \quad (12)$$

$$T_{pos} = \sum_{y=1}^{Y} TDR_{I_y} \quad (13)$$

$$TDR_{F_y} = TDR_{I_y} \; if \; TDR_{I_y} \leq 0 \quad (14)$$

$$TDR_{F_y} = T_{neg} * \frac{TDR_{I_y}}{T_{pos}} \; if \; TDR_{I_y} > 0 \quad (15)$$

where $t$ = Amount of time that could be added to cycle time, 0 if no time is allowed to be added

$TDR_{Ix}$ = Initial TDR of the $x^{th}$ segment in the list of segments that has negative $TDR_I$

$X$ = Number of segments in the list of segments that has negative $TDR_I$

$TDR_{Iy}$ = Initial TDR of the $y^{th}$ segment in the list of segments that has positive $TDR_I$

$Y$ = Number of segments in the list of segments that has positive $TDR_I$

$T_{neg}$ = Total amount of time that is available

$T_{pos}$ = Sum of $TDR_I$ of all the segments that have positive $TDR_I$

$TDR_{Fy}$ = Final TDR of the $y^{th}$ segment in the list of segments that has negative $TDR_I$

After $TDR_{Fy}$ is calculated for each segment *y*, then its value will be distributed to dwell time and traversal time recommendations based on *DTR* and *TTR* values on the segment. The final result report of the previous example is shown below:

Table 11: Final Recommendation Report (Resource Constrained Scenario 2)

| Start_ID | End_ID | +TD% | -TD% | $TDR_F$ | $DTR_F$ | $TTR_F$ | Decision |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 77% | 23% | 28 | 4 | 24 | Change |
| 2 | 3 | 65% | 35% | 32 | 0 | 32 | Change |
| 3 | 4 | 30% | 70% | -60 | 0 | -60 | Change |

where $TDR_F$ = Final recommended value for TDR

As it shows in Table 11, 60 seconds is taken out from the schedule time of the third segment, and it is utilized to add 4 seconds to the scheduled dwell time at stop 1, 24 seconds to the scheduled traversal time on the first segment and 32 seconds to the scheduled traversal time on the second segment.

# Chapter 4: Application to Grand River Transit System

## 4.1 Introduction

Grand River Transit (GRT) is a public transit agency that provides transit services for Waterloo Region in Ontario, Canada, which contains Kitchener, Waterloo, Cambridge, Elmira, and St. Jacobs. According to its official website (GRT, 2017), 70 routes have been deployed which covers 16 million kilometers annually, and ridership has reached 19.7 million per year by the end of 2016. The location of Waterloo Region is shown in the Figure 15.

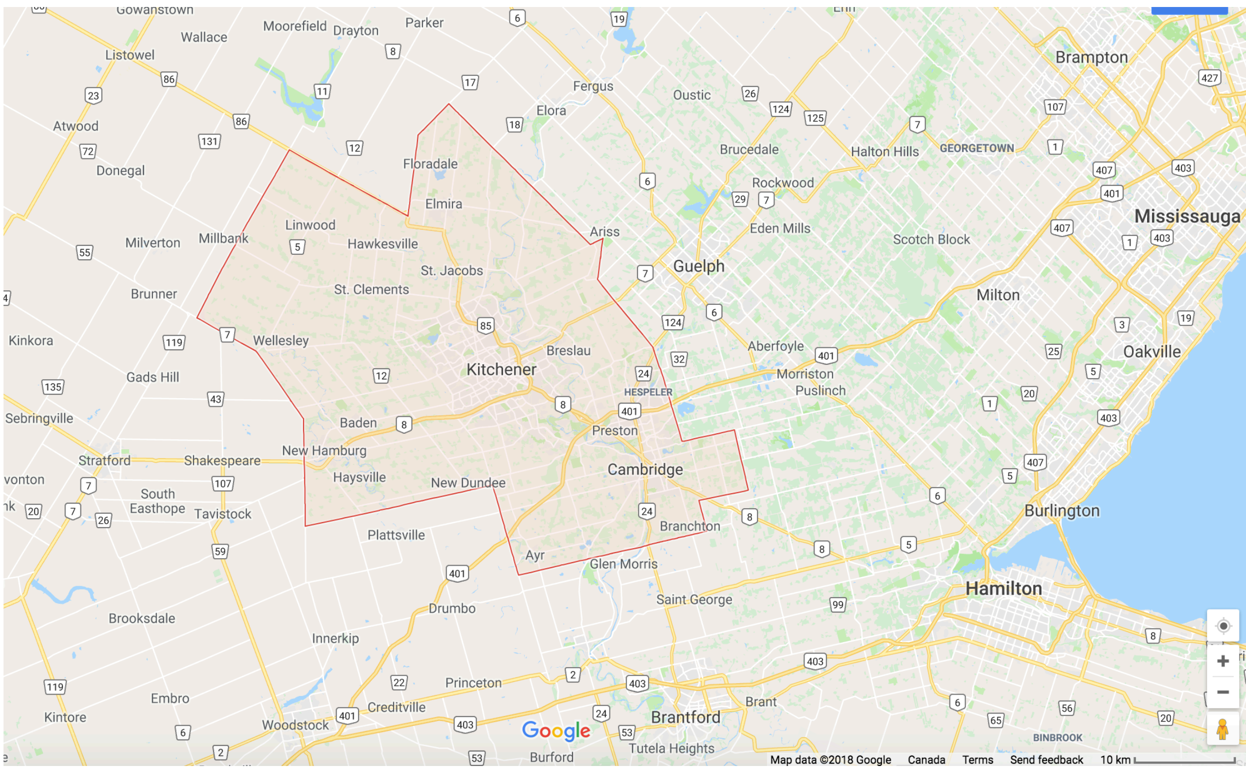


Figure 15: Waterloo Region (Google Maps)

All GRT transit routes operate according to a schedule rather than headway control. In this study, two routes, Route 31 (to Conestoga Mall direction) and Route 200 (to Ainslie Terminal direction), have been chosen to calibrate and validate the proposed methodology proposed in this study. Route maps are provided in Appendix A. The AVL/APC data collected from transit vehicles servicing these routes are used to test the proposed methodology. The main reasons for choosing these routes are:

1. Those two routes did not experience major schedule changes during the study time period;
2. Route 31 is one of the routes with the poorest overall on-time performance and Route 200 is one of the iXpress Routes with a very high passenger demand.

## 4.2 Study Time Period

The proposed methodologies are applied to AVL/APC data for weekdays trips that occurred during the summer of 2017 (July 1, 2017 to August 31, 2017). The recommendations of adjustments to the schedule are applied to the schedule in the fall of 2017 (September 1, 2017 to November 30, 2017) and the AVL/APC data reporting actual transit vehicle behavior from this period was used to evaluate the impact that the recommended schedule changes would have on transit on-time performance. Consideration was given to using the data from the fall 2016 period to generate recommended schedule changes and apply the adjustments to the fall of 2017. However, substantial road construction and road closures occurred during the fall 2016 period as a result of the construction of a new LRT service and this construction significantly influenced the operations of the bus transit service during this period.

In this study, three time of day periods are considered as listed in Table 12.

Table 12: Time of Day Period Definition

| **Time of a Day** | **Definition** |
|---|---|
| AM Period | 6:00 AM – 9:00 AM |
| Mid-day Period | 9:00 AM – 3:00 PM |
| PM Period | 3:00 PM – 7:00 PM |

## 4.3 Data Preparation and Transformation Results

The original data size of summer and fall records after quality assurance is shown in the following table (Table 13).

Table 13: Number of Records in Initial Dataset

| Period | Route 31 | Route 200 |
|---|---|---|
| Summer | 69,107 | 53,226 |
| Fall | 99,289 | 107,446 |

Each record contains data associated with a transit vehicle arriving and departing at a timepoint. Table 14 shows a sample of three records from the dataset.

Table 14: Sample Record of Original Data

| Fields | Record A | Record B | Record C |
|---|---|---|---|
| DayOfWeek | 2 | 6 | 3 |
| LINE_ID | 31 | 31 | 31 |
| PATTERN_DIRECTION | 2 | 2 | 2 |
| PATTERN_ID | 1028864 | 1028864 | 1028864 |
| PATTERN_LONG_NAME | 2: Conestoga Mall | 2: Conestoga Mall | 2: Conestoga Mall |
| DepDate | 2017-06-26 | 2017-07-07 | 2017-08-01 |
| Trip_Event_No | 459955765 | 462400223 | 467739258 |
| TripDepTime_Sched | 21600 | 24720 | 40920 |
| TripDepTime_Actual | 20639 | 24869 | 40993 |
| TripArrTime_Sched | 23700 | 26820 | 42960 |
| TripArrTime_Actual | 23965 | 27034 | 43304 |
| Stop_Event_No | 459955770 | 462400232 | 467739277 |
| StopArrTime_Sched | 21600 | NULL | 41520 |
| StopArrTime_Actual | 21394 | 25329 | 41802 |
| StopDepTime_Sched | 21600 | NULL | 41520 |
| StopDepTime_Actual | 21784 | 25329 | 41831 |
| PATTERN_IDX | 0 | 7 | 14 |
| POINT_ID | 4023 | 5026 | 3899 |
| STOP_ID | 32 | 3379 | 150 |
| POINT_LONG_NAME | Columbia / Sundew | Brentcliff / Gatestone | Columbia / U.W. |
| PASSENGER_IN | 0 | 0 | 7 |
| PASSENGER_OUT | 0 | 0 | 2 |

While most of the fields in each record are straightforward to understand, some columns are not easy to interpret. In the sample above, all records have the same value for fields such as LINE_ID, PATTERN_DIRECTION and PATTERN_ID, which indicate that those records are generated for the same direction of the same route. Trip_Event_No is a unique identification for each trip. The field StopArrTime_Sched of Record A shows a value of 21600 which is the number of seconds from 12 AM of the day. Thus, a value of 21600 means that the scheduled arrival time of that trip is at 6AM. The same units are used for scheduled and actual time records. For Record B, the value of StopArrTime_Sched and StopDepTime_Sched is 'NULL', indicating that this is an intermediate stop between timepoints, and there is no scheduled departure or arrival time for this stop. Among all three records, the passenger activity only occurred in Record C for which 7 people were reported to board the bus and 2 people departed the bus.

### 4.3.1 Results after Data Preparation

The three time period of interest (AM, Mid-day, and PM) are span the period from 6AM to 7PM, so only records for trips for which the scheduled arrival time was within this time period were extracted from the database.

$$21600(6AM) < S_{a_{i,j}} < 68400(7PM) \tag{16}$$

After the records within the study time period are filtered out, the records for intermediate stops where there's no scheduled arrival and departure time are taken out. After performing this step, the number of records within the data has been reduced to the values shown in Table 15.

Table 15: Number of Records in Dataset after Data Preparation

| Period | Route 31 | Route 200 |
|---|---|---|
| Summer | 7,925 | 27,338 |
| Fall | 11,397 | 62,766 |

It is found that compared to Route 200, there is a larger portion of data that is from the intermediate stops in the records of Route 31. Most importantly, for Route 31, no dwell time is scheduled for any of the timepoints on the route (i.e. for any trip, the scheduled arrival at a timepoint is equal to the scheduled departure time at that same timepoint).

### 4.3.2 Results after Data Transformation

In this step, data transformation is performed to transform the records from stop-level into segment structure record to fit the purpose of this study. The following table (Table 16) shows a sample of a segment data of Route 31 from the summer of 2017.

Table 16: Sample Record of a Segment on Route 31

| **Fields** | **Record** |
|---|---|
| LINE_ID | 31 |
| PATTERN_ID | 1028864 |
| DepDate | 2017-07-03 |
| Trip_Event_No | 461586485 |
| Startstop_ID | 150 |
| Endstop_ID | 28 |
| Startstop_NAME | Columbia / U. W. |
| Endstop_NAME | Columbia / King |
| StartstopArrTime_Sched | 34380 |
| StartstopArrTime_Actual | 34597 |
| StartstopDepTime_Sched | 34380 |
| StartstopDepTime_Actual | 34615 |
| EndstopArrTime_Sched | 34680 |
| EndstopArrTime_Actual | 34826 |
| PASSENGER_IN | 0 |
| PASSENGER_OUT | 0 |
| SegPsg_activity | 2 |

The sample shows a record for the segment between timepoints at Columbia / U. W. and Columbia / King, and the scheduled departure and arrival time for both timepoints are also listed. As the record shows, no passenger was recorded boarding or alighting the bus at Columbia / U. W. However, there are 2 passenger activities along the intermediate stops (i.e. at an intermediate stop, if there were 2 people reported boarding and 3 people reported alighting, there should be 3 passenger activities).

The number of records for the summer and fall periods for both routes are presented in Table 17.

Table 17: Number of Segment Records

| PERIOD | ROUTE 31 | ROUTE 200 |
|---|---|---|
| SUMMER | 6,765 | 23,762 |
| FALL | 9,700 | 57,818 |

## 4.4 Performance Report

The measure of performance on-time percentage is used to evaluate the bus's performance before and after implementing the schedule adjustments based on the results of the proposed methodology. The same thresholds used in the study of Mandelzys and Hellinga (2010) for late arrival and early departure are adopted where a bus is not considered on-time when it arrives at a timepoint more than three minutes (180 seconds) late or it departs from the timepoint more than a half minute early (30 seconds). As discussed earlier, the on-time percentage in this study needs to not only reflect a bus's performance in terms of late arrival and early departure but also consider the bus's early arrival and late departure. In this study, the bus is not considered on-time if it arrives at a timepoint more than one minute (60 seconds) early. According to TCQSM (Kittelson et al. 2013), a bus should not be considered as on-time if it departs from a time point more than 5 minutes (300 seconds) late. As a result, a bus is considered to be on-time if it meets the following conditions:

$$-60\ second < D_{a_{i,j}} < 180\ seconds \quad (17)$$

$$AND - 30\ seconds < \ D_{d_{i,j}} < 300\ seconds \quad (18)$$

The following table (Table 18) show the report of the overall 'on-time percentage' of summer and fall for Route 31 and Route 200 during different time periods of a day. The detailed report of bus's overall 'on-time percentage'(Ontime%), 'arrival on-time percentage'(Arr_Ontime%) being broken down to 'late arrival percentage'(Arr_Late%) and 'early arrival percentage'(Arr_Ealry%), and 'departure on-time percentage'(Dep_Ontime%) being broken down to ‘late departure percentage’(Dep_Late%) and ‘early departure percentage’(Dep_Early%) at each timepoints shown in Appendix B.

Table 18: Overall ‘Not On-time’ Performance Report

| | **Summer** | | **Fall** | |
|---|---|---|---|---|
| | Route 31 | Route 200 | Route 31 | Route 200 |
| AM | 49% | 60% | 39% | 56% |
| Mid-day | 36% | 59% | 21% | 56% |
| PM | 25% | 51% | 11% | 55% |
| Overall | 35% | 57% | 22% | 56% |

As it shows in the table, the bus’s performance on the chosen direction of route 31 tends to get worse later in the day. More importantly, compared to Summer, Fall has a worse performance with overall on-time percentage of 22% whereas it is 35% in the Summer. This can be explained because route 31 goes around University of Waterloo campus, and there are more students commuting by bus in Fall. As for Route 200, it tends to have a better on-time performance compared to Route 31, and the overall performance is consistent between the two seasons.

## 4.5 Hypothesis Confirmation

In this study, the reason why a day is divided into three time periods is that different traffic conditions are expected within different time of day. For example, in AM and PM peak hours, we expect more traffic demand than Mid-day period. To confirm this assumption, the distribution of *TD* of AM and PM peak hours on the segment between Columbia/Fischer-Hallman and Columbia/U.W. of Route 31 in the summer of 2017 is shown in Figure 16. As it is shown, there is a very clear separation between the two time periods where in the PM peak hour, for more trips, the bus tends to take more time to traverse on the segment. Similar results are also derived on other segments.

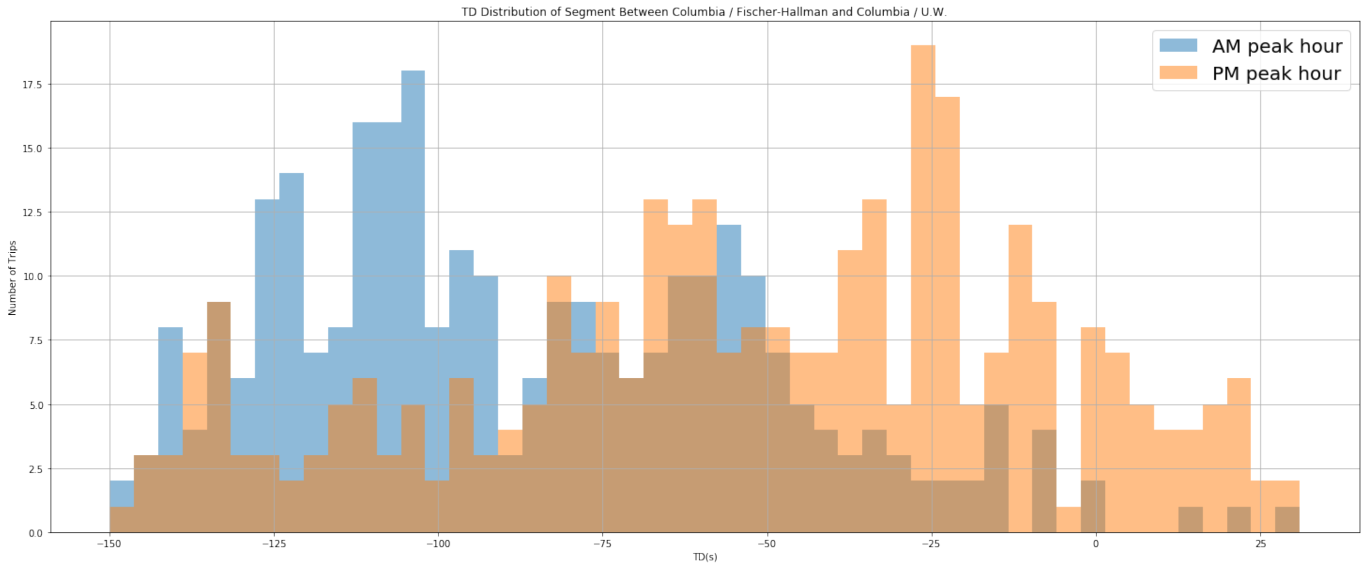


Figure 16:TD Distribution of a Segment in AM and PM Peak Hours (Route 31)

In the methodology, when resource is unconstrained, hourly adjustments to the schedule may be made to the schedule since it is assumed that bus's performance variation may exist during different one-hour period within the same time period of a day. In Figure 17, the values of *TD* of the trips within each one-hour period in AM peak hour for the same segment are plotted, and as it clearly shows, there are very good separations between each one-hour period and within each one-hour period, the value of *TD* stays relatively consistent, thus, the assumptions made for hourly adjustments are supported.

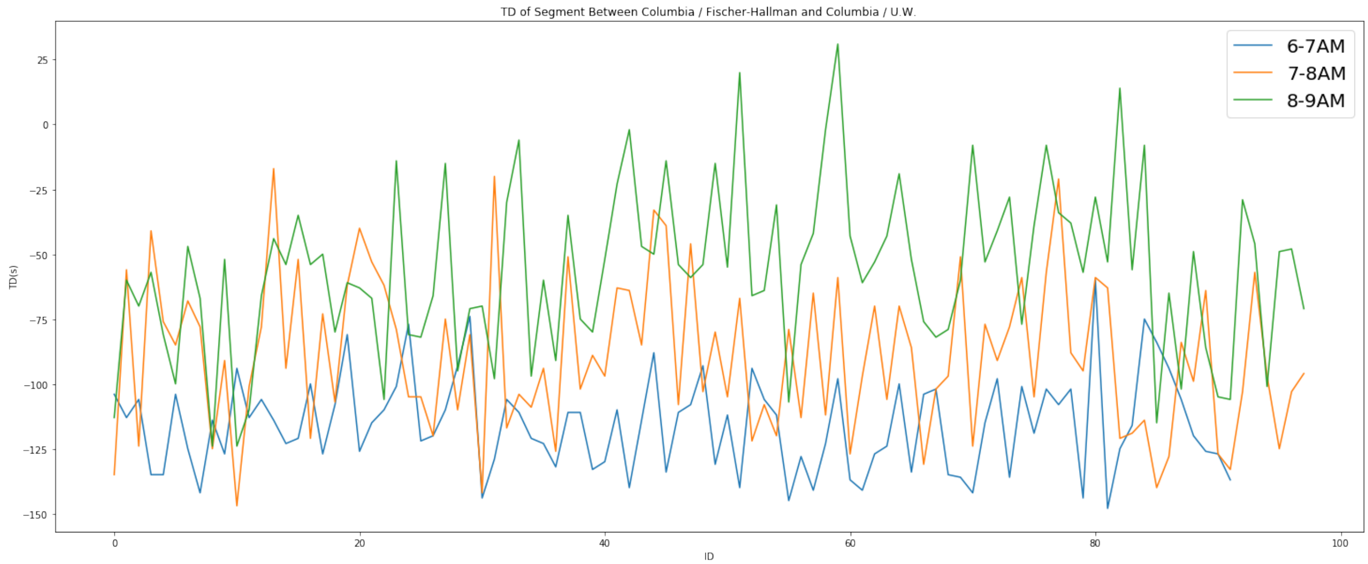


Figure 17: TD of a Segment within Different One-hour Periods in AM Peak Hour (Route31)

An assumption of the proposed methodology is that transit operating characteristics remain relatively consistent over time and as such, identifying changes to the schedule on the basis of transit operations in one period, are expected to be helpful in improving on-time performance in the next period. In this section we investigate the validity of this assumption using field data.

Here, *TDR* is used to test the correlation between two seasons. First of all, the *TDR* of each segment (same segment with different scheduled traversal time are treated separately) within the same time period of day (AM, Mid-day and PM) of the same season is calculated. The results are shown in Appendix C.

Next, the results for summer and fall are paired so that each pair is for the same segment with the same scheduled traversal time and of the same time period of a day, but in different seasons. Table 19 shows a sample of the list of paired records where 'TDR1' and 'TDR2' are for summer and fall respectively. The full list of paired records is presented in Appendix D.

Table 19: Sample of Paired Segment Records

| LINE_ID | Start_ID | End_ID | Start_NAME | End_NAME | Time_Sched | Season1 | Season2 | Time | TDR1 | TDR2 |
|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 540 | Summer | Fall | AM | 191 | 143 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | Summer | Fall | AM | 143 | 103 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | Summer | Fall | Mid-day | 117 | 152 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | Summer | Fall | PM | 192 | 22 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | Summer | Fall | Mid-day | 60 | 119 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | Summer | Fall | PM | 84 | 89 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 180 | Summer | Fall | AM | 24.5 | 24 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 240 | Summer | Fall | AM | 0 | -19 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | Summer | Fall | AM | -95 | -97 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | Summer | Fall | Mid-day | -49 | -65 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | Summer | Fall | Mid-day | -89.5 | -96 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | Summer | Fall | PM | -45 | -83 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 600 | Summer | Fall | AM | -70 | -31 |

To see how good the correlation between the two seasons is, a correlation test on the records above are performed with 'TDR1' as x axis and 'TDR2' as y axis. Figure 18 shows the result.

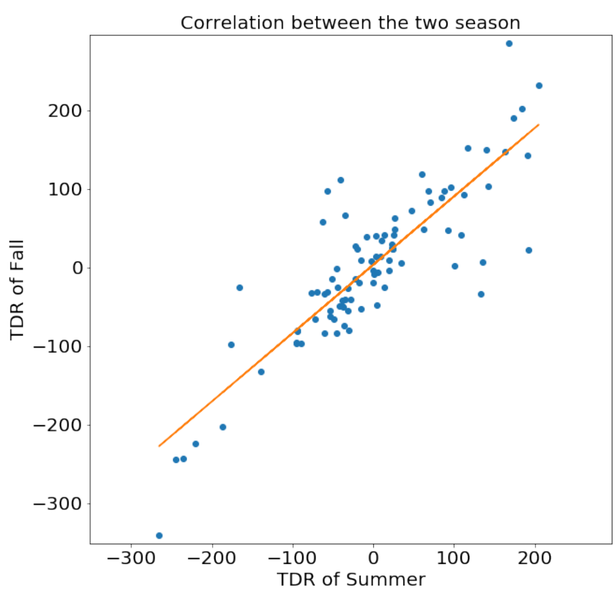


Figure 18: Correlation Test Result between Summer and Fall

As it shows in Figure 18, the red line shows the fitted linear regression results, and the result shows that Fall = 0.87*Summer + 3.5. The coefficient of determination is 73.3% which means that 73.3 percent of 'TDR' of fall can be predicted by the 'TDR' in summer. In other words, though it is two different seasons, there is still a fairly strong correlation between them, thus the hypothesis is confirmed that the results of analysis from summer can be used to improve transit system's service quality in fall.

## 4.6 Schedule Adjustment Implementation Results

In the proposed methodology, after performance measures are calculated, the records will go through two phases of data analysis to derive the recommended adjustments for the next schedule period. In this section, the results of the two-phase data analysis of the summer records are presented and how the adjustments are applied to fall's schedule under both resource unconstrained and resource constrained conditions are illustrated.

### 4.6.1 Records Correction after Schedule Adjustments

We wish to evaluate the impact that implementing the recommended adjustments to the schedule in fall would have had. We do that by using the records from the Fall period that reflect the actual behaviour of the buses. However, in some cases these records need to be corrected to properly reflect the behaviour that would have occurred if the schedule had been changed. Figure 19 shows an example where the bus arrives late at timepoint *i* and departs on-time according to the previous schedule. After the schedule adjustments, the scheduled dwell time is increased. However, the original record shows that the bus departed at the previous scheduled departure time. If the original data is utilized, then the bus would depart prior to the scheduled departure time after the schedule adjustments. Given that bus drivers are directed to not depart early, it is necessary to adjust the trajectories in the database to create more realistic bus behaviour for the situation when the schedule has been changed.

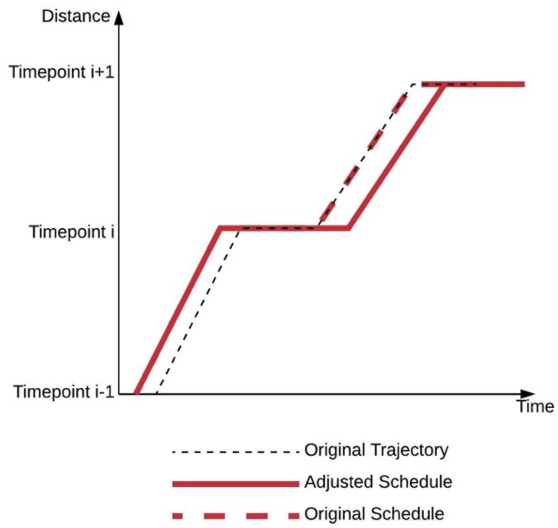


Figure 19: Illustration of Unrealistic Bus Behaviour after Schedule Changes

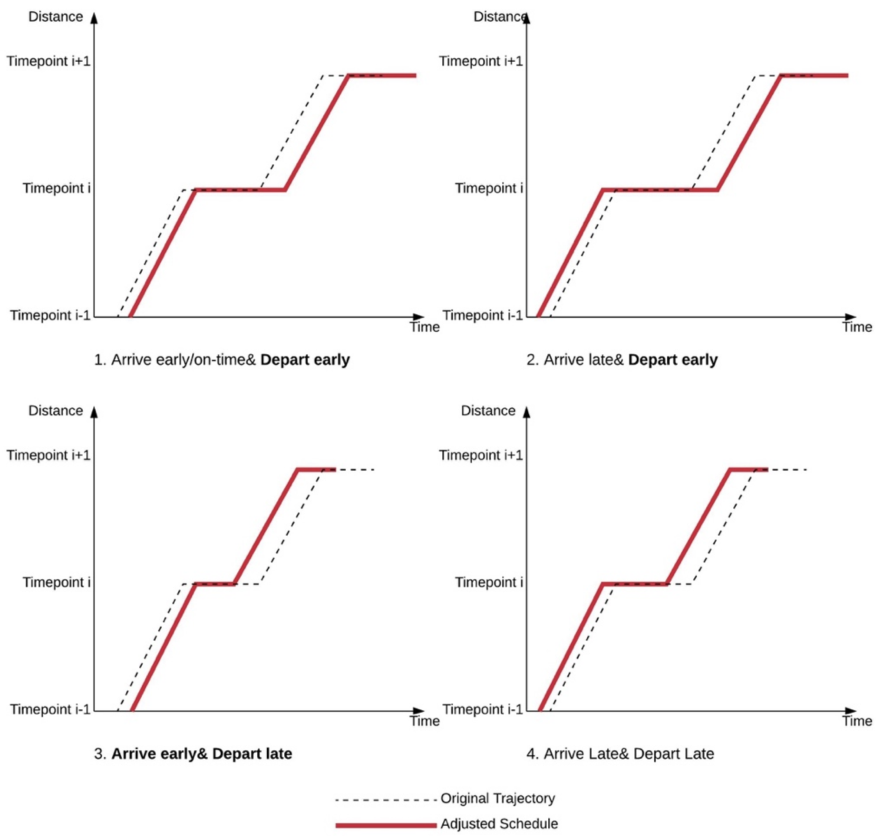


Figure 20: Possible Scenarios after Schedule Adjustments

Figure 20 shows the possible scenarios that could happen after the schedule adjustments:

- In the first two scenarios, adjustments to the schedule result in the adjusted departure time becoming later and the original bus trajectory would suggest that bus will depart early from timepoint *i*. However, buses should not depart from a timepoint early, and there is no particular reason for them to do so. Consequently, the original bus trajectory is adjusted so that the dwell time of the bus is increased so the bus departs at the scheduled departure time;
- In the third scenario, the bus arrives at timepoint *i* early but departs late, which means that the bus stays at the timepoint longer than the scheduled dwell time, and the reason could be either from the schedule adjustment or the fact that the time to board and alight passengers took longer than was scheduled. The record could be corrected if it is due to the first case. However, if the dwell time was required to serve passenger activities, then the record should not be corrected. To investigate this, Figure 21 shows the four possible scenarios before the time adjustments:

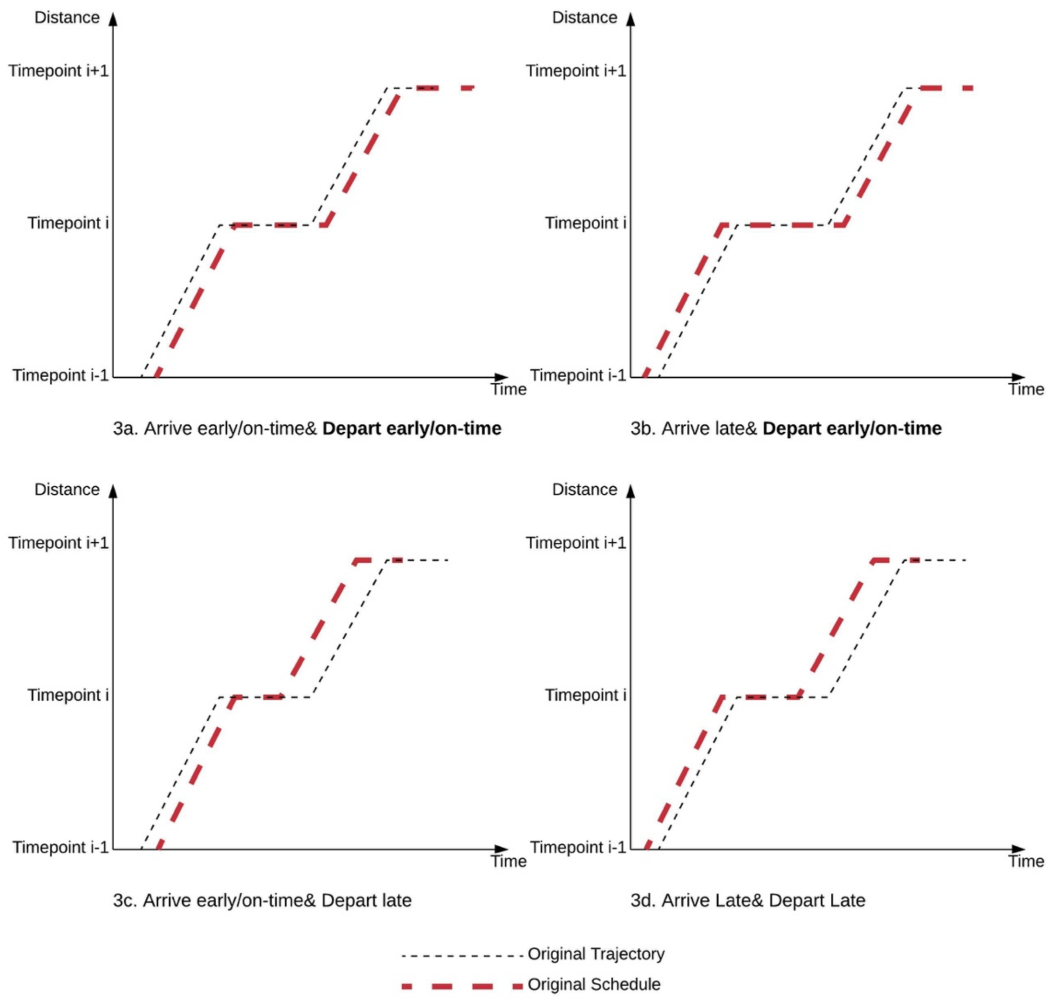


Figure 21: Possible Scenarios before Schedule Adjustments

In the first two scenarios(3a and 3b), the bus departs from timepoint *i* early or on-time, it is assumed that the bus is not delayed by passenger activities and it stays at the timepoint in order to not depart early (though in some cases, it still departs early). In those two cases, if after the schedule is adjusted, the bus's original record turns into the case of Scenario 3, the record should be corrected. As for scenarios 3c and 3d where the bus departs late from the timepoint, no action will be made to the original record.

- In Scenario 4, the bus arrives at timepoint *i* late and departs from it late, no action will be made to correct the original record;

The following two rules are used to observe the buses' abnormal behaviours and how to correct the records so that they are more realistic:

1. For each timepoint *i* (1 to N) of every trip, if a bus departs from timepoint *i* more than 30 seconds early (30 seconds is chosen for a buffer zone in case of inherent recording errors, drivers' driving behaviours, and on-board ramp use, etc.) regardless if it arrives at this timepoint early or late, the actual departure time will be 'corrected' to the new scheduled departure time and all the actual time records of the same trip of the bus at downstream timepoints will be pushed backward by the amount of time the bus departs early by at timepoint *i*. Figure 22 shows the time-space diagram of the two scenarios that meet the criteria. The dashed line shows the original trajectory, and as it shows, regardless if the bus arrives at timepoint *i* early or late according to the adjusted schedule, as long as the bus departs from timepoint *i* early than 30 seconds, the actual dwell time is extended so that the bus leaves timepoint *i* at the new scheduled departure time, and the time that the actual dwell time is extended by is also added to the following records of the same trip;

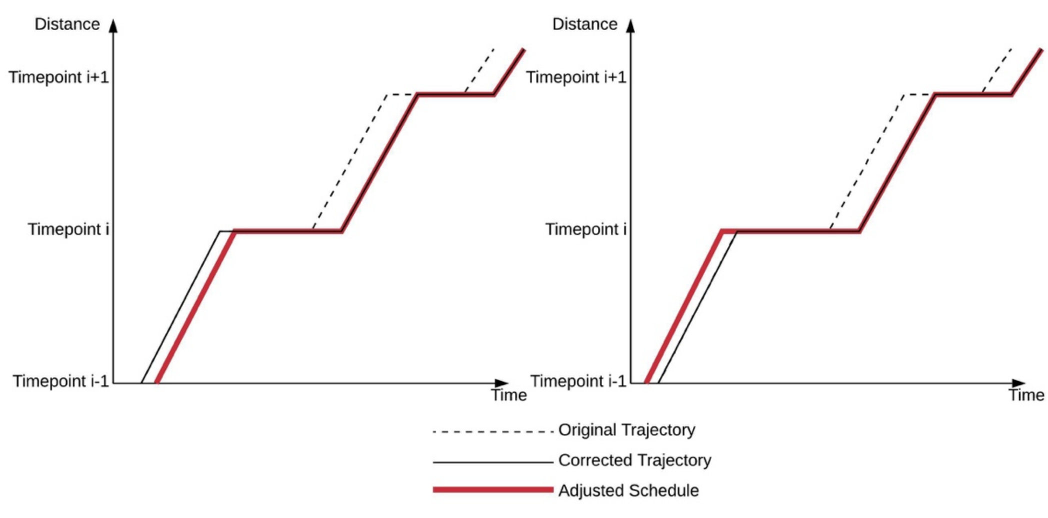


Figure 22: Time-space Diagram of Rule 1 Scenarios

2. Compared with the original schedule, if a bus departs from timepoint *i* less than 30 seconds late on trip *j* (30 seconds is chosen as buffer zone for inherent recording errors), it is assumed that the bus is not delayed by passenger activities, so its actual dwell time

can be adjusted. For the same record after the schedule is adjusted, if the bus turns to arrive early by any amount of time at timepoint *i* and depart from it more than 30 seconds late which means that the bus stays at the timepoint more than the new scheduled dwell time, and because it is already assumed that the bus does not have an issue of being delayed due to passenger activities, so it is expected to depart based on the new scheduled departure time. To correct the record, the actual departure time will be shifted to the new scheduled departure time, and all the actual time records of the bus at downstream timepoints will be pushed forward by the amount of time the bus departs late by at timepoint *i*.

Figure 23 shows the scenarios of this rule. The dashed black and red lines show the original trajectory and original schedule respectively. Regardless if the bus arrives early or late according to the original schedule, if it departs early of on-time, it is assumed that the bus does not have an issue with too many passenger activities. After the schedule is adjusted, which is the solid red line, if the original trajectory indicates that the bus arrives early and departs late, which means that it spends more than the new scheduled dwell time at timepoint *i*, the bus driver is expected to change their behaviours to depart earlier according to the adjusted schedule, thus, the records are manually modified so that the bus departs at the new scheduled departure time, and so will the following records of the same trip be shifted accordingly;

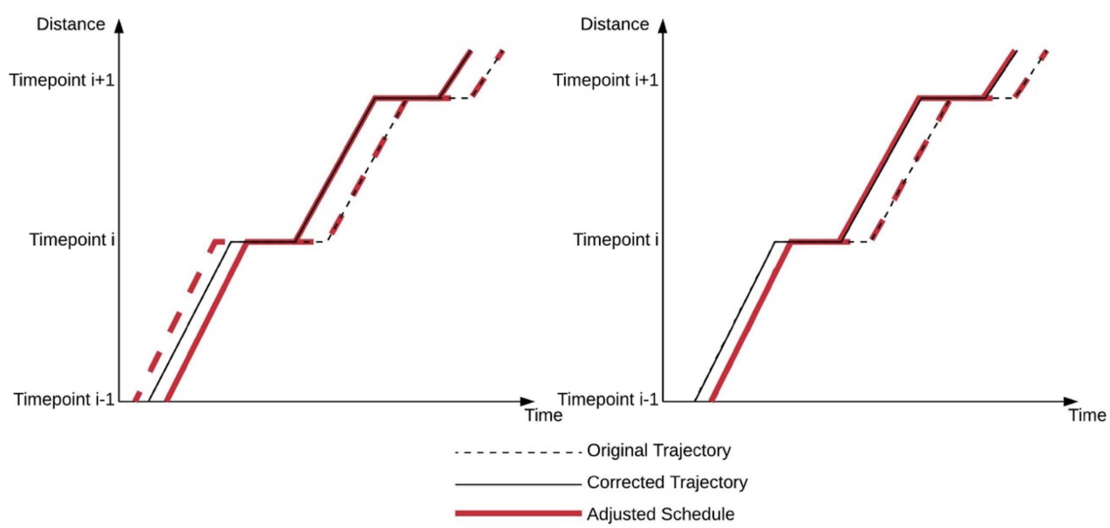


Figure 23: Time-space Diagram of Rule 2 Scenarios

After implementing the recommended schedule changes to the schedule in fall and 'correcting' the records, the on-time percentage is re-calculated to evaluate how the on-time performance is improved by the proposed methodology.

### 4.6.2 Schedule Adjustment Implementation under Resource Unconstrained Condition

When resource is unconstrained, extra time could be added to the schedule cycle time, and the performance problem on some segments where buses always run late can be better addressed by adding time to the scheduled traversal time for the segment.

In this study, 30% and 60 are used as the values for thresholds $TH_1$ and $TH_2$ in the data analysis under resource unconstrained condition, and the reasons for this decision will be explained in Chapter 5.

The recommended adjustments from the data analysis of the summer records for Route 31 and Route 200 during different time periods of a day are shown in the following tables (Table 20 and Table 21).

Table 20: Recommended Adjustments for Route 31 (Resource Unconstrained)

| Time Period | Start_ID | End_ID | Start_Name | End_Name | Time_Sched | +TD% | -TD% | TDR | DTR | TTR | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420.0 | 100.00% | 0.00% | 174 | 0 | 153 | Overall Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240.0 | 1.17% | 98.83% | -94 | 0 | -95 | Hourly Change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 300.0 | 16.67% | 82.56% | -44 | 15 | -58 | No Change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 300.0 | 53.88% | 45.74% | 6 | 17 | -28 | No Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480.0 | 29.07% | 70.16% | -22 | 0 | -23 | No Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360.0 | 71.98% | 27.63% | 35 | 0 | 31 | No Change |

## Table 20(continued): Recommended Adjustments for Route 31 (Resource Unconstrained)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mid-day | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420.0 | 100.00% | 0.00% | 140 | 0 | 140 | Overall Change |
| | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360.0 | 100.00% | 0.00% | 205 | 0 | 205 | Overall Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180.0 | 29.60% | 69.77% | -15 | 0 | -21 | No Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240.0 | 1.16% | 98.84% | -72 | 0 | -80 | Overall Change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 300.0 | 42.28% | 57.29% | -8 | 29 | -36 | No Change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 360.0 | 9.30% | 90.70% | -57 | 34 | -95 | No Change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 300.0 | 60.34% | 39.23% | 10 | 41 | -34 | No Change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 360.0 | 20.93% | 79.07% | -35 | 30 | -63 | No Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480.0 | 18.38% | 81.62% | -43 | 0 | -43 | No Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540.0 | 18.60% | 81.40% | -63 | 0 | -63 | Overall Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360.0 | 62.42% | 36.52% | 20 | 0 | 19 | No Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420.0 | 25.58% | 74.42% | -37 | 0 | -37 | No Change |
| PM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360.0 | 100.00% | 0.00% | 185 | 0 | 185 | Overall Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240.0 | 5.14% | 94.86% | -58 | 0 | -64 | No Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180.0 | 35.94% | 62.50% | -20 | 0 | -26 | No Change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 360.0 | 36.26% | 63.74% | -22 | 38 | -74 | No Change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 360.0 | 57.87% | 41.34% | 14 | 53 | -35 | No Change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 300.0 | 70.24% | 29.76% | 27 | 34 | -11 | No Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540.0 | 13.78% | 85.83% | -60 | 0 | -66 | Hourly Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480.0 | 15.48% | 82.14% | -51 | 0 | -53 | No Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420.0 | 31.64% | 67.97% | -32 | 0 | -39 | No Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360.0 | 33.33% | 66.67% | -18 | 0 | -18 | No Change |

## Table 21: Recommended Adjustments for Route 200 (Resource Unconstrained)

| Time Period | Start_ ID | End_ ID | Start_Name | End_Name | Time _Sched | +TD% | -TD% | TDR | DTR | TTR | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 3290 | 121 | Conestoga Mall | Mccormick | 420 | 77.46% | 22.34% | 62 | 0 | 35 | Overall Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 46.77% | 53.23% | -3 | 22 | -28 | No Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 17.65% | 80.80% | -39 | 32 | -74 | No Change |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | 55.93% | 43.18% | 9 | 31 | -32 | No Change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 240 | 48.78% | 49.59% | 0 | 13 | -12 | No Change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | 57.28% | 42.72% | 24 | 23 | -25 | No Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 180 | 84.57% | 14.20% | 26 | 24 | 0 | No Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 240 | 37.73% | 60.81% | -10 | 27 | -41 | No Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 0.00% | 100.00% | -72 | 31 | -98 | Overall Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 600 | 42.98% | 57.02% | -9 | 18 | -31 | No Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 46.79% | 53.21% | -5 | 16 | -23 | No Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 420 | 41.46% | 58.54% | -28 | 3 | -46 | No Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 480 | 28.21% | 71.79% | -41 | -53 | -4 | No Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 51.78% | 47.95% | 4 | -43 | 30 | No Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 0.49% | 99.51% | -139 | 30 | -183 | Overall Change |
| | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 67.40% | 32.11% | 48 | 84 | -54 | No Change |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 480 | 90.48% | 9.52% | 112 | 32 | 65 | Overall Change |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 77.05% | 22.95% | 68 | 34 | 21 | Hourly Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 3.80% | 96.20% | -187 | 27 | -212 | Overall Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 0.70% | 99.30% | -245 | 23 | -271 | Overall Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 540 | 90.76% | 8.96% | 191 | 215 | -26 | Overall Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 92.86% | 7.14% | 143 | 164 | -32 | Overall Change |
| Mid-day | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 40.81% | 58.49% | -15 | 0 | -15 | No Change |
| | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 20.51% | 79.49% | -60 | 0 | -60 | Overall Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 70.30% | 28.31% | 20 | 31 | -19 | No Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 31.45% | 68.55% | -36 | 31 | -75 | No Change |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | 52.18% | 46.91% | 3 | 30 | -33 | No Change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | 73.93% | 25.03% | 25 | 31 | -11 | No Change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 360 | 52.38% | 47.62% | 4 | 43 | -43 | No Change |

Table 22(continued): Recommended Adjustments for Route 200 (Resource Unconstrained)

| Time Period | Start_ ID | End_ ID | Start_Name | End_Name | Time_ Sched | +TD% | -TD% | TDR | DTR | TTR | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mid-day | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 9.49% | 90.04% | -64 | 25 | -93 | Hourly Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 360 | 15.85% | 84.15% | -97 | 34 | -133 | Overall Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 49.55% | 50.00% | -1 | 16 | -21 | No Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 720 | 53.66% | 46.34% | 5 | 17 | -11 | No Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 46.34% | 51.22% | -2 | 23 | -61 | No Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 77.38% | 22.27% | 101 | 35 | 58 | Hourly Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 72.84% | 27.16% | 93 | 93 | 4 | Overall Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2.67% | 97.33% | -95 | 40 | -152 | Overall Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 10.70% | 89.30% | -77 | 19 | -107 | Overall Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 600 | 0.00% | 100.00% | -166 | 33 | -209 | Overall Change |
| | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 65.41% | 33.98% | 23 | 67 | -51 | No Change |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 86.82% | 12.87% | 109 | 34 | 63 | Hourly Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 0.61% | 99.39% | -235 | 20 | -258 | Overall Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 89.65% | 10.12% | 117 | 114 | -22 | Overall Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | 69.75% | 30.25% | 60 | 122 | -79 | Overall Change |
| PM | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 24.21% | 75.46% | -53 | 0 | -53 | No Change |
| | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 36.59% | 63.41% | -30 | 0 | -30 | No Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 25.58% | 73.92% | -32 | 24 | -64 | No Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 51.22% | 48.78% | 1 | 18 | -14 | No Change |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | 68.79% | 30.28% | 23 | 48 | -30 | No Change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 360 | 62.10% | 37.62% | 27 | 48 | -40 | No Change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | 80.56% | 19.44% | 70.5 | 41 | 3.5 | Overall Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 360 | 15.23% | 84.77% | -96.5 | 28 | -133 | Overall Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 0.00% | 100.00% | -72 | 24 | -99 | Overall Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 41.58% | 57.81% | -18 | 19 | -42 | No Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 64.10% | 35.90% | 37 | 19 | 10 | No Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 78.79% | 21.06% | 136 | 92 | 18 | Overall Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 88.37% | 11.63% | 168 | 122 | 20 | Overall Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 4.05% | 95.60% | -94.5 | 50 | -143 | Overall Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 23.53% | 75.82% | -53 | 16 | -81 | No Change |
| | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 89.90% | 9.77% | 96 | 99 | -31 | Overall Change |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 91.40% | 8.60% | 163 | 38 | 109 | Hourly Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 0.76% | 99.24% | -221 | 24 | -248 | Overall Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 540 | 0.00% | 100.00% | -265.5 | 40.5 | -307 | Overall Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 0.00% | 100.00% | -176 | 18.5 | -196.5 | Overall Change |

As it shows in the table above, the three time periods of a day are analyzed separately. For any segment, if the decision is ‘No Change’, no adjustment will be made to this segment during this time period. When decision is either ‘Overall Change’ or ‘Hourly Change’, the associated treatments will be implemented.

When it is ‘Overall Change’ for the decision, the recommended *DTR* will be applied to the scheduled dwell time at starting timepoint of the segment, and the recommended *TTR* will be applied to the scheduled travel time between the starting and ending timepoints. For instance, in the AM time period of Route 31, it is decided that an overall change should be made to the schedule of the segment between timepoint 31 and timepoint 44. According to the results, *DTR* has a value of 0 which means that no change is needed for the scheduled dwell time at timepoint 31 whereas *TTR* has a value of 153, thus an extra 153 seconds should be added to the scheduled travel time. Conversely, when the decision is ‘Hourly Change’, instead of using the aggregated results shown in these tables (Table 20 and Table 21) to make changes, another report of recommended adjustments for each one-hour period within that time period of day is used. For example, in the AM peak hours of Route 31, it is recommended that an hourly change should be made to the segment between timepoint 44 and timepoint 150, then the following results report will be used to implement the change. As it shows in Table 22, changes are only recommended for two of the three one-hour periods which are 6AM to 7AM and 7AM to 8AM, and no change is recommended for 8AM to 9AM. Appendix E shows the list of hourly result reports for all the segments of the two routes where an hourly change is needed.

Table 23: Example of Hourly Change Report of a Segment on Route 31

| **Start_ID** | **End_ID** | **TT_Sched** | **Time** | **Trip#** | **+TD%** | **-TD%** | **TDR** | **DTR** | **TTR** | **Change?** |
|---|---|---|---|---|---|---|---|---|---|---|
| 44 | 150 | 240.0 | 6-7AM | 128 | 0.00% | 100.00% | -111.5 | 0.0 | -112.5 | YES |
| 44 | 150 | 240.0 | 7-8AM | 43 | 0.00% | 100.00% | -79.0 | 0.0 | -79.0 | YES |
| 44 | 150 | 240.0 | 8-9AM | 86 | 3.00% | 97.00% | -54.0 | 0.0 | -55.0 | NO |

For Route 200, there are three segments where adjustments are not applied to fall because of the road constructions that occurred in the summer, and those three segments are stop 3292 (Charles Terminal) to stop 173 (Weber/Ottawa), stop 173 (Weber/Ottawa) to stop 54 (Fairview Park) and stop 54 (Fairview Park) to stop 137 (Sportsworld Station). After implementing the changes to the schedule, the records are invested by applying the rules mentioned in Figure 22 and 23 to correct driver's unrealistic behaviours.

Last, the performance is calculated again (using the adjusted scheduled and adjusted trajectories) for each timepoint for the two routes. The performance report for each segment within each time period of a day is shown in Appendix F, and Table 23 shows the comparison of the performance before and after implementing the changes to the schedule and also the improvement that the proposed methodology brings to the system. What is worth mentioning is that in the report, the value of improvement is the percentage changes in the on-time percentage performance.

Table 24: On-time Performance Comparison Before and After Schedule Adjustment (Resource Unconstrained)

| | **Before** | | **After** | | **Improvement** | |
|---|---|---|---|---|---|---|
| | Route 31 | Route 200 | Route 31 | Route 200 | Route 31 | Route 200 |
| AM | 39% | 56% | 57% | 62% | 76% | 11% |
| Mid-day | 21% | 56% | 45% | 61% | 110% | 8% |
| PM | 11% | 55% | 27% | 58% | 147% | 6% |
| Overall | 22% | 56% | 42% | 60% | 88% | 8% |

As it shows in Table 23, for Route 31, the proposed schedule changes are expected to improve on-time performance by 76% for the AM time period, 110% for Mid-day time period, and 147% for the PM time period. Averaged across all three time periods the proposed schedule changes are estimated to improve on-time performance by 88%.

For Route 200, the estimated improvement in on-time performance is much smaller than for Route 31. This is largely because Route 200 performs quite well in terms of on-time performance in the summer period and therefore there is limited opportunity (and need) to make improvements.

### 4.6.3 Schedule Adjustment Implementation under Resource Constrained Condition

The proposed methodology was also applied to Route 31 and 200 assuming resources are constrained. In this study, 30% and 30 are used as the values for thresholds $TH_1$ and $TH_2$ in the data analysis under resource unconstrained condition, and the reasons for this decision are explained in Chapter 5.

Under resource constrained condition, it is not practical to make hourly adjustments to the schedule while maintaining the same cycle time, so adjustments are applied to the whole time period for each segment. The initial result report of the data analysis is shown in the table below (Table 24).

Table 25: Initial Data Analysis Results for Route 31 (Resource Constrained)

| Time Period | Start_ ID | End_ ID | Start_Name | End_Name | Time _Sched | #ofTrips | +TD% | -TD% | $TDR_I$ | $DTR_I$ | $TTR_I$ | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420.0 | 296 | 100.00% | 0.00% | 153.0 | 0.0 | 153.0 | Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240.0 | 257 | 1.17% | 98.83% | -95.0 | 0.0 | -95.0 | Change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 300.0 | 258 | 16.67% | 82.56% | -43.0 | 15.0 | -58.0 | Change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 300.0 | 258 | 53.88% | 45.74% | -10.5 | 17.0 | -27.5 | No change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480.0 | 258 | 29.07% | 70.16% | -23.0 | 0.0 | -23.0 | No change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360.0 | 257 | 71.98% | 27.63% | 31.0 | 0.0 | 31.0 | Change |
| Mid-day | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420.0 | 473 | 100.00% | 0.00% | 140.0 | 0.0 | 140.0 | Change |
| | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360.0 | 43 | 100.00% | 0.00% | 205.0 | 0.0 | 205.0 | Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180.0 | 473 | 29.60% | 69.77% | -21.0 | 0.0 | -21.0 | No change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240.0 | 86 | 1.16% | 98.84% | -80.0 | 0.0 | -80.0 | Change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 300.0 | 473 | 42.28% | 57.29% | -7.0 | 29.0 | -36.0 | No change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 360.0 | 43 | 9.30% | 90.70% | -61.0 | 34.0 | -95.0 | Change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 300.0 | 469 | 60.34% | 39.23% | 7.0 | 41.0 | -34.0 | No change |

Table 25(continued): Initial Data Analysis Results for Route 31 (Resource Constrained)

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mid-day | 28 | 12 | Columbia / King | Lexington / Bridge | 360.0 | 43 | 20.93% | 79.07% | -33.0 | 30.0 | -63.0 | Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480.0 | 468 | 18.38% | 81.62% | -43.0 | 0.0 | -43.0 | Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540.0 | 43 | 18.60% | 81.40% | -63.0 | 0.0 | -63.0 | Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360.0 | 471 | 62.42% | 36.52% | 19.0 | 0.0 | 19.0 | No change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420.0 | 43 | 25.58% | 74.42% | -37.0 | 0.0 | -37.0 | Change |
| PM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360.0 | 342 | 100.00% | 0.00% | 185.0 | 0.0 | 185.0 | Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240.0 | 214 | 5.14% | 94.86% | -64.0 | 0.0 | -64.0 | Change |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180.0 | 128 | 35.94% | 62.50% | -26.0 | 0.0 | -26.0 | No change |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 360.0 | 342 | 36.26% | 63.74% | -36.0 | 38.0 | -74.0 | No change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 360.0 | 254 | 57.87% | 41.34% | 19.0 | 53.0 | -35.0 | No change |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 300.0 | 84 | 70.24% | 29.76% | 23.0 | 34.0 | -11.0 | No change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540.0 | 254 | 13.78% | 85.83% | -66.0 | 0.0 | -66.0 | Change |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480.0 | 84 | 15.48% | 82.14% | -53.0 | 0.0 | -53.0 | Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420.0 | 256 | 31.64% | 67.97% | -39.0 | 0.0 | -39.0 | Change |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360.0 | 84 | 33.33% | 66.67% | -18.0 | 0.0 | -18.0 | No change |

Table 26: Initial Data Analysis Results for Route 200 (Resource Constrained)

| Time Period | Start_ID | End_ID | Start_Name | End_Name | Time_Sched | +TD% | -TD% | $TDR_I$ | $DTR_I$ | $TTR_I$ | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 3290 | 121 | Conestoga Mall | Mccormick | 420 | 77.46% | 22.34% | 35 | 0 | 35 | Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 46.77% | 53.23% | -30 | 23 | -53 | No change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 17.65% | 80.80% | -30 | 23 | -53 | Change |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | 55.93% | 43.18% | 0 | 0 | 0 | No change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 240 | 48.78% | 49.59% | 0 | 0 | 0 | No change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | 57.28% | 42.72% | 0 | 0 | 0 | No change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 180 | 84.57% | 14.20% | -6 | 3 | -8 | No change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 240 | 37.73% | 60.81% | -6 | 3 | -8 | No change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 0.00% | 100.00% | -6 | 3 | -8 | Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 600 | 42.98% | 57.02% | 0 | 0 | 0 | No change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 46.79% | 53.21% | 0 | 0 | 0 | No change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 420 | 41.46% | 58.54% | -5 | -5 | 0 | No change |

Table 27(continued): Initial Data Analysis Results for Route 200 (Resource Constrained)

| Time Period | Start_ ID | End_ ID | Start_Name | End_Name | Time_ Sched | +TD% | -TD% | $TDR_I$ | $DTR_I$ | $TTR_I$ | Decision |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 3292 | 173 | Charles Terminal | Weber / Ottawa | 480 | 28.21% | 71.79% | -5 | -5 | 0 | Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 51.78% | 47.95% | -5 | -5 | 0 | No change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 0.49% | 99.51% | -153 | 30 | -183 | Change |
| | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 67.40% | 32.11% | 30 | 84 | -54 | Change |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 480 | 90.48% | 9.52% | 59 | 34 | 25 | Change |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 77.05% | 22.95% | 59 | 34 | 25 | Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 3.80% | 96.20% | -234 | 24 | -258 | Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 0.70% | 99.30% | -234 | 24 | -258 | Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 540 | 90.76% | 8.96% | 183 | 210 | -27 | Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 92.86% | 7.14% | 183 | 210 | -27 | Change |
| Mid-day | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 40.81% | 58.49% | -7 | 0 | -7 | No change |
| | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 20.51% | 79.49% | -7 | 0 | -7 | Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 70.30% | 28.31% | -6 | 4 | -9 | No change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 31.45% | 68.55% | -6 | 4 | -9 | Change |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | 52.18% | 46.91% | 0 | 0 | 0 | No change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | 73.93% | 25.03% | 0 | 0 | 0 | No change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 360 | 52.38% | 47.62% | 0 | 0 | 0 | No change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 9.49% | 90.04% | -71 | 26 | -97 | Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 360 | 15.85% | 84.15% | -71 | 26 | -97 | Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 49.55% | 50.00% | 0 | 0 | 0 | No change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 720 | 53.66% | 46.34% | 0 | 0 | 0 | No change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 46.34% | 51.22% | 0 | 0 | 0 | No change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 77.38% | 22.27% | 93 | 40 | 53 | Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 72.84% | 27.16% | 93 | 40 | 53 | Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2.67% | 97.33% | -94 | 21 | -115 | Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 10.70% | 89.30% | -94 | 21 | -115 | Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 600 | 0.00% | 100.00% | -94 | 21 | -115 | Change |
| | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 65.41% | 33.98% | 0 | 0 | 0 | No change |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 86.82% | 12.87% | 97 | 34 | 63 | Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 0.61% | 99.39% | -238 | 20 | -258 | Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 89.65% | 10.12% | 86 | 115 | -29 | Change |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | 69.75% | 30.25% | 86 | 115 | -29 | Change |

Table 28(continued): Initial Data Analysis Results for Route 200 (Resource Constrained)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 24.21% | 75.46% | -50 | 0 | -50 | Change |
| | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 36.59% | 63.41% | -50 | 0 | -50 | No change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 25.58% | 73.92% | -37 | 22 | -60 | Change |
| | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 51.22% | 48.78% | -37 | 22 | -60 | No change |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | 68.79% | 30.28% | 0 | 0 | 0 | No change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 360 | 62.10% | 37.62% | 2 | 2 | 0 | No change |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | 80.56% | 19.44% | 2 | 2 | 0 | Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 360 | 15.23% | 84.77% | -104 | 28 | -131 | Change |
| | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 0.00% | 100.00% | -104 | 28 | -131 | Change |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 41.58% | 57.81% | 0 | 0 | 0 | No change |
| PM | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 64.10% | 35.90% | 0 | 0 | 0 | No change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 78.79% | 21.06% | 112 | 94 | 18 | Change |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 88.37% | 11.63% | 112 | 94 | 18 | Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 4.05% | 95.60% | -87 | 43 | -130 | Change |
| | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 23.53% | 75.82% | -87 | 43 | -130 | Change |
| | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 89.90% | 9.77% | 68 | 99 | -31 | Change |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 91.40% | 8.60% | 147 | 38 | 109 | Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 0.76% | 99.24% | -224 | 25 | -249 | Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 540 | 0.00% | 100.00% | -224 | 25 | -249 | Change |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 0.00% | 100.00% | -224 | 25 | -249 | Change |

Because different scheduled time is assigned to the same segment at different time of a day, so it is necessary to come up with a way to aggregate the results for each segment. In this study, a weighted average on $TDR_I$, $DTR_I$ and $TTR_I$ are calculated for each segment based on the number of trips that are recorded for each scheduled time of the same segment. When calculating the weighted average, if the decision for a scheduled time of a segment is ‘No change’, then the value of 0 will be used for all the performance measures in the calculation. For example, in the time period of Mid-day for Route 31, the segment between timepoints Columbia/ Fisher-Hallman and Columbia/ U.W., when calculating the aggregated value of $TDR_I$, because when the scheduled time for the segment is 180 seconds, no adjustment is recommended, so the following calculation process will be used:

$$TDR_{F_2} = \frac{0*473+(-80)*86}{473+86} = -12 \tag{19}$$

where $TDR_{F2}$ = Final recommended TDR value for the second segment (Columbia/ Fisher-Hallman to Columbia/ U.W.)

Table 26 and Table 27 show the results for the two routes after aggregation.

Table 29: Aggregated Data Analysis Results for Route 31 (Resource Constrained)

| Time Period | Start_ ID | End_ ID | Start_Name | End_Name | $TDR_F$ | $DTR_F$ | $TTR_F$ |
|---|---|---|---|---|---|---|---|
| AM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 153.0 | 0.0 | 153.0 |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | -95.0 | 0.0 | -95.0 |
| | 150 | 28 | Columbia / U.W. | Columbia / King | -43.0 | 15.0 | -58.0 |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 0.0 | 0.0 | 0.0 |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 0.0 | 0.0 | 0.0 |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 31.0 | 0.0 | 31.0 |
| Mid-day | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 145.0 | 0.0 | 145.0 |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | -12.0 | 0.0 | -12.0 |
| | 150 | 28 | Columbia / U.W. | Columbia / King | -5.0 | 3.0 | -8.0 |
| | 28 | 12 | Columbia / King | Lexington / Bridge | -3.0 | 3.0 | -5.0 |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | -45.0 | 0.0 | -45.0 |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | -3.0 | 0.0 | -3.0 |
| PM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 185.0 | 0.0 | 185.0 |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | -40.0 | 0.0 | -40.0 |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 0.0 | 0.0 | 0.0 |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 0.0 | 0.0 | 0.0 |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | -63.0 | 0.0 | -63.0 |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | -29.0 | 0.0 | -29.0 |

Table 30: Aggregated Data Analysis Results for Route 200 (Resource Constrained)

| Time Period | Start_ID | End_ID | Start_Name | End_Name | $TDR_F$ | $DTR_F$ | $TTR_F$ |
|---|---|---|---|---|---|---|---|
| AM | 3290 | 121 | Conestoga Mall | Mccormick | 35 | 0 | 35 |
| | 121 | 150 | Mccormick | U.W. / Columbia | -30 | 23 | -53 |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 0 | 0 | 0 |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 0 | 0 | 0 |
| | 146 | 82 | Laurier | Regina / Bridgeport | -6 | 3 | -8 |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 0 | 0 | 0 |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | -5 | -5 | 0 |
| | 173 | 54 | Weber / Ottawa | Fairview Park | -153 | 30 | -183 |
| | 54 | 137 | Fairview Park | Sportsworld Station | 30 | 84 | -54 |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 59 | 34 | 25 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | -234 | 24 | -258 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 183 | 210 | -27 |
| Mid-day | 3290 | 121 | Conestoga Mall | Mccormick | -7 | 0 | -7 |
| | 121 | 150 | Mccormick | U.W. / Columbia | -6 | 4 | -9 |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 0 | 0 | 0 |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 0 | 0 | 0 |
| | 146 | 82 | Laurier | Regina / Bridgeport | -71 | 26 | -97 |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 0 | 0 | 0 |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 93 | 40 | 53 |
| | 173 | 54 | Weber / Ottawa | Fairview Park | -94 | 21 | -115 |
| | 54 | 137 | Fairview Park | Sportsworld Station | 0 | 0 | 0 |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 97 | 34 | 63 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | -238 | 20 | -258 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 86 | 115 | -29 |

Table 29(continued): Aggregated Data Analysis Results for Route 200 (Resource Constrained)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| PM | 3290 | 121 | Conestoga Mall | Mccormick | -50 | 0 | -50 |
| | 121 | 150 | Mccormick | U.W. / Columbia | -37 | 22 | -60 |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 0 | 0 | 0 |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 2 | 2 | 0 |
| | 146 | 82 | Laurier | Regina / Bridgeport | -104 | 28 | -131 |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 0 | 0 | 0 |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 112 | 94 | 18 |
| | 173 | 54 | Weber / Ottawa | Fairview Park | -87 | 43 | -130 |
| | 54 | 137 | Fairview Park | Sportsworld Station | 68 | 99 | -31 |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 147 | 38 | 109 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | -224 | 25 | -249 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 69 | 122 | -53 |

To make sure that cycle time remains the same, the phase 2 of data analysis is conducted based on the aggregated results. In this case, since no extra time could be added to the cycle time, the variable *t* will have a value of 0. Table 28 and Table 29 show the final report of recommendations.

Table 31: Final Recommendation Report for Route 31 (Resource Constrained)

| Time Period | Start_ID | End_ID | Start_Name | End_Name | $TDR_F$ | $DTR_F$ | $TTR_F$ |
|---|---|---|---|---|---|---|---|
| AM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 115.0 | 0.0 | 115.0 |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | -95.0 | 0.0 | -95.0 |
| | 150 | 28 | Columbia / U.W. | Columbia / King | -43.0 | 15.0 | -58.0 |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 0.0 | 0.0 | 0.0 |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 0.0 | 0.0 | 0.0 |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 23.0 | 0.0 | 23.0 |

Table 30(continued): Final Recommendation Report for Route 31 (Resource Constrained)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mid-day | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 68.0 | 0.0 | 68.0 |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | -12.0 | 0.0 | -12.0 |
| | 150 | 28 | Columbia / U.W. | Columbia / King | -5.0 | 3.0 | -8.0 |
| | 28 | 12 | Columbia / King | Lexington / Bridge | -3.0 | 3.0 | -5.0 |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | -45.0 | 0.0 | -45.0 |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | -3.0 | 0.0 | -3.0 |
| PM | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 131.0 | 0.0 | 131.0 |
| | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | -40.0 | 0.0 | -40.0 |
| | 150 | 28 | Columbia / U.W. | Columbia / King | 0.0 | 0.0 | 0.0 |
| | 28 | 12 | Columbia / King | Lexington / Bridge | 0.0 | 0.0 | 0.0 |
| | 12 | 103 | Lexington / Bridge | Bridge / Northfield | -63.0 | 0.0 | -63.0 |
| | 103 | 3290 | Bridge / Northfield | Conestoga Mall | -29.0 | 0.0 | -29.0 |

Table 32: Final Recommendation Report for Route 200 (Resource Constrained)

| Time Period | Start_ ID | End_ ID | Start_Name | End_Name | $TDR_F$ | $DTR_F$ | $TTR_F$ |
|---|---|---|---|---|---|---|---|
| AM | 3290 | 121 | Conestoga Mall | Mccormick | 35 | 0 | 35 |
| | 121 | 150 | Mccormick | U.W. / Columbia | -30 | 23 | -53 |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 0 | 0 | 0 |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 0 | 0 | 0 |
| | 146 | 82 | Laurier | Regina / Bridgeport | -6 | 3 | -8 |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 0 | 0 | 0 |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | -5 | -5 | 0 |
| | 173 | 54 | Weber / Ottawa | Fairview Park | -153 | 30 | -183 |
| | 54 | 137 | Fairview Park | Sportsworld Station | 30 | 84 | -54 |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 59 | 34 | 25 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | -234 | 24 | -258 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 183 | 210 | -27 |

Table 31(continued): Final Recommendation Report for Route 200 (Resource Constrained)

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Mid-day | 3290 | 121 | Conestoga Mall | Mccormick | -7 | 0 | -7 |
| | 121 | 150 | Mccormick | U.W. / Columbia | -6 | 4 | -9 |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 0 | 0 | 0 |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 0 | 0 | 0 |
| | 146 | 82 | Laurier | Regina / Bridgeport | -71 | 26 | -97 |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 0 | 0 | 0 |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 93 | 40 | 53 |
| | 173 | 54 | Weber / Ottawa | Fairview Park | -94 | 21 | -115 |
| | 54 | 137 | Fairview Park | Sportsworld Station | 0 | 0 | 0 |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 97 | 34 | 63 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | -238 | 20 | -258 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 86 | 115 | -29 |
| PM | 3290 | 121 | Conestoga Mall | Mccormick | -50 | 0 | -50 |
| | 121 | 150 | Mccormick | U.W. / Columbia | -37 | 22 | -60 |
| | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 0 | 0 | 0 |
| | 151 | 146 | U.W. - Davis Centre | Laurier | 2 | 2 | 0 |
| | 146 | 82 | Laurier | Regina / Bridgeport | -104 | 28 | -131 |
| | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 0 | 0 | 0 |
| | 3292 | 173 | Charles Terminal | Weber / Ottawa | 112 | 94 | 18 |
| | 173 | 54 | Weber / Ottawa | Fairview Park | -87 | 43 | -130 |
| | 54 | 137 | Fairview Park | Sportsworld Station | 68 | 99 | -31 |
| | 137 | 70 | Sportsworld Station | Pinebush Station | 147 | 38 | 109 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | -224 | 25 | -249 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 69 | 122 | -53 |

Table 28 and Table 29 show the final recommendation of schedule adjustments to improve performance. If no change is recommended for a segment, then the segment will have value of 0 for all the performance measures. Again, because of the construction in the summer, the segments between stop 3292 (Charles Terminal) to stop 173 (Weber/Ottawa), stop 173 (Weber/Ottawa) to stop 54 (Fairview Park) and stop 54 (Fairview Park) to stop 137 (Sportsworld Station) are not included in the schedule adjustments.

After adjusting the schedule and correcting the records, the performance of the transit vehicles under the new schedule is calculated again. The performance report for each segment within each time period of a day for the two routes is shown in Appendix G and the following table illustrates the improvements that the proposed methodology brings to the system.

Table 33: On-time Performance Comparison Before and After Schedule Change (Resource Constrained)

| | **Before** | | **After** | | **Improvement** | |
|---|---|---|---|---|---|---|
| | Route 31 | Route 200 | Route 31 | Route 200 | Route 31 | Route 200 |
| AM | 39% | 56% | 45% | 61% | 14% | 9% |
| Mid-day | 21% | 56% | 29% | 60% | 36% | 8% |
| PM | 11% | 55% | 18% | 55% | 69% | 1% |
| Overall | 22% | 56% | 30% | 59% | 32% | 6% |

It is clear to see that when resource is constrained, the proposed methodology provides less improvement to the system compared with the improvement introduced when resource is unconstrained. However, improvements are brought to all the time periods of a day and overall, the performance gets improved by 32% for Route 31 and 6% for Route 200.

The proposed methodology incorporates several parameters. In this analysis presented in this section, specific values have been selected for these parameters. The next section examines the sensitivity of the methodology to these parameters and provides justification for the values that have been used in this section

## 4.7 Sensitivity Analysis

In this study, the value threshold $TH_1$ is set as 30% arbitrarily which means that as long as the difference between *+TD%* and *-TD%* is larger than 30%, it is concluded that the bus tend to run late or early on the segment for most the trips, then *TDR* will be compared with the value of $TH_2$ to decide if there is a systematic problem on the schedule of that segment. To have a better understanding on how the values of the threshold $TH_2$ will impact on the improvements that the methodology can create, different values of $TH_2$ are tested because $TH_2$ is more dominant when evaluating buses' performance on a segment. Figure 24 to Figure 27 show the improvement reports of Route 31 and Route 200 under both resource unconstrained and constrained conditions.

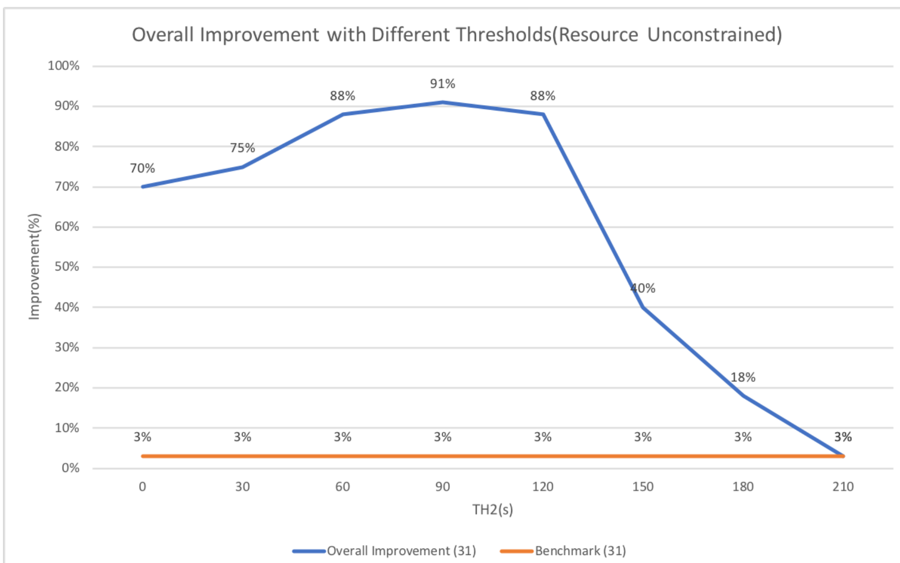


Figure 24: Sensitivity of Improvement in On-time Performance to the value of Parameter $TH_2$ (Route 31 – Resource Unconstrained)

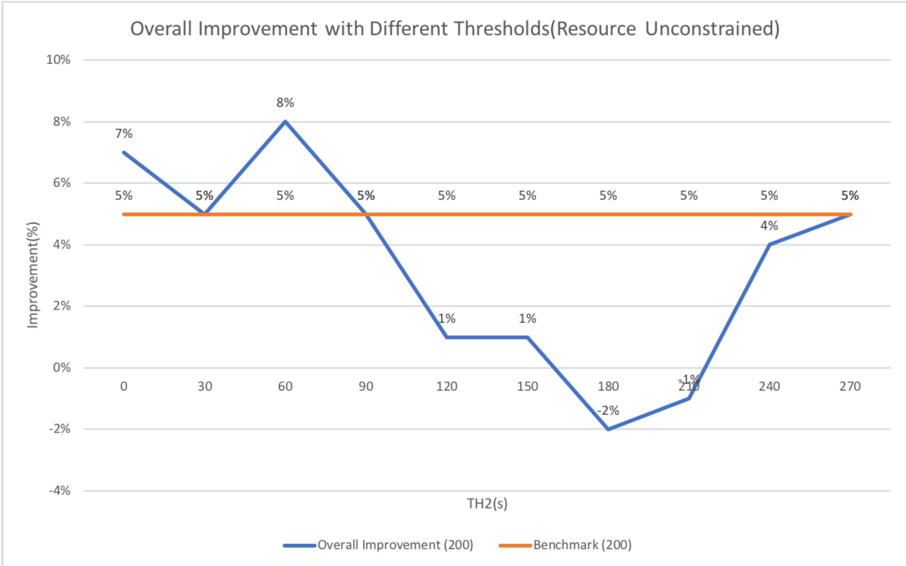


Figure 25: Sensitivity of Improvement in On-time Performance to the value of Parameter $TH_2$

(Route 200 – Resource Unconstrained)

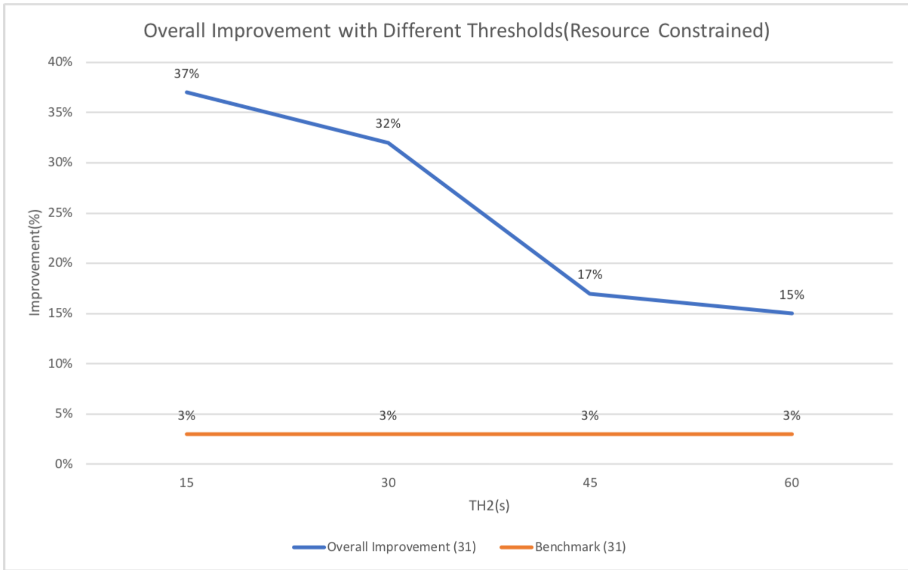


Figure 26: Sensitivity of Improvement in On-time Performance to the value of Parameter $TH_2$

(Route 31 – Resource Constrained)

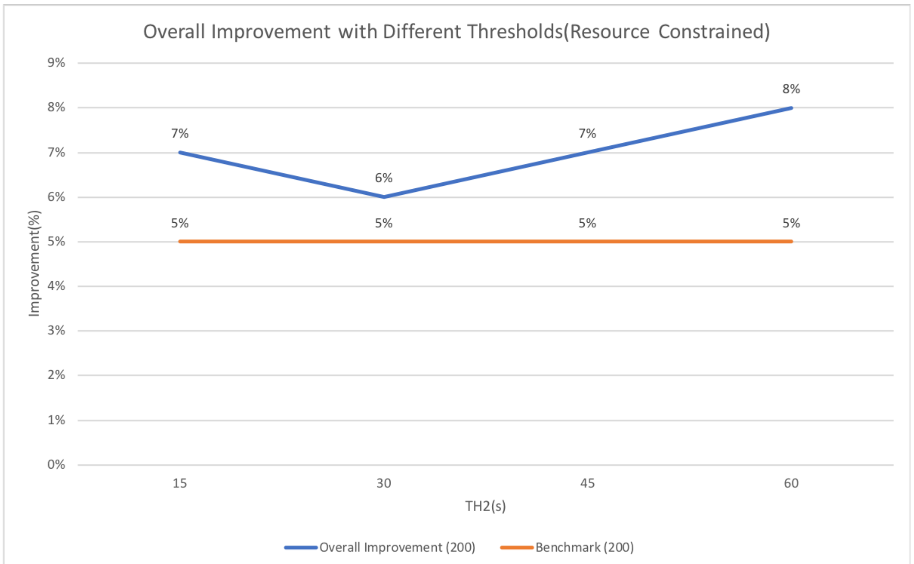


Figure 27: Sensitivity of Improvement in On-time Performance to the value of Parameter $TH_2$ (Route 200 – Resource Constrained)

As it shows in the figures, 'benchmark' represents the improvements obtained by just applying the bus trajectory 'correcting' algorithms (described in Secions 4.5.1) without changing the schedule. Consequently, the benchmark indicates the improvements that would have been achieved if buses had not departed from a timepoint more than 30 seconds early. As indicated in the figures, on-time performance would have been improved by 3% and 5% for Route 31and Route 200 respectively. The relatively small magnitude of this improvement implies that when using the old schedule, these routes do not have a big problem with early departures.

'Overall improvement' represents the percentage of improvement of the original performance that the proposed methodology brings to the whole route with different values of the threshold $TH_2$. It is very clear that for route 31 when resource is unconstrained, the improvement increases as the threshold increases, but when the threshold reaches a certain point, the methodology starts to not be able to pick up the potential improvements of segments, and the overall improvement decreases dramatically. Conversely, when resource is constrained, with a smaller threshold value, the methodology is able to pick up more time that could be taken out from the schedule and put it to the segments where more time is needed, thus leads to a better improvement.

Because buses run late on most of the segments on Route 31, in term of on-time percentage, the proposed methodology helps improve the performance significantly.

In contrast, for Route 200, the proposed methodology does not improve the performance as mush. This occurs for the following reasons:

1. Route 200's on-time performance is already good in the summer;
2. The adjustments recommended by the proposed methodology indicate that for most of the segments for which schedules need to be adjusted, the scheduled traversal time needs to be reduced and more time needs to be added to the scheduled dwell time at those timepoints;
3. Third, when a threshold value of 120 seconds or more is used, the performance is made worse than doing nothing. This is caused by the last two segments of the route. The following table (Table 31) shows the results of data analysis for those two segments. Based on the results, approximately 4 minutes can be removed from the scheduled traversal time between stop 70 and stop 3289, and approximately 3 minutes needs to be added to the scheduled dwell time at stop 3289. When a threshold value larger than 120 seconds is chosen then the adjustment needed to be done for the segment between stop 3289 and stop 3288 is not implemented, and therefore after the schedule adjustments, buses tend to depart fairly late at stop 3289, which also leads to their late arrival at stop 3288.

Table 34: Data Analysis Report for the Last Two Segments of Route 200 (Resource Unconstrained)

| | Start_ID | End_ID | Start_Name | End_Name | Time | Time_Sched | +TD % | -TD% | TDR | DTR | TTR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 6-7AM | 420 | 4% | 96% | -187 | 27 | -212 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 7-9AM | 480 | 1% | 99% | -245 | 23 | -271 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 6-9AM | 540 | 91% | 9% | 191 | 215 | -26 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 9-9AM | 600 | 93% | 7% | 143 | 164 | -32 |
| Mid-day | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 9-15AM | 480 | 1% | 99% | -235 | 20 | -258 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 9-14AM | 600 | 90% | 10% | 117 | 114 | -22 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 14-15AM | 660 | 70% | 30% | 60 | 122 | -79 |

Table 33(continued): Data Analysis Report for the Last Two Segments of Route 200 (Resource Unconstrained)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PM | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 15-19AM | 480 | 1% | 99% | -221 | 24 | -248 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 15-15AM | 540 | 0% | 100% | -266 | 41 | -307 |
| | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 19-19AM | 420 | 0% | 100% | -176 | 19 | -197 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 15-18AM | 660 | 71% | 29% | 84 | 114 | -53 |
| | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 19-19AM | 600 | 89% | 11% | 192 | 230 | -50 |

To be confident to say that the bus's schedule adherence variations are not mainly caused by the randomness of the records due to various traffic conditions, traffic lights, etc., the value of threshold $TH_2$ should be relatively large. For example, when the *TDR* value for a segment is 90 seconds, compared to a segment where the *TDR* value is 20 seconds, it is much more likely that the bus experiences difficulties trying to complete this segment on time. More importantly, the value of the threshold should not be too large because having a large value will result in the methodology not being able to make improvements on some segments which may lead to worse performance. Considering those factors, 60 and 30 are chosen for $TH_2$ when resource is unconstrained and constrained respectively, and they are also the values recommended for future analysis. However, the values might vary because of different routes' characteristics

# Chapter 5: Conclusions and Recommendations

The rich dataset generated by AVL/APC system makes it possible for the proposed methodology in this study to identify systemic problems in the transit schedule and make recommendations to adjust a transit route's schedule automatically in order to achieve a better service quality.

The proposed methodology focuses on analyzing a bus's performance on each route segment, then identifies where the real problems are for causing the bus to have poor on-time performance along the route and automatically generate recommendation of adjustments to the next schedule period to improve the system's performance.

The output of the proposed methodology in this research study consists of:

1. On-time performance measures for each segment of the route of interest;
2. Recommended changes to the transit schedule. These recommendations can be made under two different assumptions related to transit agency resources. The "Resource unconstrained" approach assumes that there is no constrain on the amount of time that can be added to the schedule. The "Resource constrained" approach assumes that time can be reallocated within the schedule, but the route traversal time must not be extended.

The output above is automatically generated and pushed to the transit agency to make better decisions for the future schedule. It significantly releases the pressure from the traditional approach where the transit agency spends a lot of resources trying to find and solve the problems based on the report of the performance report at each timepoint.

Based on the results of this study, it shows that this methodology can significantly improve the system's service quality when the bus has poor on-time performance. However, there are some limitations in this study that are worth mentioning:

1. The proposed methodology was only applied to two routes in the GRT and therefore it is unknown how well the methodology works for other GRT routes. Additionally, the transferability of the proposed methodology to other transit agencies needs to be tested;

2. Using historical data is not the most ideal way to test the methodology. For example, after using a new schedule, we expect the drivers to behave differently. However, this is not feasible when dealing with historical data, and that's why the records are corrected based on the two rules after the schedule adjustment. However, doing so may also introduce some inherent errors;
3. In the applications described in this thesis, the recommendations of the analysis results of the Summer records are applied to Fall in the same year. We expect that there are seasonal variations in both traffic conditions and transit ridership patterns. Consequently, it may be desirable to use historical data from the same season in the previous year. It was not possible to evaluate whether or not this would produce better results because of the extensive road construction activities in Waterloo Region during the previous year.

After conducting the methodology, there are several findings and recommendations that could be considered for future research and application in GRT system:

1. It is important to find the appropriate value range for thresholds $TH_2$ since it has direct impacts on the decision making for each segment of a route like it is discussed before. In this study, 30% is chosen subjectively for $TH_1$ while 60 seconds is chosen for $TH_2$ based on the results of the sensitivity analysis. It is recommended that, when applying the methodology to a different transit system, the same sensitivity analysis as it is described in Section 4.6 should be performed on the historical data to find the reasonable range for the two thresholds;
2. As it is discussed, testing on historical data is not the best way to evaluate the improvements that this methodology could produce. Instead, it is recommended to apply the adjusted schedule in the field to test the improvement that the proposed methodology could bring to have a better understanding on how the service quality is affected after schedule adjustment;
3. We expect variations in both traffic conditions and transit ridership patterns in different seasons. In this thesis, we utilized data from the summer season to inform schedule changes for the fall season. It was not possible to utilize data from the fall season from the previous year. However, it is recommended that future work be carried out to

examine the impact of utilizing data from the same season in the previous year rather than data from the previous season of the same year.

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**Appendix A: Routes Map and Schedule**

(4 pages)

# EasyGO Stops

## To Clair Hills

| | |
|---|---|
| **A Conestoga Mall** | **4005** |
| Davenport / Old Abbey | 1205 |
| Davenport / Northfield | 1206 |
| Frobisher / Davenport | 1208 |
| Frobisher / McMurray | 1210 |
| Frobisher / Superior | 3760 |
| Bridge / Frobisher | 3593 |
| **B Bridge / Northfield** | **4051** |
| Chesapeake / Brigantine | 3781 |
| Chesapeake / Seawind | 1133 |
| Chesapeake / Seawind | 3780 |
| Chesapeake / Sandy Cove | 3782 |
| New Bedford / Starboard | 3594 |
| New Bedford / Eastbridge | 3595 |
| Path To St. Luke | 2038 |
| Eastbridge / Windjammer | 2039 |
| Eastbridge / Mayflower | 2040 |
| Eastbridge / Bridge | 2041 |
| Bridge / Whitmore | 3783 |
| **C Lexington / Bridge** | **3768** |
| Lexington / Lee | 3764 |
| Lexington / Dunvegan | 2803 |
| Lexington / Davenport | 3900 |
| Lexington / Dearborn | 3769 |
| Lexington / Dearborn | 3770 |
| Columbia / Marsland | 3771 |
| Columbia / Weber | 3772 |
| **D Columbia / King** | **3772** |
| Columbia / Holly | 2511 |
| Columbia / Hazel | 2512 |
| Columbia / Albert | 2513 |
| Columbia / Lester | 2514 |
| Columbia / Phillip | 1093 |
| Columbia / U.W. Optometry | 1094 |
| **E Columbia / UW** | **3898** |
| Columbia / Village 1 | 1096 |
| Columbia / Ron Eydt Village | 1097 |
| Columbia / Old Post | 1098 |
| Columbia / Beechlawn | 1099 |
| **F Columbia / Fischer-Hallman** | **4027** |
| Columbia / Fischer-Hallman | 1100 |
| Columbia / Gatestone | 1102 |
| Columbia / Cavendish | 1104 |
| Columbia / Erbsville | 1105 |
| Columbia / Salzburg | 4017 |
| Columbia / Zurich | 4022 |
| Columbia / St. Moritz | 4020 |
| **G Columbia / Sundew** | **4023** |

## To Conestoga Mall

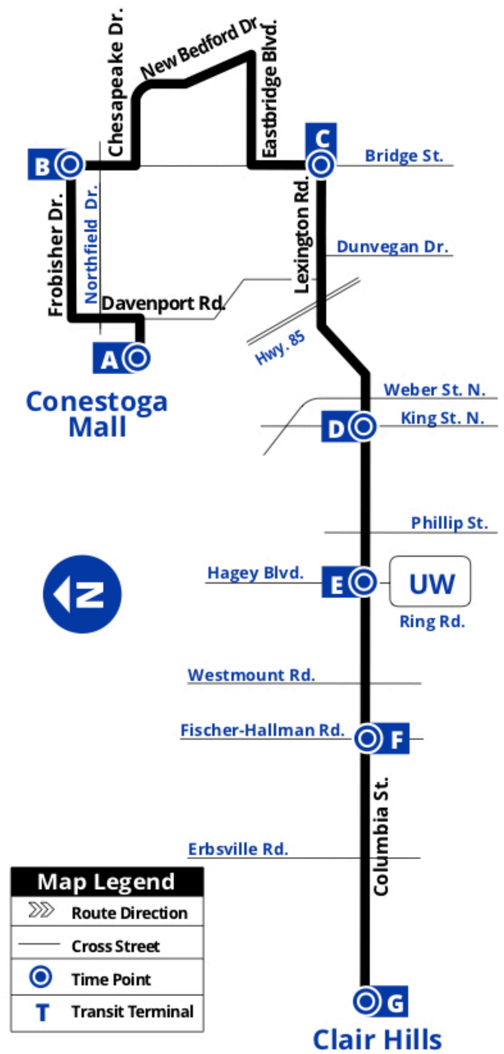
| | |
|---|---|
| **G Columbia / Sundew** | **4023** |
| Columbia / St. Moritz | 4019 |
| Columbia / Lucerne | 4021 |
| Columbia / Salzburg | 4018 |
| Columbia / Erbsville | 4012 |
| Columbia / Cavendish | 4013 |
| Columbia / Bennington | 4024 |
| Columbia / Gatestone | 4025 |
| **F Columbia / Fischer-Hallman** | **1116** |
| Columbia / Beechlawn | 1117 |
| Columbia / Old Post | 1118 |
| Columbia / Ron Eydt Village | 1119 |
| Columbia / Village 1 | 1120 |
| **E Columbia / UW** | **3899** |
| Columbia / U.W. Optometry | 2520 |
| Columbia / Phillip | 2521 |
| Columbia / Lester | 2522 |
| Columbia / Albert | 2523 |
| Columbia / Hazel | 2524 |
| Columbia / Holly | 2525 |
| **D Columbia / King** | **2526** |
| Columbia / Weber | 3773 |
| Columbia / Marsland | 3747 |
| Lexington / Dearborn | 3622 |
| Lexington / Dearborn | 3748 |
| Lexington / Davenport | 2817 |
| Lexington / Dunvegan | 3677 |
| Lexington / Lee | 2819 |
| **C Lexington / Bridge** | **3749** |
| Bridge / Whitmore | 3790 |
| Eastbridge / Acadia | 1925 |
| Eastbridge / Cabot | 1926 |
| Eastbridge / Bonavista | 1927 |
| Eastbridge / Bonavista | 1928 |
| Eastbridge / New Bedford | 1929 |
| New Bedford / Starboard | 3598 |
| New Bedford / Chesapeake | 3599 |
| Chesapeake / Seawind | 3443 |
| Chesapeake/ Chesapeake Cr. | 1121 |
| Bridge / Chesapeake | 4016 |
| **B Bridge / Northfield** | **4050** |
| Frobisher / Bridge | 3757 |
| Frobisher / Superior | 3758 |
| Frobisher / McMurray | 3759 |
| Frobisher / Davenport | 2067 |
| Davenport / Northfield | 1204 |
| Davenport / Old Abbey | 3393 |
| **A Conestoga Mall** | **4005** |

# Columbia

GRT GRAND RIVER TRANSIT

# Route 31

Effective: April 24, 2017




easyGO

519-585-7555 www.grt.ca TTY: 519-575-4608
Text: 57555 & key in your bus stop number

Map of Route 31

## Weekday Schedule
(No Saturday, Sunday or Holiday Service)

### to Clair Hills

| Conestoga Mall (Depart) A | Bridge / Northfield B | Bridge / Lexington C | Columbia / King D | Columbia / U.W. E | Columbia / Fischer-Hallman F | Columbia / Sundew (Arrive) G |
|---|---|---|---|---|---|---|
| 6:15 | 6:22 | 6:31 | 6:38 | 6:43 | 6:46 | 6:52 |
| 6:45 | 6:52 | 7:01 | 7:08 | 7:13 | 7:17 | 7:23 |
| 7:15 | 7:22 | 7:31 | 7:38 | 7:43 | 7:47 | 7:53 |
| 7:45 | 7:52 | 8:01 | 8:08 | 8:13 | 8:17 | 8:23 |
| 8:15 | 8:22 | 8:31 | 8:38 | 8:43 | 8:47 | 8:53 |
| 8:45 | 8:52 | 9:01 | 9:07 | 9:12 | 9:15 | 9:22 |
| 9:15 | 9:22 | 9:30 | 9:36 | 9:41 | 9:44 | 9:51 |
| 9:45 | 9:52 | 10:00 | 10:06 | 10:11 | 10:14 | 10:21 |
| 10:15 | 10:22 | 10:30 | 10:36 | 10:41 | 10:44 | 10:51 |
| 10:45 | 10:52 | 11:00 | 11:06 | 11:11 | 11:14 | 11:21 |
| 11:15 | 11:22 | 11:30 | 11:36 | 11:41 | 11:44 | 11:51 |
| 11:45 | 11:52 | 12:00 | 12:06 | 12:11 | 12:14 | 12:21 |
| 12:15 | 12:22 | 12:30 | 12:36 | 12:41 | 12:44 | 12:51 |
| 12:45 | 12:52 | 1:00 | 1:06 | 1:11 | 1:14 | 1:21 |
| 1:15 | 1:22 | 1:30 | 1:36 | 1:41 | 1:44 | 1:51 |
| 1:45 | 1:52 | 2:00 | 2:06 | 2:11 | 2:14 | 2:21 |
| 2:15 | 2:22 | 2:30 | 2:36 | 2:42 | 2:45 | 2:52 |
| 2:45 | 2:52 | 3:01 | 3:07 | 3:13 | 3:16 | 3:23 |
| 3:15 | 3:22 | 3:31 | 3:37 | 3:43 | 3:46 | 3:53 |
| 3:45 | 3:52 | 4:01 | 4:07 | 4:13 | 4:16 | 4:23 |
| 4:15 | 4:22 | 4:31 | 4:37 | 4:43 | 4:46 | 4:53 |
| 4:45 | 4:52 | 5:01 | 5:07 | 5:13 | 5:16 | 5:23 |
| 5:15 | 5:22 | 5:31 | 5:37 | 5:43 | 5:46 | 5:53 |
| 5:45 | 5:52 | 6:01 | 6:06 | 6:11 | 6:14 | 6:20 |
| 6:15 | 6:22 | 6:30 | 6:35 | 6:40 | 6:43 | 6:49 |
| 6:45 | 6:52 | 7:00 | 7:05 | 7:10 | 7:13 | 7:19 |
| 7:15 | 7:22 | 7:30 | 7:35 | 7:40 | 7:43 | 7:49 |
| 7:45 | 7:52 | 8:00 | 8:05 | 8:10 | 8:13 | 8:19 |
| 8:15 | 8:22 | 8:30 | 8:35 | 8:40 | 8:43 | 8:49 |
| 8:45 | 8:52 | 9:00 | 9:05 | 9:10 | 9:13 | 9:19 |
| 9:15 | 9:22 | 9:30 | 9:35 | 9:40 | 9:43 | 9:49 |
| 9:45 | 9:52 | 10:00 | 10:05 | 10:10 | 10:13 | 10:19 |
| 10:15 | 10:22 | 10:30 | 10:35 | 10:40 | 10:43 | 10:49 |

### to Conestoga Mall

| Columbia / Sundew (Depart) G | Columbia / Fischer-Hallman F | Columbia / U.W. E | Columbia / King D | Bridge / Lexington C | Bridge / Northfield B | Conestoga Mall (Arrive) A |
|---|---|---|---|---|---|---|
| 6:00 | 6:07 | 6:11 | 6:16 | 6:21 | 6:29 | 6:35 |
| 6:30 | 6:37 | 6:41 | 6:46 | 6:51 | 6:59 | 7:05 |
| 6:52 | 6:59 | 7:03 | 7:08 | 7:13 | 7:21 | 7:27 |
| 7:24 | 7:31 | 7:35 | 7:40 | 7:45 | 7:53 | 8:01 |
| 7:54 | 8:01 | 8:05 | 8:10 | 8:15 | 8:23 | 8:32 |
| 8:24 | 8:31 | 8:35 | 8:40 | 8:45 | 8:53 | 9:02 |
| 8:54 | 9:01 | 9:04 | 9:09 | 9:14 | 9:22 | 9:31 |
| 9:23 | 9:30 | 9:33 | 9:38 | 9:43 | 9:51 | 9:59 |
| 9:52 | 9:59 | 10:02 | 10:07 | 10:12 | 10:20 | 10:29 |
| 10:22 | 10:29 | 10:32 | 10:37 | 10:42 | 10:50 | 10:59 |
| 10:52 | 10:59 | 11:02 | 11:07 | 11:12 | 11:20 | 11:29 |
| 11:22 | 11:29 | 11:32 | 11:37 | 11:42 | 11:50 | 11:59 |
| 11:52 | 11:59 | 12:02 | 12:07 | 12:12 | 12:20 | 12:29 |
| 12:22 | 12:29 | 12:32 | 12:37 | 12:42 | 12:50 | 12:59 |
| 12:52 | 12:59 | 1:02 | 1:07 | 1:12 | 1:20 | 1:29 |
| 1:22 | 1:29 | 1:32 | 1:37 | 1:42 | 1:50 | 1:59 |
| 1:52 | 1:59 | 2:02 | 2:07 | 2:12 | 2:20 | 2:29 |
| 2:22 | 2:29 | 2:33 | 2:39 | 2:45 | 2:54 | 3:04 |
| 2:53 | 2:59 | 3:03 | 3:09 | 3:15 | 3:24 | 3:33 |
| 3:24 | 3:30 | 3:34 | 3:40 | 3:46 | 3:55 | 4:03 |
| 3:54 | 4:00 | 4:04 | 4:10 | 4:16 | 4:25 | 4:33 |
| 4:24 | 4:30 | 4:34 | 4:40 | 4:46 | 4:55 | 5:03 |
| 4:54 | 5:00 | 5:04 | 5:10 | 5:16 | 5:25 | 5:33 |
| 5:24 | 5:30 | 5:34 | 5:40 | 5:46 | 5:55 | 6:03 |
| 5:54 | 6:00 | 6:03 | 6:09 | 6:14 | 6:22 | 6:29 |
| 6:21 | 6:27 | 6:30 | 6:36 | 6:41 | 6:49 | 6:57 |
| 6:50 | 6:56 | 6:59 | 7:05 | 7:10 | 7:18 | 7:27 |
| 7:20 | 7:26 | 7:29 | 7:35 | 7:40 | 7:48 | 7:56 |
| 7:50 | 7:56 | 7:59 | 8:05 | 8:10 | 8:18 | 8:26 |
| 8:20 | 8:26 | 8:29 | 8:35 | 8:40 | 8:48 | 8:56 |
| 8:50 | 8:56 | 8:59 | 9:05 | 9:10 | 9:18 | 9:26 |
| 9:20 | 9:26 | 9:29 | 9:35 | 9:40 | 9:48 | 9:56 |
| 9:50 | 9:56 | 9:59 | 10:05 | 10:10 | 10:18 | 10:26 |

Schedule of Route 31

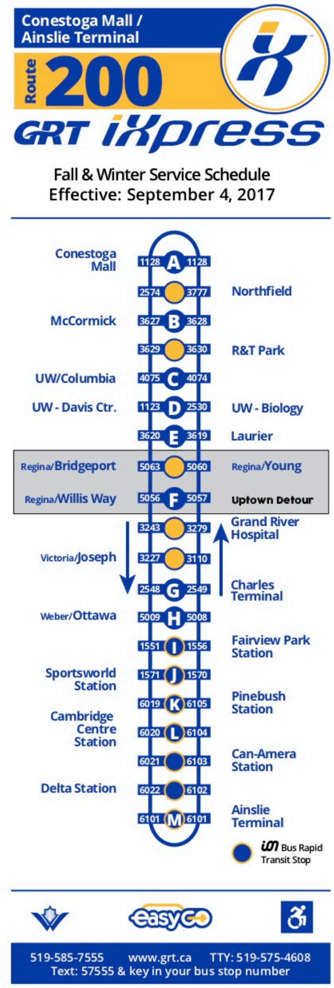
## Weekday Schedule

### 200 iXpress to Ainslie Terminal

| Conestoga Mall (Depart) A | McCormick B | UW / Columbia C | UW - Davis Centre D | Laurier E | Regina / Willis Way F | Charles Terminal G | Ottawa H | Fairview I | Sportsworld J | Pinebush K | Cambridge Centre L | Ainslie Terminal (Arrive) M |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 5:35 | 5:43 | 5:51 | 6:00 | 6:09 |
| | | | | | | 5:52 | 5:58 | 6:07 | 6:15 | 6:23 | 6:30 | 6:39 |
| 5:45 | 5:52 | 5:56 | 5:57 | 6:01 | 6:04 | 6:15 | 6:21 | 6:30 | 6:38 | 6:46 | 6:52 | 7:01 |
| 6:10 | 6:17 | 6:21 | 6:22 | 6:26 | 6:29 | 6:42 | 6:48 | 6:57 | 7:05 | 7:13 | 7:19 | 7:29 |
| 6:25 | 6:32 | 6:36 | 6:37 | 6:41 | 6:44 | 6:58 | 7:04 | 7:13 | 7:21 | 7:30 | 7:38 | 7:48 |
| 6:45 | 6:52 | 6:56 | 6:58 | 7:03 | 7:07 | 7:19 | 7:25 | 7:34 | 7:42 | 7:51 | 7:59 | 8:09 |
| 7:00 | 7:07 | 7:11 | 7:13 | 7:18 | 7:22 | 7:34 | 7:40 | 7:49 | 7:57 | 8:06 | 8:14 | 8:24 |
| 7:10 | 7:17 | 7:22 | 7:24 | 7:29 | 7:33 | 7:45 | 7:51 | 8:00 | 8:08 | 8:17 | 8:25 | 8:35 |
| 7:20 | 7:27 | 7:32 | 7:34 | 7:39 | 7:43 | 7:55 | 8:01 | 8:10 | 8:18 | 8:27 | 8:35 | 8:45 |
| 7:30 | 7:37 | 7:42 | 7:44 | 7:49 | 7:53 | 8:05 | 8:11 | 8:20 | 8:28 | 8:37 | 8:45 | 8:55 |
| 7:40 | 7:47 | 7:52 | 7:54 | 7:59 | 8:03 | 8:15 | 8:21 | 8:30 | 8:38 | 8:47 | 8:55 | 9:05 |
| 7:50 | 7:57 | 8:02 | 8:04 | 8:09 | 8:13 | 8:25 | 8:31 | 8:40 | 8:48 | 8:57 | 9:05 | 9:15 |
| 8:00 | 8:07 | 8:12 | 8:14 | 8:19 | 8:23 | 8:35 | 8:41 | 8:50 | 8:58 | 9:07 | 9:15 | 9:25 |
| 8:10 | 8:17 | 8:22 | 8:24 | 8:29 | 8:33 | 8:45 | 8:51 | 9:00 | 9:08 | 9:17 | 9:25 | 9:35 |
| 8:20 | 8:27 | 8:32 | 8:34 | 8:39 | 8:43 | 8:55 | 9:01 | 9:09 | 9:17 | 9:26 | 9:34 | 9:44 |
| 8:30 | 8:37 | 8:42 | 8:44 | 8:49 | 8:53 | 9:05 | 9:11 | 9:19 | 9:27 | 9:36 | 9:44 | 9:54 |
| 8:40 | 8:47 | 8:52 | 8:54 | 8:59 | 9:04 | 9:17 | 9:23 | 9:31 | 9:39 | 9:48 | 9:56 | 10:06 |
| 8:50 | 8:57 | 9:02 | 9:04 | 9:09 | 9:14 | 9:27 | 9:33 | 9:41 | 9:49 | 9:58 | 10:06 | 10:16 |
| RUNS EVERY 10 MINUTES DURING THE DAY | | | | | | | | | | | | |
| 5:50 | 5:59 | 6:04 | 6:06 | 6:12 | 6:18 | 6:33 | 6:40 | 6:49 | 6:57 | 7:05 | 7:12 | 7:21 |
| 6:00 | 6:09 | 6:14 | 6:16 | 6:22 | 6:28 | 6:43 | 6:50 | 6:59 | 7:07 | 7:15 | 7:22 | 7:31 |
| 6:10 | 6:19 | 6:24 | 6:26 | 6:32 | 6:38 | 6:53 | 7:00 | 7:09 | 7:17 | 7:25 | 7:32 | 7:41 |
| 6:20 | 6:29 | 6:34 | 6:36 | 6:42 | 6:48 | 7:04 | 7:10 | 7:19 | 7:27 | 7:35 | 7:42 | 7:51 |
| 6:30 | 6:39 | 6:44 | 6:46 | 6:52 | 6:58 | 7:11 | 7:17 | 7:26 | 7:34 | 7:42 | 7:49 | 7:58 |
| 6:45 | 6:54 | 6:59 | 7:01 | 7:06 | 7:11 | 7:23 | 7:29 | 7:37 | 7:45 | 7:53 | 8:00 | 8:09 |
| 7:00 | 7:08 | 7:12 | 7:14 | 7:19 | 7:24 | 7:37 | 7:43 | 7:52 | 8:00 | 8:08 | 8:15 | 8:24 |
| 7:15 | 7:23 | 7:27 | 7:29 | 7:34 | 7:39 | 7:52 | 7:58 | 8:07 | 8:15 | 8:23 | 8:30 | 8:39 |
| 7:30 | 7:38 | 7:42 | 7:44 | 7:49 | 7:54 | 8:07 | 8:13 | 8:22 | 8:30 | 8:38 | 8:45 | 8:54 |
| 7:45 | 7:53 | 7:57 | 7:59 | 8:04 | 8:09 | 8:22 | 8:28 | 8:37 | 8:45 | 8:53 | 9:00 | 9:09 |
| 8:00 | 8:08 | 8:12 | 8:14 | 8:19 | 8:24 | 8:37 | 8:43 | 8:52 | 9:00 | 9:08 | 9:15 | 9:24 |
| 8:15 | 8:23 | 8:27 | 8:29 | 8:34 | 8:39 | 8:52 | 8:58 | 9:07 | 9:15 | 9:23 | 9:30 | 9:39 |
| 8:45 | 8:53 | 8:57 | 8:59 | 9:04 | 9:09 | 9:22 | 9:28 | 9:37 | 9:45 | 9:53 | 10:00 | 10:09 |
| 9:15 | 9:23 | 9:27 | 9:29 | 9:34 | 9:39 | 9:52 | 9:58 | 10:07 | 10:15 | 10:23 | 10:30 | 10:39 |
| 9:45 | 9:53 | 9:57 | 9:59 | 10:04 | 10:08 | 10:20 | 10:26 | 10:35 | 10:43 | 10:51 | 10:57 | 11:06 |
| 10:15 | 10:22 | 10:26 | 10:28 | 10:33 | 10:37 | 10:50 | 10:56 | 11:05 | 11:13 | 11:21 | 11:27 | 11:36 |
| 10:45 | 10:52 | 10:56 | 10:58 | 11:03 | 11:07 | 11:20 | 11:26 | 11:35 | 11:43 | 11:51 | 11:57 | 12:06 |

### 200 iXpress to Conestoga Mall

| Ainslie Terminal (Depart) M | Cambridge Centre L | Pinebush K | Sportsworld J | Fairview I | Ottawa H | Charles Terminal G | Regina / Willis Way F | Laurier E | UW - Biology D | UW / Columbia C | McCormick B | Conestoga Mall (Arrive) A |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 5:52 | 6:01 | 6:04 | 6:08 | 6:09 | 6:13 | 6:19 |
| | 5:32 | 5:35 | 5:45 | 5:55 | 6:02 | 6:10 | 6:22 | 6:22 | 6:26 | 6:27 | 6:31 | 6:37 |
| | 5:52 | 5:55 | 6:04 | 6:17 | 6:24 | 6:32 | 6:41 | 6:45 | 6:50 | 6:52 | 6:56 | 7:02 |
| 5:57 | 6:07 | 6:10 | 6:21 | 6:32 | 6:39 | 6:47 | 6:57 | 7:01 | 7:06 | 7:08 | 7:12 | 7:18 |
| 6:15 | 6:27 | 6:30 | 6:41 | 6:53 | 7:00 | 7:08 | 7:15 | 7:22 | 7:27 | 7:29 | 7:33 | 7:39 |
| | 6:40 | 6:43 | 6:55 | 7:08 | 7:15 | 7:23 | 7:34 | 7:39 | 7:44 | 7:46 | 7:50 | 7:56 |
| 6:45 | 6:57 | 7:01 | 7:13 | 7:26 | 7:33 | 7:41 | 7:52 | 7:57 | 8:02 | 8:04 | 8:08 | 8:14 |
| 6:55 | 7:05 | 7:09 | 7:20 | 7:35 | 7:42 | 7:51 | 8:03 | 8:07 | 8:12 | 8:14 | 8:18 | 8:24 |
| | | | | 7:40 | 7:47 | 7:55 | 8:08 | 8:11 | 8:16 | 8:18 | 8:22 | 8:28 |
| 7:05 | 7:15 | 7:19 | 7:30 | 7:45 | 7:52 | 8:00 | 8:13 | 8:16 | 8:21 | 8:23 | 8:27 | 8:33 |
| 7:15 | 7:25 | 7:29 | 7:40 | 7:55 | 8:02 | 8:11 | 8:23 | 8:27 | 8:32 | 8:34 | 8:38 | 8:44 |
| 7:25 | 7:35 | 7:39 | 7:50 | 8:05 | 8:12 | 8:21 | 8:33 | 8:37 | 8:42 | 8:44 | 8:48 | 8:54 |
| 7:35 | 7:45 | 7:49 | 8:00 | 8:15 | 8:22 | 8:31 | 8:43 | 8:47 | 8:52 | 8:54 | 8:58 | 9:04 |
| 7:45 | 7:55 | 7:59 | 8:10 | 8:25 | 8:32 | 8:41 | 8:53 | 8:57 | 9:02 | 9:04 | 9:08 | 9:14 |
| | | | | | | 8:46 | 8:58 | 9:02 | 9:07 | | | |
| 7:55 | 8:05 | 8:09 | 8:20 | 8:35 | 8:42 | 8:51 | 9:03 | 9:07 | 9:12 | 9:14 | 9:18 | 9:24 |
| 8:05 | 8:15 | 8:19 | 8:30 | 8:45 | 8:52 | 9:01 | 9:13 | 9:17 | 9:22 | 9:24 | 9:28 | 9:34 |
| 8:15 | 8:25 | 8:29 | 8:40 | 8:55 | 9:02 | 9:11 | 9:23 | 9:27 | 9:32 | 9:34 | 9:38 | 9:44 |
| RUNS EVERY 10 MINUTES DURING THE DAY | | | | | | | | | | | | |
| 5:25 | 5:36 | 5:42 | 5:53 | 6:08 | 6:16 | 6:25 | 6:37 | 6:41 | 6:47 | 6:49 | 6:53 | 6:59 |
| 5:35 | 5:46 | 5:52 | 6:03 | 6:18 | 6:26 | 6:35 | 6:47 | 6:50 | 6:55 | 6:57 | 7:01 | 7:07 |
| 5:45 | 5:56 | 6:02 | 6:13 | 6:28 | 6:36 | 6:45 | 6:56 | 6:59 | 7:04 | 7:06 | 7:10 | 7:16 |
| 6:00 | 6:11 | 6:17 | 6:28 | 6:43 | 6:50 | 6:57 | 7:08 | 7:11 | 7:16 | 7:18 | 7:22 | 7:28 |
| 6:15 | 6:26 | 6:32 | 6:43 | 6:55 | 7:02 | 7:09 | 7:20 | 7:23 | 7:28 | 7:30 | 7:34 | 7:40 |
| 6:30 | 6:41 | 6:46 | 6:56 | 7:08 | 7:15 | 7:22 | 7:33 | 7:36 | 7:41 | 7:43 | 7:47 | 7:53 |
| 6:45 | 6:55 | 6:59 | 7:09 | 7:21 | 7:28 | 7:35 | 7:46 | 7:49 | 7:54 | 7:56 | 8:00 | 8:06 |
| 7:00 | 7:10 | 7:14 | 7:24 | 7:36 | 7:43 | 7:50 | 8:01 | 8:04 | 8:09 | 8:11 | 8:15 | 8:21 |
| 7:15 | 7:25 | 7:29 | 7:39 | 7:51 | 7:58 | 8:05 | 8:16 | 8:19 | 8:24 | 8:26 | 8:30 | 8:36 |
| 7:30 | 7:40 | 7:44 | 7:54 | 8:06 | 8:13 | 8:20 | 8:31 | 8:34 | 8:39 | 8:41 | 8:45 | 8:51 |
| 7:45 | 7:55 | 7:59 | 8:09 | 8:21 | 8:28 | 8:35 | 8:46 | 8:49 | 8:54 | 8:56 | 9:00 | 9:06 |
| 8:15 | 8:25 | 8:29 | 8:39 | 8:51 | 8:58 | 9:05 | 9:16 | 9:19 | 9:24 | 9:26 | 9:30 | 9:36 |
| 8:45 | 8:55 | 8:59 | 9:09 | 9:21 | 9:28 | 9:35 | 9:46 | 9:49 | 9:54 | 9:56 | 10:00 | 10:06 |
| 9:15 | 9:25 | 9:29 | 9:39 | 9:51 | 9:58 | 10:07 | 10:16 | 10:19 | 10:23 | 10:24 | 10:28 | 10:34 |
| 9:45 | 9:55 | 9:59 | 10:08 | 10:20 | 10:27 | 10:36 | 10:45 | 10:48 | 10:52 | 10:53 | 10:57 | 11:03 |
| 10:15 | 10:25 | 10:29 | 10:38 | 10:50 | 10:57 | 11:06 | 11:15 | 11:18 | 11:22 | 11:23 | 11:27 | 11:33 |
| 10:45 | 10:55 | 10:59 | 11:08 | 11:20 | 11:27 | 11:36 | 11:45 | 11:48 | 11:52 | 11:53 | 11:57 | 12:03 |




Map for Route 200

## Saturday Schedule

### 200 iXpress to Ainslie Terminal

| Conestoga Mall (Depart) (A) | McCormick (B) | UW / Columbia (C) | UW - Davis Centre (D) | Laurier (E) | Regina / Willis Way (F) | Charles Terminal (G) | Ottawa (H) | Fairview (I) | Sportsworld (J) | Pinebush (K) | Cambridge Centre (L) | Ainslie Terminal (Arrive) (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 8:10 | 8:17 | 8:25 | 8:32 | 8:41 |
| 7:50 | 7:57 | 8:01 | 8:03 | 8:07 | 8:11 | 8:22 | 8:28 | 8:37 | 8:45 | 8:53 | 9:00 | 9:09 |
| 8:20 | 8:27 | 8:31 | 8:33 | 8:37 | 8:41 | 8:52 | 8:58 | 9:07 | 9:15 | 9:23 | 9:30 | 9:40 |
| 8:50 | 8:57 | 9:01 | 9:03 | 9:07 | 9:11 | 9:22 | 9:28 | 9:37 | 9:45 | 9:53 | 10:00 | 10:10 |
| 9:25 | 9:32 | 9:36 | 9:38 | 9:43 | 9:47 | 10:00 | 10:06 | 10:15 | 10:23 | 10:32 | 10:40 | 10:50 |
| 9:55 | 10:03 | 10:07 | 10:09 | 10:14 | 10:18 | 10:30 | 10:36 | 10:45 | 10:53 | 11:02 | 11:10 | 11:20 |
| | | | | | | 10:45 | 10:51 | 11:00 | 11:08 | 11:17 | 11:25 | 11:35 |
| 10:25 | 10:33 | 10:37 | 10:39 | 10:44 | 10:48 | 11:00 | 11:06 | 11:15 | 11:23 | 11:32 | 11:40 | 11:50 |
| 10:40 | 10:48 | 10:52 | 10:54 | 10:59 | 11:03 | 11:15 | 11:21 | 11:30 | 11:38 | 11:47 | 11:55 | 12:05 |
| 10:55 | 11:03 | 11:07 | 11:09 | 11:14 | 11:18 | 11:30 | 11:36 | 11:45 | 11:53 | 12:02 | 12:10 | 12:20 |
| 11:10 | 11:18 | 11:22 | 11:24 | 11:29 | 11:33 | 11:45 | 11:51 | 12:00 | 12:08 | 12:17 | 12:25 | 12:35 |
| 11:25 | 11:33 | 11:37 | 11:39 | 11:44 | 11:48 | 12:00 | 12:06 | 12:15 | 12:23 | 12:32 | 12:40 | 12:50 |
| 11:40 | 11:48 | 11:52 | 11:54 | 11:59 | 12:03 | 12:15 | 12:21 | 12:30 | 12:38 | 12:47 | 12:55 | 1:05 |
| 11:55 | 12:03 | 12:07 | 12:09 | 12:14 | 12:18 | 12:30 | 12:36 | 12:45 | 12:53 | 1:02 | 1:10 | 1:20 |
| 12:10 | 12:18 | 12:22 | 12:24 | 12:29 | 12:33 | 12:45 | 12:51 | 1:00 | 1:08 | 1:17 | 1:25 | 1:35 |
| 12:25 | 12:33 | 12:37 | 12:39 | 12:44 | 12:48 | 1:00 | 1:06 | 1:15 | 1:23 | 1:32 | 1:40 | 1:50 |
| 12:40 | 12:48 | 12:52 | 12:54 | 12:59 | 1:03 | 1:15 | 1:21 | 1:30 | 1:38 | 1:47 | 1:55 | 2:05 |
| 12:55 | 1:03 | 1:07 | 1:09 | 1:14 | 1:18 | 1:30 | 1:36 | 1:45 | 1:53 | 2:02 | 2:10 | 2:20 |
| 1:10 | 1:18 | 1:22 | 1:24 | 1:29 | 1:33 | 1:45 | 1:51 | 2:00 | 2:08 | 2:17 | 2:25 | 2:35 |
| 1:25 | 1:33 | 1:37 | 1:39 | 1:44 | 1:48 | 2:00 | 2:06 | 2:15 | 2:23 | 2:32 | 2:40 | 2:50 |
| 1:40 | 1:48 | 1:52 | 1:54 | 1:59 | 2:03 | 2:15 | 2:21 | 2:30 | 2:38 | 2:47 | 2:55 | 3:05 |
| 1:55 | 2:03 | 2:07 | 2:09 | 2:14 | 2:18 | 2:30 | 2:36 | 2:45 | 2:53 | 3:02 | 3:10 | 3:20 |
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| 2:25 | 2:33 | 2:37 | 2:39 | 2:44 | 2:48 | 3:00 | 3:06 | 3:15 | 3:23 | 3:32 | 3:40 | 3:50 |
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| 4:25 | 4:33 | 4:37 | 4:39 | 4:44 | 4:48 | 5:00 | 5:06 | 5:15 | 5:23 | 5:32 | 5:40 | 5:50 |
| 4:40 | 4:48 | 4:52 | 4:54 | 4:59 | 5:03 | 5:15 | 5:21 | 5:30 | 5:38 | 5:47 | 5:55 | 6:05 |
| 4:55 | 5:03 | 5:07 | 5:09 | 5:14 | 5:18 | 5:30 | 5:36 | 5:45 | 5:53 | 6:02 | 6:10 | 6:19 |
| 5:10 | 5:18 | 5:22 | 5:24 | 5:29 | 5:33 | 5:45 | 5:51 | 6:00 | 6:08 | 6:16 | 6:23 | 6:32 |
| 5:25 | 5:33 | 5:37 | 5:39 | 5:44 | 5:48 | 6:00 | 6:06 | 6:15 | 6:23 | 6:31 | 6:38 | 6:47 |
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| 6:25 | 6:32 | 6:36 | 6:38 | 6:43 | 6:47 | 6:59 | 7:05 | 7:14 | 7:22 | 7:30 | 7:40 | 7:49 |
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### 200 iXpress to Conestoga Mall

| Ainslie Terminal (Depart) (M) | Cambridge Centre (L) | Pinebush (K) | Sportsworld (J) | Fairview (I) | Ottawa (H) | Charles Terminal (G) | Regina / Willis Way (F) | Laurier (E) | UW - Biology (D) | UW / Columbia (C) | McCormick (B) | Conestoga Mall (Arrive) (A) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 7:30 | 7:34 | 7:44 | 7:56 | 8:03 | 8:11 | 8:22 | 8:25 | 8:30 | 8:32 | 8:36 | 8:42 |
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| | 9:41 | 9:46 | 9:57 | 10:10 | 10:17 | 10:26 | 10:38 | 10:42 | 10:47 | 10:49 | 10:53 | 11:00 |
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| 7:45 | 7:55 | 7:59 | 8:09 | 8:21 | 8:28 | 8:36 | 8:47 | 8:50 | 8:55 | 8:57 | 9:01 | 9:07 |
| 8:15 | 8:25 | 8:29 | 8:39 | 8:51 | 8:58 | 9:06 | 9:17 | 9:20 | 9:25 | 9:27 | 9:31 | 9:37 |
| 8:45 | 8:55 | 8:59 | 9:09 | 9:21 | 9:28 | 9:36 | 9:47 | 9:50 | 9:55 | 9:57 | 10:01 | 10:07 |
| 9:15 | 9:25 | 9:29 | 9:39 | 9:51 | 9:58 | 10:06 | 10:17 | 10:20 | 10:25 | 10:27 | 10:31 | 10:37 |
| 9:45 | 9:55 | 9:59 | 10:09 | 10:21 | 10:28 | 10:36 | 10:47 | 10:50 | 10:55 | 10:57 | 11:01 | 11:07 |
| 10:15 | 10:25 | 10:29 | 10:39 | 10:51 | 10:58 | 11:06 | 11:17 | 11:20 | 11:25 | 11:27 | 11:31 | 11:37 |

## Sunday / Holiday Schedule

### 200 iXpress to Ainslie Terminal

| Conestoga Mall (Depart) (A) | McCormick (B) | UW / Columbia (C) | UW - Davis Centre (D) | Laurier (E) | Regina / Willis Way (F) | Charles Terminal (G) | Ottawa (H) | Fairview (I) | Sportsworld (J) | Pinebush (K) | Cambridge Centre (L) | Ainslie Terminal (Arrive) (M) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8:15 | 8:22 | 8:26 | 8:28 | 8:33 | 8:37 | 8:49 | 8:55 | 9:04 | 9:12 | 9:20 | 9:27 | 9:36 |
| 8:45 | 8:52 | 8:56 | 8:58 | 9:03 | 9:07 | 9:19 | 9:25 | 9:34 | 9:42 | 9:51 | 9:59 | 10:08 |
| 9:15 | 9:22 | 9:26 | 9:28 | 9:33 | 9:37 | 9:49 | 9:55 | 10:04 | 10:12 | 10:21 | 10:29 | 10:38 |
| 9:45 | 9:52 | 9:56 | 9:58 | 10:03 | 10:07 | 10:20 | 10:26 | 10:35 | 10:43 | 10:52 | 11:00 | 11:09 |
| 10:15 | 10:22 | 10:26 | 10:28 | 10:33 | 10:37 | 10:50 | 10:56 | 11:05 | 11:13 | 11:22 | 11:30 | 11:39 |
| 10:45 | 10:52 | 10:56 | 10:58 | 11:03 | 11:07 | 11:20 | 11:26 | 11:35 | 11:43 | 11:52 | 12:00 | 12:09 |
| 11:15 | 11:22 | 11:26 | 11:28 | 11:33 | 11:37 | 11:50 | 11:56 | 12:05 | 12:13 | 12:22 | 12:30 | 12:39 |
| 11:45 | 11:52 | 11:56 | 11:58 | 12:03 | 12:07 | 12:20 | 12:26 | 12:35 | 12:43 | 12:52 | 1:00 | 1:09 |
| 12:15 | 12:22 | 12:26 | 12:28 | 12:33 | 12:37 | 12:50 | 12:56 | 1:05 | 1:13 | 1:22 | 1:30 | 1:39 |
| 12:45 | 12:52 | 12:56 | 12:58 | 1:03 | 1:07 | 1:20 | 1:26 | 1:35 | 1:43 | 1:52 | 2:00 | 2:09 |
| 1:15 | 1:22 | 1:26 | 1:28 | 1:33 | 1:37 | 1:50 | 1:56 | 2:05 | 2:13 | 2:22 | 2:30 | 2:39 |
| 1:45 | 1:52 | 1:56 | 1:58 | 2:03 | 2:07 | 2:20 | 2:26 | 2:35 | 2:43 | 2:52 | 3:00 | 3:09 |
| 2:15 | 2:22 | 2:26 | 2:28 | 2:33 | 2:37 | 2:50 | 2:56 | 3:05 | 3:13 | 3:22 | 3:30 | 3:39 |
| 2:45 | 2:52 | 2:56 | 2:58 | 3:03 | 3:07 | 3:20 | 3:26 | 3:35 | 3:43 | 3:52 | 4:00 | 4:09 |
| 3:15 | 3:22 | 3:26 | 3:28 | 3:33 | 3:37 | 3:50 | 3:56 | 4:05 | 4:13 | 4:22 | 4:30 | 4:39 |
| 3:45 | 3:52 | 3:56 | 3:58 | 4:03 | 4:07 | 4:20 | 4:26 | 4:35 | 4:43 | 4:52 | 5:00 | 5:09 |
| 4:15 | 4:22 | 4:26 | 4:28 | 4:33 | 4:37 | 4:50 | 4:56 | 5:05 | 5:13 | 5:22 | 5:30 | 5:39 |
| 4:45 | 4:52 | 4:56 | 4:58 | 5:03 | 5:07 | 5:20 | 5:26 | 5:35 | 5:43 | 5:52 | 6:00 | 6:09 |
| 5:15 | 5:22 | 5:26 | 5:28 | 5:33 | 5:37 | 5:50 | 5:56 | 6:05 | 6:13 | 6:21 | 6:28 | 6:37 |
| 5:45 | 5:52 | 5:56 | 5:58 | 6:03 | 6:07 | 6:20 | 6:26 | 6:35 | 6:43 | 6:51 | 6:58 | 7:07 |
| 6:15 | 6:22 | 6:26 | 6:28 | 6:33 | 6:37 | 6:49 | 6:55 | 7:04 | 7:12 | 7:20 | 7:27 | 7:36 |
| 6:45 | 6:52 | 6:56 | 6:58 | 7:03 | 7:07 | 7:19 | 7:25 | 7:34 | 7:42 | 7:50 | 7:57 | 8:06 |
| 7:15 | 7:22 | 7:26 | 7:28 | 7:33 | 7:37 | 7:49 | 7:55 | 8:04 | 8:12 | 8:20 | 8:27 | 8:36 |
| 7:45 | 7:52 | 7:56 | 7:58 | 8:03 | 8:07 | 8:19 | 8:25 | 8:34 | 8:42 | 8:50 | 8:57 | 9:06 |
| 8:15 | 8:22 | 8:26 | 8:28 | 8:33 | 8:37 | 8:49 | 8:55 | 9:04 | 9:12 | 9:20 | 9:27 | 9:36 |

### 200 iXpress to Conestoga Mall

| Ainslie Terminal (Depart) (M) | Cambridge Centre (L) | Pinebush (K) | Sportsworld (J) | Fairview (I) | Ottawa (H) | Charles Terminal (G) | Regina / Willis Way (F) | Laurier (E) | UW - Biology (D) | UW / Columbia (C) | McCormick (B) | Conestoga Mall (Arrive) (A) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8:15 | 8:25 | 8:29 | 8:39 | 8:51 | 8:58 | 9:06 | 9:17 | 9:20 | 9:25 | 9:27 | 9:31 | 9:37 |
| 8:45 | 8:55 | 8:59 | 9:09 | 9:21 | 9:28 | 9:37 | 9:49 | 9:53 | 9:58 | 10:00 | 10:04 | 10:10 |
| 9:15 | 9:25 | 9:29 | 9:39 | 9:51 | 9:58 | 10:07 | 10:19 | 10:23 | 10:28 | 10:30 | 10:34 | 10:40 |
| 9:45 | 9:55 | 9:59 | 10:09 | 10:21 | 10:28 | 10:37 | 10:49 | 10:53 | 10:58 | 11:00 | 11:04 | 11:10 |
| 10:15 | 10:25 | 10:29 | 10:39 | 10:51 | 10:58 | 11:07 | 11:19 | 11:23 | 11:28 | 11:30 | 11:34 | 11:40 |
| 10:45 | 10:55 | 10:59 | 11:09 | 11:21 | 11:28 | 11:37 | 11:49 | 11:53 | 11:58 | 12:00 | 12:04 | 12:10 |
| 11:15 | 11:25 | 11:29 | 11:39 | 11:51 | 11:58 | 12:07 | 12:19 | 12:23 | 12:28 | 12:30 | 12:34 | 12:40 |
| 11:45 | 11:55 | 11:59 | 12:09 | 12:21 | 12:28 | 12:37 | 12:49 | 12:53 | 12:58 | 1:00 | 1:04 | 1:10 |
| 12:15 | 12:25 | 12:29 | 12:39 | 12:51 | 12:58 | 1:07 | 1:19 | 1:23 | 1:28 | 1:30 | 1:34 | 1:40 |
| 12:45 | 12:55 | 12:59 | 1:09 | 1:21 | 1:28 | 1:37 | 1:49 | 1:53 | 1:58 | 2:00 | 2:04 | 2:10 |
| 1:15 | 1:25 | 1:29 | 1:39 | 1:51 | 1:58 | 2:07 | 2:19 | 2:23 | 2:28 | 2:30 | 2:34 | 2:40 |
| 1:45 | 1:55 | 1:59 | 2:09 | 2:21 | 2:28 | 2:37 | 2:49 | 2:53 | 2:58 | 3:00 | 3:04 | 3:10 |
| 2:15 | 2:25 | 2:29 | 2:39 | 2:51 | 2:58 | 3:07 | 3:19 | 3:23 | 3:28 | 3:30 | 3:34 | 3:40 |
| 2:45 | 2:55 | 2:59 | 3:09 | 3:21 | 3:28 | 3:37 | 3:49 | 3:53 | 3:58 | 4:00 | 4:04 | 4:10 |
| 3:15 | 3:25 | 3:29 | 3:39 | 3:51 | 3:58 | 4:07 | 4:19 | 4:23 | 4:28 | 4:30 | 4:34 | 4:40 |
| 3:45 | 3:55 | 3:59 | 4:09 | 4:21 | 4:28 | 4:37 | 4:49 | 4:53 | 4:58 | 5:00 | 5:04 | 5:10 |
| 4:15 | 4:25 | 4:29 | 4:39 | 4:51 | 4:58 | 5:07 | 5:19 | 5:23 | 5:28 | 5:30 | 5:34 | 5:40 |
| 4:45 | 4:55 | 4:59 | 5:09 | 5:21 | 5:28 | 5:37 | 5:49 | 5:53 | 5:58 | 6:00 | 6:04 | 6:10 |
| 5:15 | 5:25 | 5:29 | 5:39 | 5:51 | 5:58 | 6:07 | 6:19 | 6:23 | 6:28 | 6:30 | 6:34 | 6:40 |
| 5:45 | 5:55 | 5:59 | 6:09 | 6:21 | 6:28 | 6:36 | 6:47 | 6:50 | 6:55 | 6:57 | 7:01 | 7:07 |
| 6:15 | 6:25 | 6:29 | 6:39 | 6:51 | 6:58 | 7:06 | 7:17 | 7:20 | 7:25 | 7:27 | 7:31 | 7:37 |
| 6:45 | 6:55 | 6:59 | 7:09 | 7:21 | 7:28 | 7:36 | 7:47 | 7:50 | 7:55 | 7:57 | 8:01 | 8:07 |
| 7:15 | 7:25 | 7:29 | 7:39 | 7:51 | 7:58 | 8:06 | 8:17 | 8:20 | 8:25 | 8:27 | 8:31 | 8:37 |
| 7:45 | 7:55 | 7:59 | 8:09 | 8:21 | 8:28 | 8:36 | 8:47 | 8:50 | 8:55 | 8:57 | 9:01 | 9:07 |
| 8:15 | 8:25 | 8:29 | 8:39 | 8:51 | 8:58 | 9:06 | 9:17 | 9:20 | 9:25 | 9:27 | 9:31 | 9:37 |

### EasyGO makes taking transit easy!

1. Online Trip Planner
   **www.grt.ca**
2. Next Bus Text - get information on the next bus times sent to your phone
   **Text 57555 + (4 digit bus stop #)**
3. Next Bus Call - call to hear the next bus times for your stop
   **519-585-7555**
4. EasyGO Mobile - GRT's official mobile application for real-time bus departure information
   **Available on Android, Blackberry, iOS & Windows App Stores**
5. EasyGO Real-Time Desktop Map - plan trips by seeing and click on different routes and stops
   **www.grt.ca**

Schedule for Route 200

**Appendix B: Segment Performance Report for Summer& Fall**

(6 pages)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 32 | Columbia / Sundew | 60% | 60% | 27% | 13% | 91% | 9% | 1% |
| | 44 | Columbia / Fischer-Hallman | 15% | 15% | 85% | 0% | 55% | 45% | 0% |
| | 150 | Columbia / U.W. | 48% | 48% | 51% | 0% | 80% | 19% | 0% |
| | 28 | Columbia / King | 59% | 63% | 36% | 0% | 75% | 21% | 5% |
| | 12 | Lexington / Bridge | 55% | 58% | 39% | 3% | 76% | 18% | 6% |
| | 103 | Bridge / Northfield | 60% | 63% | 35% | 2% | 78% | 16% | 6% |
| | 3290 | Conestoga Mall | 44% | 47% | 49% | 3% | 68% | 25% | 7% |
| MID-DAY | 32 | Columbia / Sundew | 66% | 70% | 29% | 2% | 85% | 10% | 5% |
| | 44 | Columbia / Fischer-Hallman | 24% | 24% | 76% | 0% | 57% | 43% | 0% |
| | 150 | Columbia / U.W. | 30% | 30% | 70% | 0% | 55% | 45% | 0% |
| | 28 | Columbia / King | 32% | 33% | 66% | 1% | 52% | 47% | 1% |
| | 12 | Lexington / Bridge | 31% | 33% | 65% | 2% | 58% | 39% | 4% |
| | 103 | Bridge / Northfield | 35% | 38% | 57% | 4% | 59% | 33% | 8% |
| | 3290 | Conestoga Mall | 31% | 33% | 65% | 1% | 57% | 40% | 4% |
| PM | 32 | Columbia / Sundew | 45% | 47% | 52% | 1% | 74% | 23% | 3% |
| | 44 | Columbia / Fischer-Hallman | 8% | 8% | 92% | 0% | 31% | 69% | 0% |
| | 150 | Columbia / U.W. | 17% | 17% | 83% | 0% | 35% | 65% | 0% |
| | 28 | Columbia / King | 26% | 26% | 73% | 1% | 43% | 56% | 1% |
| | 12 | Lexington / Bridge | 22% | 23% | 75% | 2% | 43% | 54% | 4% |
| | 103 | Bridge / Northfield | 27% | 30% | 63% | 8% | 44% | 46% | 10% |
| | 3290 | Conestoga Mall | 31% | 35% | 53% | 12% | 48% | 37% | 15% |
| OVERALL | - | - | 35% | 37% | - | - | 59% | - | - |

Performance Report for Route 31 (Summer)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 32 | Columbia / Sundew | 45% | 45% | 40% | 14% | 80% | 19% | 1% |
| | 44 | Columbia / Fischer-Hallman | 13% | 13% | 87% | 0% | 49% | 51% | 0% |
| | 150 | Columbia / U.W. | 41% | 41% | 58% | 1% | 64% | 35% | 1% |
| | 28 | Columbia / King | 45% | 46% | 51% | 2% | 56% | 41% | 4% |
| | 12 | Lexington / Bridge | 43% | 46% | 50% | 4% | 61% | 32% | 7% |
| | 103 | Bridge / Northfield | 48% | 51% | 47% | 2% | 62% | 33% | 5% |
| | 3290 | Conestoga Mall | 40% | 45% | 54% | 1% | 55% | 39% | 6% |
| MID-DAY | 32 | Columbia / Sundew | 57% | 59% | 39% | 2% | 82% | 14% | 4% |
| | 44 | Columbia / Fischer-Hallman | 16% | 16% | 84% | 0% | 45% | 54% | 0% |
| | 150 | Columbia / U.W. | 17% | 17% | 82% | 1% | 36% | 64% | 1% |
| | 28 | Columbia / King | 14% | 14% | 85% | 1% | 27% | 72% | 0% |
| | 12 | Lexington / Bridge | 12% | 12% | 88% | 1% | 29% | 70% | 1% |
| | 103 | Bridge / Northfield | 17% | 17% | 82% | 1% | 37% | 61% | 2% |
| | 3290 | Conestoga Mall | 17% | 18% | 80% | 2% | 39% | 58% | 2% |
| PM | 32 | Columbia / Sundew | 24% | 25% | 73% | 2% | 51% | 46% | 3% |
| | 44 | Columbia / Fischer-Hallman | 4% | 4% | 96% | 0% | 15% | 85% | 0% |
| | 150 | Columbia / U.W. | 6% | 6% | 94% | 0% | 14% | 86% | 0% |
| | 28 | Columbia / King | 8% | 8% | 92% | 0% | 15% | 85% | 0% |
| | 12 | Lexington / Bridge | 7% | 7% | 92% | 0% | 17% | 82% | 1% |
| | 103 | Bridge / Northfield | 11% | 12% | 87% | 2% | 22% | 76% | 2% |
| | 3290 | Conestoga Mall | 16% | 17% | 80% | 3% | 27% | 69% | 4% |
| OVERALL | - | - | 22% | 23% | - | - | 41% | - | - |

Performance Report for Route 31 (Fall)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 3290 | Conestoga Mall | 65% | 66% | 17% | 17% | 94% | 5% | 1% |
| | 121 | Mccormick | 67% | 67% | 31% | 2% | 82% | 16% | 2% |
| | 150 | U.W. / Columbia | 65% | 65% | 29% | 6% | 80% | 15% | 5% |
| | 151 | U.W. - Davis Centre | 65% | 65% | 30% | 5% | 84% | 14% | 2% |
| | 146 | Laurier | 62% | 64% | 29% | 7% | 79% | 14% | 8% |
| | 82 | Regina / Bridgeport | 57% | 62% | 32% | 6% | 74% | 15% | 10% |
| | 3292 | Charles Terminal | 50% | 53% | 36% | 11% | 88% | 9% | 3% |
| | 173 | Weber / Ottawa | 72% | 72% | 26% | 1% | 82% | 16% | 1% |
| | 54 | Fairview Park | 51% | 51% | 10% | 39% | 94% | 6% | 0% |
| | 137 | Sportsworld Station | 69% | 69% | 12% | 19% | 91% | 6% | 3% |
| | 70 | Pinebush Station | 68% | 69% | 24% | 7% | 84% | 9% | 7% |
| | 3289 | Cambridge Centre Station | 23% | 23% | 3% | 74% | 97% | 2% | 0% |
| | 3288 | Ainslie Terminal | 71% | 81% | 8% | 11% | 76% | 3% | 21% |
| | 3467 | Regina / Bridgeport | 55% | 55% | 27% | 18% | 82% | 0% | 18% |
| MID-DAY | 3290 | Conestoga Mall | 88% | 89% | 10% | 0% | 95% | 3% | 2% |
| | 121 | Mccormick | 71% | 71% | 16% | 12% | 84% | 10% | 6% |
| | 150 | U.W. / Columbia | 68% | 73% | 20% | 7% | 80% | 11% | 10% |
| | 151 | U.W. - Davis Centre | 68% | 69% | 22% | 10% | 85% | 12% | 3% |
| | 146 | Laurier | 65% | 65% | 30% | 5% | 81% | 15% | 4% |
| | 82 | Regina / Bridgeport | 61% | 66% | 20% | 14% | 71% | 11% | 18% |
| | 3292 | Charles Terminal | 51% | 56% | 24% | 20% | 84% | 11% | 5% |
| | 173 | Weber / Ottawa | 51% | 52% | 47% | 1% | 79% | 20% | 1% |
| | 54 | Fairview Park | 63% | 63% | 26% | 11% | 79% | 19% | 2% |
| | 137 | Sportsworld Station | 53% | 55% | 35% | 10% | 74% | 21% | 5% |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 70 | Pinebush Station | 38% | 39% | 58% | 3% | 58% | 38% | 4% |
| | 3289 | Cambridge Centre Station | 37% | 38% | 21% | 41% | 79% | 20% | 1% |
| | 3288 | Ainslie Terminal | 55% | 59% | 32% | 10% | 67% | 19% | 14% |
| | 3467 | Regina / Bridgeport | 50% | 58% | 13% | 29% | 63% | 4% | 33% |
| PM | 3290 | Conestoga Mall | 84% | 85% | 14% | 1% | 92% | 6% | 2% |
| | 121 | Mccormick | 64% | 66% | 15% | 19% | 76% | 11% | 14% |
| | 150 | U.W. / Columbia | 58% | 60% | 14% | 26% | 69% | 10% | 21% |
| | 151 | U.W. - Davis Centre | 59% | 59% | 15% | 26% | 85% | 10% | 5% |
| | 146 | Laurier | 69% | 71% | 17% | 12% | 79% | 11% | 10% |
| | 82 | Regina / Bridgeport | 40% | 43% | 14% | 43% | 49% | 11% | 41% |
| | 3292 | Charles Terminal | 38% | 43% | 16% | 41% | 81% | 11% | 8% |
| | 173 | Weber / Ottawa | 59% | 61% | 33% | 6% | 73% | 22% | 6% |
| | 54 | Fairview Park | 43% | 44% | 24% | 32% | 79% | 16% | 5% |
| | 137 | Sportsworld Station | 51% | 51% | 34% | 15% | 68% | 23% | 9% |
| | 70 | Pinebush Station | 32% | 33% | 65% | 2% | 48% | 50% | 3% |
| | 3289 | Cambridge Centre Station | 33% | 36% | 34% | 30% | 66% | 33% | 1% |
| | 3288 | Ainslie Terminal | 34% | 40% | 47% | 13% | 51% | 31% | 18% |
| | 3467 | Regina / Bridgeport | 32% | 32% | 32% | 37% | 53% | 16% | 32% |
| OVERALL | - | - | 57% | 59% | - | - | 77% | - | - |

Performance Report for Route 200 (Summer)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 3290 | Conestoga Mall | 63% | 64% | 17% | 19% | 90% | 9% | 1% |
| | 121 | Mccormick | 73% | 74% | 23% | 3% | 85% | 13% | 2% |
| | 150 | U.W. / Columbia | 72% | 73% | 17% | 10% | 83% | 9% | 8% |
| | 151 | U.W. - Davis Centre | 69% | 69% | 24% | 6% | 86% | 10% | 4% |
| | 146 | Laurier | 63% | 66% | 26% | 7% | 78% | 13% | 9% |
| | 3467 | Regina / Bridgeport | 60% | 65% | 26% | 9% | 73% | 13% | 14% |
| | 3292 | Charles Terminal | 31% | 34% | 65% | 1% | 76% | 20% | 4% |
| | 173 | Weber / Ottawa | 56% | 57% | 39% | 4% | 72% | 25% | 3% |
| | 54 | Fairview Park | 39% | 41% | 55% | 3% | 82% | 16% | 2% |
| | 137 | Sportsworld Station | 63% | 64% | 19% | 17% | 82% | 11% | 7% |
| | 70 | Pinebush Station | 54% | 54% | 40% | 5% | 71% | 23% | 6% |
| | 3289 | Cambridge Centre Station | 32% | 33% | 12% | 55% | 89% | 9% | 2% |
| | 3288 | Ainslie Terminal | 54% | 68% | 15% | 16% | 62% | 7% | 31% |
| | 3463 | Grand River Hospital - Green Street | 43% | 44% | 55% | 1% | 63% | 35% | 1% |
| MID-DAY | 3290 | Conestoga Mall | 84% | 85% | 14% | 0% | 94% | 5% | 1% |
| | 121 | Mccormick | 69% | 71% | 11% | 18% | 82% | 5% | 13% |
| | 150 | U.W. / Columbia | 69% | 74% | 12% | 13% | 77% | 7% | 16% |
| | 151 | U.W. - Davis Centre | 69% | 69% | 16% | 15% | 85% | 9% | 6% |
| | 146 | Laurier | 68% | 70% | 25% | 5% | 81% | 13% | 6% |
| | 3467 | Regina / Bridgeport | 58% | 62% | 17% | 22% | 67% | 9% | 24% |
| | 3292 | Charles Terminal | 46% | 51% | 42% | 7% | 78% | 17% | 5% |
| | 173 | Weber / Ottawa | 52% | 55% | 44% | 1% | 67% | 30% | 3% |
| | 54 | Fairview Park | 40% | 41% | 58% | 1% | 72% | 27% | 1% |
| | 137 | Sportsworld Station | 52% | 53% | 38% | 9% | 68% | 28% | 4% |
| | 70 | Pinebush Station | 40% | 42% | 49% | 8% | 55% | 36% | 10% |
| | 3289 | Cambridge Centre Station | 27% | 29% | 21% | 50% | 80% | 19% | 1% |
| | 3288 | Ainslie Terminal | 51% | 58% | 33% | 9% | 65% | 19% | 16% |
| | 3463 | Grand River Hospital - Green Street | 56% | 58% | 34% | 8% | 73% | 18% | 10% |
| PM | 3290 | Conestoga Mall | 83% | 84% | 12% | 4% | 93% | 5% | 2% |
| | 121 | Mccormick | 61% | 64% | 11% | 25% | 76% | 6% | 18% |
| | 150 | U.W. / Columbia | 59% | 61% | 10% | 29% | 71% | 7% | 22% |
| | 151 | U.W. - Davis Centre | 69% | 69% | 13% | 18% | 85% | 10% | 5% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 146 | Laurier | 69% | 70% | 23% | 7% | 80% | 14% | 6% |
| | 3467 | Regina / Bridgeport | 47% | 48% | 19% | 32% | 56% | 13% | 31% |
| | 3292 | Charles Terminal | 42% | 47% | 33% | 20% | 79% | 15% | 6% |
| | 173 | Weber / Ottawa | 60% | 61% | 32% | 7% | 71% | 23% | 6% |
| | 54 | Fairview Park | 55% | 56% | 39% | 5% | 80% | 19% | 2% |
| | 137 | Sportsworld Station | 64% | 64% | 30% | 6% | 75% | 23% | 2% |
| | 70 | Pinebush Station | 32% | 32% | 66% | 1% | 52% | 46% | 1% |
| | 3289 | Cambridge Centre Station | 37% | 39% | 32% | 29% | 68% | 31% | 1% |
| | 3288 | Ainslie Terminal | 36% | 42% | 48% | 10% | 51% | 33% | 16% |
| | 3463 | Grand River Hospital - Green Street | 53% | 55% | 39% | 6% | 66% | 26% | 8% |
| OVERALL | - | - | 56% | 58% | - | - | 74% | - | - |

## Performance Report for Route 200 (Fall)

**Appendix C: *TDR* Result for Each Segment in Correlation Test**

(6 pages)

| LINE_ID | Start_ID | End_ID | Start_NAME | End_NAME | Time_Sched | Year | Season | Time | TDR | DTR | TTR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 540 | 2017 | Summer | AM | 191 | 215 | -26 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 540 | 2017 | Fall | AM | 143 | 188 | -39 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 2017 | Summer | AM | 143 | 164 | -31.5 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 2017 | Summer | Mid-day | 117 | 114 | -22 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 2017 | Summer | PM | 192 | 230 | -49.5 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 2017 | Fall | AM | 103 | 135 | -45 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 2017 | Fall | Mid-day | 152 | 158.5 | -17 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | 2017 | Fall | PM | 22 | 72 | -50 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | 2017 | Summer | Mid-day | 60 | 122 | -79 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | 2017 | Summer | PM | 84 | 113.5 | -53 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | 2017 | Fall | Mid-day | 119 | 114 | -27 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | 2017 | Fall | PM | 89 | 105 | -40 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 180 | 2017 | Summer | AM | 24.5 | 17 | 6.5 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 180 | 2017 | Fall | AM | 24 | 22 | -2.5 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 240 | 2017 | Summer | AM | 0 | 21 | -19 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 240 | 2017 | Fall | AM | -19 | 24 | -47 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | 2017 | Summer | AM | -95 | 18 | -113 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | 2017 | Summer | Mid-day | -49 | 23 | -79 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | 2017 | Summer | PM | -97 | 15 | -112 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | 2017 | Fall | AM | -97 | 19 | -118 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | 2017 | Fall | Mid-day | -65 | 25 | -92 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | 2017 | Summer | Mid-day | -89.5 | 78 | -167.5 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | 2017 | Summer | PM | -45 | 29 | -99 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | 2017 | Fall | Mid-day | -96 | 36.5 | -135.5 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | 2017 | Fall | PM | -83 | 32 | -118 |
| 200 | 146 | 82 | Laurier | Regina / Bridgeport | 180 | 2017 | Summer | AM | 26 | 24 | 0 |
| 200 | 146 | 82 | Laurier | Regina / Bridgeport | 240 | 2017 | Summer | AM | -10 | 27 | -41 |
| 200 | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 2017 | Summer | AM | -72 | 31 | -98 |
| 200 | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 2017 | Summer | Mid-day | -64 | 25 | -93 |
| 200 | 146 | 82 | Laurier | Regina / Bridgeport | 300 | 2017 | Summer | PM | -72 | 24 | -99 |
| 200 | 146 | 82 | Laurier | Regina / Bridgeport | 360 | 2017 | Summer | Mid-day | -97 | 34 | -133 |
| 200 | 146 | 82 | Laurier | Regina / Bridgeport | 360 | 2017 | Summer | PM | -96.5 | 28 | -133 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 600 | 2017 | Summer | AM | -70 | 15 | -88 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 600 | 2017 | Fall | AM | -31 | 15 | -43 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Summer | AM | -45 | 15.5 | -58.5 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Summer | Mid-day | 13.5 | 16 | -10.5 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Summer | PM | -36 | 0 | -36 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Fall | AM | -1 | 25 | -15 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Fall | Mid-day | -25 | 17 | -31 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Fall | PM | -74 | 15 | -89 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 720 | 2017 | Summer | Mid-day | 88 | 28 | 60 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 720 | 2017 | Fall | Mid-day | 98 | 29 | 69 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 2017 | Summer | Mid-day | 133 | 127 | 6 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 2017 | Summer | PM | -39 | 17.5 | -64 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 2017 | Fall | Mid-day | -34 | 47 | -81 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 2017 | Fall | PM | -48.5 | 19 | -80.5 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 540 | 2017 | Fall | AM | 367 | 26 | 341 |
| 200 | 3467 | 3463 | Regina / Bridgeport | Grand River Hospital - Green Street | 180 | 2017 | Fall | AM | 111 | 21 | 105 |
| 200 | 3467 | 3463 | Regina / Bridgeport | Grand River Hospital - Green Street | 240 | 2017 | Fall | AM | 131 | 14 | 118 |
| 200 | 3467 | 3463 | Regina / Bridgeport | Grand River Hospital - Green Street | 300 | 2017 | Fall | Mid-day | 80 | 16 | 59 |
| 200 | 3467 | 3463 | Regina / Bridgeport | Grand River Hospital - Green Street | 300 | 2017 | Fall | PM | 123 | 22 | 96 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 420 | 2017 | Summer | AM | -28 | 3 | -46 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 420 | 2017 | Fall | AM | -41 | -4 | -37 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 480 | 2017 | Summer | AM | -41 | -53 | -4 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 480 | 2017 | Fall | AM | 112 | 84 | 28 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 2017 | Summer | AM | 4 | -43 | 30 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 2017 | Summer | Mid-day | 101 | 35 | 58 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 2017 | Summer | PM | 168 | 122 | 20 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 2017 | Fall | AM | -48 | -103 | 27 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 2017 | Fall | Mid-day | 2 | -45 | 34 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | 2017 | Fall | PM | 286 | 196 | 90 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 2017 | Summer | Mid-day | 93 | 93 | 4 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 2017 | Summer | PM | 136 | 92 | 18 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 2017 | Fall | Mid-day | 48 | 18.5 | -2 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | 2017 | Fall | PM | 7 | -13 | -11 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 660 | 2017 | Fall | AM | -209 | -215 | -31 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2017 | Summer | AM | -139 | 30 | -183 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2017 | Summer | Mid-day | -95 | 40 | -152 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2017 | Summer | PM | -94.5 | 50 | -143 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2017 | Fall | AM | -132.5 | 49.5 | -190.5 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2017 | Fall | Mid-day | -95 | 47.5 | -142.5 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | 2017 | Fall | PM | -80 | 62 | -139 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 2017 | Summer | Mid-day | -77 | 19 | -107 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 2017 | Summer | PM | -53 | 16 | -81 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 2017 | Fall | Mid-day | -32 | 70 | -90 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | 2017 | Fall | PM | -62.5 | 40.5 | -119.5 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 600 | 2017 | Summer | Mid-day | -165.5 | 32.5 | -208.5 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 600 | 2017 | Fall | Mid-day | -25 | 79 | -104 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 360 | 2017 | Fall | AM | 54 | 19 | 28.5 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 360 | 2017 | Fall | Mid-day | 48 | 16 | 20 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 420 | 2017 | Fall | Mid-day | 31 | 26 | -17 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 420 | 2017 | Fall | PM | 32 | 32 | -9 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 2017 | Summer | AM | 47.5 | 84 | -54 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 2017 | Summer | Mid-day | 23 | 67 | -51 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 2017 | Summer | PM | 96 | 99 | -31 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 2017 | Fall | AM | 73 | 136 | -63.5 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 2017 | Fall | Mid-day | 25 | 86 | -63 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | 2017 | Fall | PM | 102.5 | 117.5 | -18.5 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 660 | 2017 | Fall | AM | -156 | -122 | -49 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 600 | 2017 | Fall | Mid-day | -110 | -62 | -56 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 600 | 2017 | Fall | PM | -45.5 | -44 | -32 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 480 | 2017 | Summer | AM | 112 | 32 | 65 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 480 | 2017 | Fall | AM | 92.5 | 37 | 49.5 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 2017 | Summer | AM | 68 | 34 | 20.5 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 2017 | Summer | Mid-day | 109 | 34 | 63 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 2017 | Summer | PM | 163 | 38 | 109 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 2017 | Fall | AM | 98 | 29 | 50 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 2017 | Fall | Mid-day | 41 | 29 | 0 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | 2017 | Fall | PM | 147 | 31 | 109 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 2017 | Summer | AM | -187 | 27 | -212 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 2017 | Summer | PM | -176 | 18.5 | -196.5 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 2017 | Fall | AM | -203 | 25 | -232 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | 2017 | Fall | PM | -98 | 39 | -137 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 2017 | Summer | AM | -245 | 23 | -271 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 2017 | Summer | Mid-day | -235 | 20 | -258 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 2017 | Summer | PM | -221 | 24 | -248 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 2017 | Fall | AM | -244 | 20 | -267 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 2017 | Fall | Mid-day | -243 | 18 | -262 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | 2017 | Fall | PM | -224 | 23 | -252 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 540 | 2017 | Summer | PM | -265.5 | 40.5 | -307 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 540 | 2017 | Fall | PM | -341 | 21 | -362 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 360 | 2017 | Fall | AM | -123 | 25 | -151 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 420 | 2017 | Summer | AM | 62 | 0 | 34.5 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 420 | 2017 | Fall | AM | 48.5 | 0 | 19.5 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 2017 | Summer | Mid-day | -15 | 0 | -15 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 2017 | Summer | PM | -30 | 0 | -30 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 2017 | Fall | AM | -69 | 0 | -69 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 2017 | Fall | Mid-day | -53 | 0 | -53 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 480 | 2017 | Fall | PM | -80 | 0 | -80 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 2017 | Summer | Mid-day | -60 | 0 | -60 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 2017 | Summer | PM | -53 | 0 | -53 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 2017 | Fall | Mid-day | -83.5 | 0 | -83.5 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 540 | 2017 | Fall | PM | -55 | 0 | -58 |
| 200 | 3290 | 3292 | Conestoga Mall | Charles Terminal | 1080 | 2017 | Fall | AM | -107 | 0 | -107 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 2017 | Summer | AM | -2.5 | 22 | -27.5 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 2017 | Summer | Mid-day | 20 | 31 | -19 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 2017 | Summer | PM | 1 | 18 | -14 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 2017 | Fall | AM | 8.5 | 27 | -20.5 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 2017 | Fall | Mid-day | 9 | 29 | -26 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | 2017 | Fall | PM | -8 | 14 | -22 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 2017 | Summer | AM | -39 | 32 | -74 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 2017 | Summer | Mid-day | -35.5 | 30.5 | -75 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 2017 | Summer | PM | -32 | 24 | -64 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 2017 | Fall | AM | -42 | 33 | -81 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 2017 | Fall | Mid-day | -40 | 29 | -73.5 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | 2017 | Fall | PM | -26 | 23 | -57 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. -  Davis Centre | 120 | 2017 | Summer | AM | 9 | 31 | -32 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. -  Davis Centre | 120 | 2017 | Summer | Mid-day | 3 | 30 | -33 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. -  Davis Centre | 120 | 2017 | Summer | PM | 23 | 48 | -30 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. -  Davis Centre | 120 | 2017 | Fall | AM | 14 | 34 | -30 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. -  Davis Centre | 120 | 2017 | Fall | Mid-day | 14 | 35 | -29 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. -  Davis Centre | 120 | 2017 | Fall | PM | 30 | 50 | -24 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. -  Davis Centre | 60 | 2017 | Fall | AM | 28 | 0 | 21 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 240 | 2017 | Summer | AM | 0 | 13 | -12 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 240 | 2017 | Fall | AM | -4 | 0 | -14 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 300 | 2017 | Summer | AM | 24 | 23 | -25 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 300 | 2017 | Summer | Mid-day | 25 | 31 | -11 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 300 | 2017 | Summer | PM | 70.5 | 41 | 3.5 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 300 | 2017 | Fall | AM | 24 | 25 | -11 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 300 | 2017 | Fall | Mid-day | 42 | 36 | 1 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 300 | 2017 | Fall | PM | 83 | 145 | -62 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 360 | 2017 | Summer | Mid-day | 3.5 | 42.5 | -43 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 360 | 2017 | Summer | PM | 27 | 48 | -40 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 360 | 2017 | Fall | Mid-day | 40.5 | 47.5 | -25 |
| 200 | 151 | 146 | U.W. -  Davis Centre | Laurier | 360 | 2017 | Fall | PM | 62.5 | 54 | -5 |
| 200 | 3463 | 3292 | Grand River Hospital - Green Street | Charles Terminal | 300 | 2017 | Fall | AM | 34 | 17 | 16 |
| 200 | 3463 | 3292 | Grand River Hospital - Green Street | Charles Terminal | 300 | 2017 | Fall | Mid-day | 34 | 16 | 19 |
| 200 | 3463 | 3292 | Grand River Hospital - Green Street | Charles Terminal | 420 | 2017 | Fall | Mid-day | -58.5 | 32.5 | -104 |
| 200 | 3463 | 3292 | Grand River Hospital - Green Street | Charles Terminal | 420 | 2017 | Fall | PM | -57 | 18 | -81 |

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|---|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 600 | 2017 | Summer | AM | -9 | 18 | -31 |
| 200 | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Summer | AM | -4.5 | 16 | -23 |
| 200 | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Summer | Mid-day | -0.5 | 16 | -21 |
| 200 | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | 2017 | Summer | PM | 37 | 19 | 10 |
| 200 | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 720 | 2017 | Summer | Mid-day | 5 | 17 | -11 |
| 200 | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 2017 | Summer | Mid-day | -2 | 23 | -61 |
| 200 | 82 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | 2017 | Summer | PM | -18 | 19 | -42 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420 | 2017 | Summer | AM | 174 | 0 | 153 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420 | 2017 | Summer | Mid-day | 140 | 0 | 140 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420 | 2017 | Fall | AM | 190.5 | 0 | 168 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420 | 2017 | Fall | Mid-day | 150 | 0 | 150 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360 | 2017 | Summer | Mid-day | 205 | 0 | 205 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360 | 2017 | Summer | PM | 184.5 | 0 | 184.5 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360 | 2017 | Fall | Mid-day | 231.5 | 0 | 231.5 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360 | 2017 | Fall | PM | 202 | 0 | 202 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | 2017 | Summer | AM | -94 | 0 | -95 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | 2017 | Summer | Mid-day | -72 | 0 | -80 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | 2017 | Summer | PM | -57.5 | 0 | -63.5 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | 2017 | Fall | AM | -81 | 0 | -86 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | 2017 | Fall | Mid-day | -65 | 0 | -71 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | 2017 | Fall | PM | -31 | 0 | -38 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180 | 2017 | Summer | Mid-day | -15 | 0 | -21 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180 | 2017 | Summer | PM | -19.5 | 0 | -26 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180 | 2017 | Fall | Mid-day | 9 | 0 | 3 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180 | 2017 | Fall | PM | 24 | 11 | 14 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 300 | 2017 | Summer | AM | -44 | 15 | -58 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 300 | 2017 | Summer | Mid-day | -8 | 29 | -36 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 300 | 2017 | Fall | AM | -25 | 18 | -46 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 300 | 2017 | Fall | Mid-day | 39 | 41 | -4 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 360 | 2017 | Summer | Mid-day | -57 | 34 | -95 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 360 | 2017 | Summer | PM | -22 | 38 | -73.5 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 360 | 2017 | Fall | Mid-day | 98 | 68 | 18 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 360 | 2017 | Fall | PM | 27 | 56 | -32 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | 2017 | Summer | AM | 5.5 | 17 | -27.5 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | 2017 | Summer | Mid-day | 10 | 41 | -34 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | 2017 | Summer | PM | 26.5 | 33.5 | -10.5 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | 2017 | Fall | AM | -6.5 | 18 | -42 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | 2017 | Fall | Mid-day | 34 | 37 | -5 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | 2017 | Fall | PM | 49 | 49 | 6 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 360 | 2017 | Summer | Mid-day | -35 | 30 | -63 |

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| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 360 | 2017 | Summer | PM | 13.5 | 53 | -34.5 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 360 | 2017 | Fall | Mid-day | 66 | 54.5 | 16 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 360 | 2017 | Fall | PM | 42 | 56 | -6 |
| 31 | 28 | 103 | Columbia / King | Bridge / Northfield | 780 | 2017 | Fall | AM | 30.5 | 20.5 | -4 |
| 31 | 28 | 103 | Columbia / King | Bridge / Northfield | 780 | 2017 | Fall | Mid-day | -1 | 32 | -27.5 |
| 31 | 28 | 103 | Columbia / King | Bridge / Northfield | 780 | 2017 | Fall | PM | 27 | 64 | -3 |
| 31 | 28 | 103 | Columbia / King | Bridge / Northfield | 900 | 2017 | Fall | Mid-day | 361 | 61 | 300 |
| 31 | 28 | 103 | Columbia / King | Bridge / Northfield | 900 | 2017 | Fall | PM | -13 | 54 | -63 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | 2017 | Summer | AM | -22 | 0 | -23 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | 2017 | Summer | Mid-day | -42.5 | 0 | -43 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | 2017 | Summer | PM | -51 | 0 | -52.5 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | 2017 | Fall | AM | -15 | 0 | -17 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | 2017 | Fall | Mid-day | -49 | 0 | -52 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | 2017 | Fall | PM | -14 | 0 | -21 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540 | 2017 | Summer | Mid-day | -63 | 0 | -63 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540 | 2017 | Summer | PM | -60 | 0 | -66 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540 | 2017 | Fall | Mid-day | 58 | 15 | 40 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540 | 2017 | Fall | PM | -33 | 10 | -44 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | 2017 | Summer | AM | 35 | 0 | 31 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | 2017 | Summer | Mid-day | 20 | 0 | 19 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | 2017 | Summer | PM | -18 | 0 | -18 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | 2017 | Fall | AM | 6 | 0 | 5 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | 2017 | Fall | Mid-day | -4 | 0 | -7 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | 2017 | Fall | PM | -19 | 0 | -22 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420 | 2017 | Summer | Mid-day | -37 | 0 | -37 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420 | 2017 | Summer | PM | -32 | 0 | -38.5 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420 | 2017 | Fall | Mid-day | -50 | 0 | -55 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420 | 2017 | Fall | PM | -55 | 0 | -57 |

## Appendix D: List of Paired Records of TDR Correlation Test

(3 pages)

| LINE_ID | Start_ID | End_ID | Start_NAME | End_NAME | Time_Sched | Season1 | Season2 | Time | TDR1 | TDR2 |
|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 540 | Summer | Fall | AM | 191 | 143 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | Summer | Fall | AM | 143 | 103 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | Summer | Fall | Mid-day | 117 | 152 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 600 | Summer | Fall | PM | 192 | 22 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | Summer | Fall | Mid-day | 60 | 119 |
| 200 | 3289 | 3288 | Cambridge Centre Station | Ainslie Terminal | 660 | Summer | Fall | PM | 84 | 89 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 180 | Summer | Fall | AM | 24.5 | 24 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 240 | Summer | Fall | AM | 0 | -19 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | Summer | Fall | AM | -95 | -97 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 300 | Summer | Fall | Mid-day | -49 | -65 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | Summer | Fall | Mid-day | -89.5 | -96 |
| 200 | 146 | 3467 | Laurier | Regina / Bridgeport | 360 | Summer | Fall | PM | -45 | -83 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 600 | Summer | Fall | AM | -70 | -31 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | Summer | Fall | AM | -45 | -1 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | Summer | Fall | Mid-day | 13.5 | -25 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 660 | Summer | Fall | PM | -36 | -74 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 720 | Summer | Fall | Mid-day | 88 | 98 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | Summer | Fall | Mid-day | 133 | -34 |
| 200 | 3467 | 3292 | Regina / Bridgeport | Charles Terminal | 780 | Summer | Fall | PM | -39 | -48.5 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 420 | Summer | Fall | AM | -28 | -41 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 480 | Summer | Fall | AM | -41 | 112 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | Summer | Fall | AM | 4 | -48 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | Summer | Fall | Mid-day | 101 | 2 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 540 | Summer | Fall | PM | 168 | 286 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | Summer | Fall | Mid-day | 93 | 48 |
| 200 | 3292 | 173 | Charles Terminal | Weber / Ottawa | 600 | Summer | Fall | PM | 136 | 7 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | Summer | Fall | AM | -139 | -132.5 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | Summer | Fall | Mid-day | -95 | -95 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 540 | Summer | Fall | PM | -94.5 | -80 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | Summer | Fall | Mid-day | -77 | -32 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 480 | Summer | Fall | PM | -53 | -62.5 |
| 200 | 173 | 54 | Weber / Ottawa | Fairview Park | 600 | Summer | Fall | Mid-day | -165.5 | -25 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | Summer | Fall | AM | 47.5 | 73 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | Summer | Fall | Mid-day | 23 | 25 |
| 200 | 54 | 137 | Fairview Park | Sportsworld Station | 480 | Summer | Fall | PM | 96 | 102.5 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 480 | Summer | Fall | AM | 112 | 92.5 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | Summer | Fall | AM | 68 | 98 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | Summer | Fall | Mid-day | 109 | 41 |
| 200 | 137 | 70 | Sportsworld Station | Pinebush Station | 540 | Summer | Fall | PM | 163 | 147 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | Summer | Fall | AM | -187 | -203 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 420 | Summer | Fall | PM | -176 | -98 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | Summer | Fall | AM | -245 | -244 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | Summer | Fall | Mid-day | -235 | -243 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 480 | Summer | Fall | PM | -221 | -224 |
| 200 | 70 | 3289 | Pinebush Station | Cambridge Centre Station | 540 | Summer | Fall | PM | -265.5 | -341 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 420 | Summer | Fall | AM | 62 | 48.5 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 480 | Summer | Fall | Mid-day | -15 | -53 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 480 | Summer | Fall | PM | -30 | -80 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 540 | Summer | Fall | Mid-day | -60 | -83.5 |
| 200 | 3290 | 121 | Conestoga Mall | Mccormick | 540 | Summer | Fall | PM | -53 | -55 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | Summer | Fall | AM | -2.5 | 8.5 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | Summer | Fall | Mid-day | 20 | 9 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 240 | Summer | Fall | PM | 1 | -8 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | Summer | Fall | AM | -39 | -42 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | Summer | Fall | Mid-day | -35.5 | -40 |
| 200 | 121 | 150 | Mccormick | U.W. / Columbia | 300 | Summer | Fall | PM | -32 | -26 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | Summer | Fall | AM | 9 | 14 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | Summer | Fall | Mid-day | 3 | 14 |
| 200 | 150 | 151 | U.W. / Columbia | U.W. - Davis Centre | 120 | Summer | Fall | PM | 23 | 30 |
| 200 | 151 | 146 | U.W. - Davis Centre | Laurier | 240 | Summer | Fall | AM | 0 | -4 |
| 200 | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | Summer | Fall | AM | 24 | 24 |
| 200 | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | Summer | Fall | Mid-day | 25 | 42 |
| 200 | 151 | 146 | U.W. - Davis Centre | Laurier | 300 | Summer | Fall | PM | 70.5 | 83 |
| 200 | 151 | 146 | U.W. - Davis Centre | Laurier | 360 | Summer | Fall | Mid-day | 3.5 | 40.5 |
| 200 | 151 | 146 | U.W. - Davis Centre | Laurier | 360 | Summer | Fall | PM | 27 | 62.5 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420 | Summer | Fall | AM | 174 | 190.5 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 420 | Summer | Fall | Mid-day | 140 | 150 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360 | Summer | Fall | Mid-day | 205 | 231.5 |
| 31 | 32 | 44 | Columbia / Sundew | Columbia / Fischer-Hallman | 360 | Summer | Fall | PM | 184.5 | 202 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | Summer | Fall | AM | -94 | -81 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | Summer | Fall | Mid-day | -72 | -65 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 240 | Summer | Fall | PM | -57.5 | -31 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180 | Summer | Fall | Mid-day | -15 | 9 |
| 31 | 44 | 150 | Columbia / Fischer-Hallman | Columbia / U.W. | 180 | Summer | Fall | PM | -19.5 | 24 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 300 | Summer | Fall | AM | -44 | -25 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 300 | Summer | Fall | Mid-day | -8 | 39 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 360 | Summer | Fall | Mid-day | -57 | 98 |
| 31 | 150 | 28 | Columbia / U.W. | Columbia / King | 360 | Summer | Fall | PM | -22 | 27 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | Summer | Fall | AM | 5.5 | -6.5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | Summer | Fall | Mid-day | 10 | 34 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 300 | Summer | Fall | PM | 26.5 | 49 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 360 | Summer | Fall | Mid-day | -35 | 66 |
| 31 | 28 | 12 | Columbia / King | Lexington / Bridge | 360 | Summer | Fall | PM | 13.5 | 42 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | Summer | Fall | AM | -22 | -15 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | Summer | Fall | Mid-day | -42.5 | -49 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 480 | Summer | Fall | PM | -51 | -14 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540 | Summer | Fall | Mid-day | -63 | 58 |
| 31 | 12 | 103 | Lexington / Bridge | Bridge / Northfield | 540 | Summer | Fall | PM | -60 | -33 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | Summer | Fall | AM | 35 | 6 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | Summer | Fall | Mid-day | 20 | -4 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 360 | Summer | Fall | PM | -18 | -19 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420 | Summer | Fall | Mid-day | -37 | -50 |
| 31 | 103 | 3290 | Bridge / Northfield | Conestoga Mall | 420 | Summer | Fall | PM | -32 | -55 |

## Appendix E: Hourly Result Report of Summer

(2 page)

| Time | Start_ID | End_ID | TT_Sched | Time | Trip# | +TD% | -TD% | TDR | DTR | TTR | Change? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 44 | 150 | 240 | 6-7AM | 128 | 0.00% | 100.00% | -111.5 | 0 | -112.5 | YES |
| | 44 | 150 | 240 | 7-8AM | 43 | 0.00% | 100.00% | -79 | 0 | -79 | YES |
| | 44 | 150 | 240 | 8-9AM | 86 | 3.49% | 96.51% | -54 | 0 | -55 | NO |
| PM | 12 | 103 | 540 | 3-4PM | 85 | 12.94% | 87.06% | -69 | 0 | -74 | YES |
| | 12 | 103 | 540 | 4-5PM | 85 | 15.29% | 84.71% | -38 | 10 | -44 | NO |
| | 12 | 103 | 540 | 5-6PM | 84 | 13.10% | 85.71% | -68.5 | 0 | -74.5 | YES |

Hourly Result Report for Route 31

| Time | Start_ID | End_ID | TT_Sched | Time | Trip# | +TD% | -TD% | TDR | DTR | TTR | Change? |
|---|---|---|---|---|---|---|---|---|---|---|---|
| AM | 137 | 70 | 540 | 6-7AM | 37 | 0.297297 | 0.702703 | -26 | 40 | -78 | NO |
| | 137 | 70 | 540 | 7-8AM | 166 | 0.819277 | 0.180723 | 78 | 36 | 31 | YES |
| | 137 | 70 | 540 | 8-9AM | 163 | 0.828221 | 0.171779 | 75 | 30 | 39 | YES |
| MID-DAY | 137 | 70 | 540 | 9-10AM | 158 | 0.759494 | 0.240506 | 60 | 30.5 | 21.5 | YES |
| | 137 | 70 | 540 | 10-11AM | 167 | 0.790419 | 0.203593 | 67 | 35 | 16 | YES |
| | 137 | 70 | 540 | 11-12AM | 165 | 0.866667 | 0.127273 | 94 | 30 | 51 | YES |
| | 137 | 70 | 540 | 12-13AM | 162 | 0.925926 | 0.074074 | 132.5 | 34 | 90.5 | YES |
| | 137 | 70 | 540 | 13-14AM | 167 | 0.922156 | 0.071856 | 129 | 34 | 89 | YES |
| | 137 | 70 | 540 | 14-15AM | 160 | 0.94375 | 0.05625 | 150 | 38 | 109.5 | YES |
| | 3292 | 173 | 540 | 9-10AM | 167 | 0.682635 | 0.311377 | 52 | 3 | 49 | NO |
| | 3292 | 173 | 540 | 10-11AM | 210 | 0.866667 | 0.133333 | 129.5 | 67 | 58 | YES |
| | 3292 | 173 | 540 | 11-12AM | 205 | 0.853659 | 0.146341 | 127 | 51 | 62 | YES |
| | 3292 | 173 | 540 | 12-13AM | 202 | 0.69802 | 0.292079 | 64.5 | -9 | 58 | YES |
| | 3292 | 173 | 540 | 13-14AM | 211 | 0.796209 | 0.203791 | 110 | 44 | 60 | YES |
| | 3292 | 173 | 540 | 14-15AM | 83 | 0.759036 | 0.240964 | 102 | 44 | 55 | YES |
| | 146 | 82 | 300 | 9-10AM | 162 | 0.037037 | 0.962963 | -77 | 25 | -105.5 | YES |
| | 146 | 82 | 300 | 10-11AM | 159 | 0.050314 | 0.949686 | -71 | 23 | -96 | YES |
| | 146 | 82 | 300 | 11-12AM | 158 | 0.113924 | 0.886076 | -58 | 24 | -89 | NO |
| | 146 | 82 | 300 | 12-13AM | 164 | 0.152439 | 0.835366 | -57 | 27 | -87 | NO |
| | 146 | 82 | 300 | 13-14AM | 162 | 0.12963 | 0.864198 | -55.5 | 26 | -90 | NO |
| | 146 | 82 | 300 | 14-15AM | 38 | 0.052632 | 0.921053 | -58.5 | 24 | -81 | NO |
| PM | 3289 | 3288 | 660 | 15-16AM | 124 | 0.693548 | 0.306452 | 84.5 | 101 | -43.5 | YES |
| | 3289 | 3288 | 660 | 16-17AM | 157 | 0.853503 | 0.146497 | 116 | 112 | -12 | YES |
| | 3289 | 3288 | 660 | 17-18AM | 152 | 0.710526 | 0.289474 | 84.5 | 127 | -49 | YES |
| | 3289 | 3288 | 660 | 18-19AM | 79 | 0.455696 | 0.544304 | -15 | 106 | -127 | NO |
| | 137 | 70 | 540 | 15-16AM | 124 | 0.991935 | 0.008065 | 194 | 49.5 | 126.5 | YES |
| | 137 | 70 | 540 | 16-17AM | 160 | 0.975 | 0.025 | 188 | 37 | 142.5 | YES |
| | 137 | 70 | 540 | 17-18AM | 168 | 0.958333 | 0.041667 | 165.5 | 34 | 113.5 | YES |
| | 137 | 70 | 540 | 18-19AM | 118 | 0.686441 | 0.313559 | 53 | 32 | 12.5 | NO |

Hourly Result Report for Route 200

**Appendix F: Performance Report for Fall after Schedule Adjustment (Resource Unconstrained)**

(4 page)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 32 | Columbia / Sundew | 45.48% | 45.48% | 40.37% | 14.15% | 80.97% | 19.03% | 0.00% |
| | 44 | Columbia / Fischer-Hallman | 61.60% | 61.60% | 36.27% | 2.13% | 77.33% | 22.67% | 0.00% |
| | 150 | Columbia / U.W. | 61.60% | 61.87% | 37.60% | 0.53% | 74.13% | 25.87% | 0.00% |
| | 28 | Columbia / King | 52.94% | 52.94% | 39.84% | 7.22% | 73.26% | 26.74% | 0.00% |
| | 12 | Lexington / Bridge | 55.06% | 55.06% | 39.58% | 5.36% | 75.30% | 24.70% | 0.00% |
| | 103 | Bridge / Northfield | 60.16% | 60.16% | 37.70% | 2.14% | 74.87% | 25.13% | 0.00% |
| | 3290 | Conestoga Mall | 62.38% | 62.38% | 36.98% | 0.64% | 77.17% | 22.83% | 0.00% |
| MID-DAY | 32 | Columbia / Sundew | 59.10% | 59.10% | 39.04% | 1.86% | 86.45% | 13.55% | 0.00% |
| | 44 | Columbia / Fischer-Hallman | 52.93% | 52.93% | 42.95% | 4.12% | 81.12% | 18.88% | 0.00% |
| | 150 | Columbia / U.W. | 51.13% | 51.13% | 48.20% | 0.67% | 70.84% | 29.16% | 0.00% |
| | 28 | Columbia / King | 41.89% | 41.89% | 57.31% | 0.80% | 57.98% | 42.02% | 0.00% |
| | 12 | Lexington / Bridge | 29.96% | 29.96% | 69.03% | 1.01% | 57.31% | 42.69% | 0.00% |
| | 103 | Bridge / Northfield | 36.88% | 36.88% | 59.65% | 3.46% | 62.58% | 37.42% | 0.00% |
| | 3290 | Conestoga Mall | 42.25% | 42.25% | 56.02% | 1.74% | 63.90% | 36.10% | 0.00% |
| PM | 32 | Columbia / Sundew | 25.05% | 25.05% | 73.35% | 1.60% | 53.71% | 46.29% | 0.00% |
| | 44 | Columbia / Fischer-Hallman | 27.99% | 27.99% | 67.38% | 4.63% | 51.16% | 48.84% | 0.00% |
| | 150 | Columbia / U.W. | 32.80% | 32.80% | 60.76% | 6.44% | 49.50% | 50.50% | 0.00% |
| | 28 | Columbia / King | 28.17% | 28.17% | 66.60% | 5.23% | 42.05% | 57.95% | 0.00% |
| | 12 | Lexington / Bridge | 22.44% | 22.44% | 72.00% | 5.56% | 41.11% | 58.89% | 0.00% |
| | 103 | Bridge / Northfield | 24.80% | 24.80% | 71.98% | 3.23% | 43.55% | 56.45% | 0.00% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3290 | Conestoga Mall | 27.32% | 27.32% | 66.79% | 5.89% | 45.89% | 54.11% | 0.00% |
| OVERALL | - | - | 42.03% | 42.04% | - | - | 63.57% | - | - |

Performance Report of Fall after Schedule Adjustments for Route 31 (Resource Unconstrained)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 3290 | Conestoga Mall | 64% | 64% | 17% | 19% | 91% | 9% | 0% |
| | 121 | Mccormick | 74% | 74% | 18% | 8% | 90% | 10% | 0% |
| | 150 | U.W. / Columbia | 73% | 73% | 13% | 14% | 94% | 6% | 0% |
| | 151 | U.W. - Davis Centre | 82% | 82% | 16% | 2% | 94% | 6% | 0% |
| | 146 | Laurier | 68% | 68% | 22% | 10% | 88% | 12% | 0% |
| | 3467 | Regina / Bridgeport | 72% | 72% | 23% | 5% | 88% | 12% | 0% |
| | 3292 | Charles Terminal | 36% | 36% | 64% | 0% | 82% | 18% | 0% |
| | 173 | Weber / Ottawa | 56% | 56% | 41% | 3% | 74% | 26% | 0% |
| | 54 | Fairview Park | 43% | 43% | 55% | 2% | 85% | 15% | 0% |
| | 137 | Sportsworld Station | 69% | 69% | 18% | 12% | 91% | 9% | 0% |
| | 70 | Pinebush Station | 58% | 58% | 29% | 13% | 83% | 17% | 0% |
| | 3289 | Cambridge Centre Station | 52% | 54% | 25% | 22% | 90% | 10% | 0% |
| | 3288 | Ainslie Terminal | 70% | 70% | 22% | 8% | 91% | 9% | 0% |
| | 3463 | Grand River Hospital - Green Street | 47% | 47% | 53% | 0% | 69% | 31% | 0% |
| MID-DAY | 3290 | Conestoga Mall | 85% | 85% | 14% | 0% | 95% | 5% | 0% |
| | 121 | Mccormick | 73% | 73% | 11% | 16% | 95% | 5% | 0% |
| | 150 | U.W. / Columbia | 81% | 81% | 12% | 7% | 93% | 7% | 0% |
| | 151 | U.W. - Davis Centre | 82% | 83% | 16% | 1% | 91% | 9% | 0% |
| | 146 | Laurier | 72% | 72% | 26% | 2% | 87% | 13% | 0% |
| | 3467 | Regina / Bridgeport | 65% | 65% | 17% | 18% | 91% | 9% | 0% |
| | 3292 | Charles Terminal | 52% | 54% | 45% | 1% | 82% | 18% | 0% |
| | 173 | Weber / Ottawa | 47% | 47% | 53% | 0% | 66% | 34% | 0% |
| | 54 | Fairview Park | 34% | 35% | 65% | 0% | 71% | 29% | 0% |
| | 137 | Sportsworld Station | 53% | 53% | 42% | 5% | 75% | 25% | 0% |
| | 70 | Pinebush Station | 44% | 44% | 37% | 19% | 77% | 23% | 0% |
| | 3289 | Cambridge Centre Station | 53% | 58% | 38% | 4% | 74% | 26% | 0% |
| | 3288 | Ainslie Terminal | 41% | 41% | 58% | 1% | 69% | 31% | 0% |
| | 3463 | Grand River Hospital - Green Street | 64% | 64% | 35% | 1% | 82% | 18% | 0% |
| PM | 3290 | Conestoga Mall | 84% | 84% | 12% | 4% | 95% | 5% | 0% |
| | 121 | Mccormick | 65% | 65% | 11% | 24% | 94% | 6% | 0% |
| | 150 | U.W. / Columbia | 67% | 67% | 10% | 23% | 93% | 7% | 0% |
| | 151 | U.W. - Davis Centre | 86% | 86% | 14% | 0% | 90% | 10% | 0% |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 146 | Laurier | 71% | 71% | 27% | 2% | 85% | 15% | 0% |
| | 3467 | Regina / Bridgeport | 56% | 56% | 20% | 23% | 86% | 14% | 0% |
| | 3292 | Charles Terminal | 53% | 55% | 38% | 7% | 82% | 18% | 0% |
| | 173 | Weber / Ottawa | 55% | 55% | 43% | 2% | 71% | 29% | 0% |
| | 54 | Fairview Park | 48% | 48% | 51% | 1% | 77% | 23% | 0% |
| | 137 | Sportsworld Station | 57% | 57% | 41% | 2% | 75% | 25% | 0% |
| | 70 | Pinebush Station | 42% | 42% | 51% | 7% | 67% | 33% | 0% |
| | 3289 | Cambridge Centre Station | 41% | 47% | 52% | 2% | 59% | 41% | 0% |
| | 3288 | Ainslie Terminal | 35% | 35% | 62% | 3% | 56% | 44% | 0% |
| | 3463 | Grand River Hospital - Green Street | 53% | 53% | 47% | 0% | 71% | 29% | 0% |
| OVERALL | - | - | 60% | 60% | - | - | 82% | - | - |

Performance Report of Fall after Schedule Adjustments for Route 200 (Resource Unconstrained)

**Appendix G: Segment Performance Report for Fall after Schedule Adjustment (Resource Constrained)**

(4 page)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 32 | Columbia / Sundew | 45.48% | 45.48% | 40.37% | 14.15% | 80.97% | 19.03% | 0.00% |
| | 44 | Columbia / Fischer-Hallman | 46.67% | 46.67% | 53.07% | 0.27% | 68.53% | 31.47% | 0.00% |
| | 150 | Columbia / U.W. | 44.27% | 44.53% | 55.47% | 0.00% | 68.00% | 32.00% | 0.00% |
| | 28 | Columbia / King | 43.32% | 43.32% | 56.15% | 0.53% | 59.09% | 40.91% | 0.00% |
| | 12 | Lexington / Bridge | 42.56% | 42.56% | 55.95% | 1.49% | 65.77% | 34.23% | 0.00% |
| | 103 | Bridge / Northfield | 46.79% | 46.79% | 52.94% | 0.27% | 63.90% | 36.10% | 0.00% |
| | 3290 | Conestoga Mall | 44.65% | 44.65% | 54.55% | 0.80% | 60.96% | 39.04% | 0.00% |
| MID-DAY | 32 | Columbia / Sundew | 59.10% | 59.10% | 39.04% | 1.86% | 86.45% | 13.55% | 0.00% |
| | 44 | Columbia / Fischer-Hallman | 34.84% | 34.84% | 64.89% | 0.27% | 65.43% | 34.57% | 0.00% |
| | 150 | Columbia / U.W. | 31.69% | 31.69% | 67.38% | 0.93% | 49.53% | 50.47% | 0.00% |
| | 28 | Columbia / King | 24.07% | 24.07% | 75.40% | 0.53% | 43.35% | 56.65% | 0.00% |
| | 12 | Lexington / Bridge | 16.64% | 16.64% | 83.07% | 0.29% | 37.92% | 62.08% | 0.00% |
| | 103 | Bridge / Northfield | 18.24% | 18.24% | 81.49% | 0.27% | 39.55% | 60.45% | 0.00% |
| | 3290 | Conestoga Mall | 18.39% | 18.39% | 80.88% | 0.73% | 41.75% | 58.25% | 0.00% |
| PM | 32 | Columbia / Sundew | 25.05% | 25.05% | 73.35% | 1.60% | 53.71% | 46.29% | 0.00% |
| | 44 | Columbia / Fischer-Hallman | 17.29% | 17.29% | 82.35% | 0.36% | 39.04% | 60.96% | 0.00% |
| | 150 | Columbia / U.W. | 19.72% | 19.72% | 80.08% | 0.20% | 28.97% | 71.03% | 0.00% |
| | 28 | Columbia / King | 17.71% | 17.71% | 81.49% | 0.80% | 27.57% | 72.43% | 0.00% |
| | 12 | Lexington / Bridge | 14.44% | 14.44% | 83.78% | 1.78% | 27.33% | 72.67% | 0.00% |
| | 103 | Bridge / Northfield | 14.92% | 14.92% | 83.67% | 1.41% | 26.61% | 73.39% | 0.00% |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 3290 | Conestoga Mall | 19.82% | 19.82% | 79.11% | 1.07% | 31.79% | 68.21% | 0.00% |
| OVERALL | - | - | 29.52% | 29.53% | - | - | 49.91% | - | - |

Performance Report of Fall after Schedule Adjustments for Route 31 (Resource Constrained)

| TIME_PERIOD | STOP_ID | NAME | ONTIME% | ARR_ONTIME % | ARR_LATE% | ARR_EARLY% | DEP_ONTIME% | DEP_LATE% | DEP_EARLY% |
|---|---|---|---|---|---|---|---|---|---|
| AM | 3290 | Conestoga Mall | 64% | 64% | 17% | 19% | 91% | 9% | 0% |
| | 121 | Mccormick | 74% | 74% | 18% | 8% | 91% | 9% | 0% |
| | 150 | U.W. / Columbia | 80% | 80% | 17% | 3% | 90% | 10% | 0% |
| | 151 | U.W. - Davis Centre | 76% | 76% | 23% | 1% | 90% | 10% | 0% |
| | 146 | Laurier | 69% | 69% | 26% | 5% | 87% | 13% | 0% |
| | 3467 | Regina / Bridgeport | 68% | 68% | 27% | 5% | 86% | 14% | 0% |
| | 3292 | Charles Terminal | 31% | 31% | 69% | 0% | 80% | 20% | 0% |
| | 173 | Weber / Ottawa | 53% | 53% | 44% | 3% | 72% | 28% | 0% |
| | 54 | Fairview Park | 38% | 38% | 60% | 2% | 83% | 17% | 0% |
| | 137 | Sportsworld Station | 69% | 69% | 22% | 10% | 90% | 10% | 0% |
| | 70 | Pinebush Station | 59% | 59% | 34% | 7% | 81% | 19% | 0% |
| | 3289 | Cambridge Centre Station | 55% | 56% | 33% | 11% | 90% | 10% | 0% |
| | 3288 | Ainslie Terminal | 74% | 74% | 19% | 7% | 92% | 8% | 0% |
| | 3463 | Grand River Hospital - Green Street | 42% | 42% | 58% | 0% | 65% | 35% | 0% |
| MID-DAY | 3290 | Conestoga Mall | 85% | 85% | 14% | 0% | 95% | 5% | 0% |
| | 121 | Mccormick | 74% | 74% | 11% | 15% | 94% | 6% | 0% |
| | 150 | U.W. / Columbia | 81% | 81% | 14% | 5% | 93% | 7% | 0% |
| | 151 | U.W. - Davis Centre | 82% | 82% | 17% | 2% | 93% | 7% | 0% |
| | 146 | Laurier | 72% | 72% | 25% | 3% | 88% | 13% | 0% |
| | 3467 | Regina / Bridgeport | 64% | 64% | 17% | 20% | 92% | 8% | 0% |
| | 3292 | Charles Terminal | 53% | 55% | 44% | 1% | 82% | 18% | 0% |
| | 173 | Weber / Ottawa | 47% | 47% | 52% | 0% | 67% | 33% | 0% |
| | 54 | Fairview Park | 35% | 35% | 64% | 1% | 71% | 29% | 0% |
| | 137 | Sportsworld Station | 53% | 53% | 42% | 5% | 74% | 26% | 0% |
| | 70 | Pinebush Station | 43% | 43% | 38% | 19% | 76% | 24% | 0% |
| | 3289 | Cambridge Centre Station | 52% | 57% | 40% | 3% | 73% | 27% | 0% |
| | 3288 | Ainslie Terminal | 40% | 40% | 59% | 1% | 68% | 32% | 0% |
| | 3463 | Grand River Hospital - Green Street | 65% | 65% | 34% | 1% | 83% | 18% | 0% |
| PM | 3290 | Conestoga Mall | 84% | 84% | 12% | 4% | 95% | 5% | 0% |
| | 121 | Mccormick | 76% | 76% | 16% | 8% | 93% | 7% | 0% |
| | 150 | U.W. / Columbia | 80% | 80% | 19% | 2% | 88% | 12% | 0% |
| | 151 | U.W. - Davis Centre | 74% | 74% | 26% | 0% | 84% | 16% | 0% |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 146 | Laurier | 55% | 55% | 43% | 2% | 76% | 24% | 0% |
| | 3467 | Regina / Bridgeport | 56% | 56% | 30% | 15% | 81% | 19% | 0% |
| | 3292 | Charles Terminal | 48% | 50% | 45% | 5% | 77% | 23% | 0% |
| | 173 | Weber / Ottawa | 47% | 47% | 51% | 2% | 65% | 35% | 0% |
| | 54 | Fairview Park | 41% | 41% | 58% | 1% | 71% | 29% | 0% |
| | 137 | Sportsworld Station | 51% | 51% | 47% | 2% | 71% | 29% | 0% |
| | 70 | Pinebush Station | 42% | 42% | 53% | 6% | 65% | 35% | 0% |
| | 3289 | Cambridge Centre Station | 40% | 43% | 56% | 1% | 64% | 36% | 0% |
| | 3288 | Ainslie Terminal | 36% | 36% | 63% | 2% | 55% | 45% | 0% |
| | 3463 | Grand River Hospital - Green Street | 44% | 44% | 56% | 0% | 63% | 37% | 0% |
| OVERALL | - | - | 59% | 59% | - | - | 80% | - | - |

## Performance Report of Fall after Schedule Adjustments for Route 200 (Resource Constrained)