APPENDIX 4: Transit Performance Summary

1. Evaluation Framework

The framework to assess the King Street Transit Pilot was outlined in the October 16, 2017 TTC Board report entitled, “King Street Pilot: Monitoring and Evaluation”. From a transit perspective, the success of the pilot is defined by improvements to transit performance informed primarily by three metrics: reliability, ridership and travel times.

- **Reliability:** The reliability of transit service is defined by the variability of a customer’s experience. This can be measured by their time spent waiting for service and/or on board the vehicle. The more variable a customer’s time either waiting for service and the more variable a customer’s time spent travelling onboard the vehicle between locations, the more unreliable the transit service is.

- **Ridership:** The two key measures of ridership are related to daily boardings and peak point, busiest hour demand. Daily boardings represent the total all-day number of customers using the service regardless of location and time. A customer is counted towards this metric when they board a transit vehicle. The second metric, peak point, peak hour demand, is the total number of customers passing through the busiest segment of the route during the busiest hour.

- **Travel times:** The travel time for streetcars varies based on vehicle type, traffic conditions, crowding levels, and level of transit priority given. In mixed-traffic situations, streetcar travel times are generally longer and more variable than in a semi-dedicated or dedicated right-of-way.

2. Success of the King Street Transit Pilot

a) Predictable and improved transit journeys

The most significant improvement to transit on King Street is that streetcar journeys are not only faster, but more predictable. Predictable transit service results in tangible benefits for customers who now can budget less travel time to complete their journeys because they don’t need to account for variability. This means that customers can board a streetcar with more confidence that they will arrive to their destination by a certain time. Without the pilot, particularly in the most congested times, transit travel times were highly variable.

Average travel times reduced during all time periods with significantly reduced variability

Figure 1 shows peak period average and 90% range travel times within the pilot zone on a monthly basis compared to the previous year. This year-over-year comparison allows for better understanding of how seasonal changes impact travel times and demonstrates that the pilot resulted in consistent and predictable travel times. The greatest benefit of the pilot was observed during the summer months. Compared to

summer 2017, the *longest* observed streetcar travel times on King Street in the afternoon peak period were lower than the previous year's *average*.

Figure 1 also shows that the pilot was beneficial, overall, in the morning peak period and afternoon peak period. During the morning peak period, the improvements were less pronounced than in the afternoon peak period. This is attributed to three primary reasons:

- Morning peak period travel in the downtown is less congested than most other periods resulting from less variable travel patterns. Comparatively, the afternoon peak period is more congested as work-based travel patterns overlap with other trip purposes which generates more traffic conflicts that result in delay.
- Transit signal priority in the pilot area was temporarily disabled at the start of the project to observe the impact of the pilot on overall traffic patterns. Significant improvement in travel times was observed upon reactivation of transit signal priority in July 2018.
- Increased customer demand at the start of the pilot project resulted in more crowded vehicles and longer dwell times at stops, particularly with the smaller CLRV streetcars. Consequent improvements to service capacity through the deployment of low-floor streetcars resulted in improved travel times.
- Overall, on average, customers on King streetcars are saving approximately 30,000 minutes in travel time per day, creating an economic benefit of $2.7 million per year.

Travel times were also affected starting in October 2018 due to the change in route structure of the 504 King route. Schedule deficiencies coupled with customer adjustment to changes resulted in slower journey times, compared to the start of the pilot project. Improvements to the schedule in spring 2019 will address these issues.

Greatest improvements observed during the afternoon peak period

Figure 2 shows the daily variability in travel times in the westbound direction during the busiest hour in the afternoon peak period. The chart includes data from the start of 2016 to the end of 2018, illustrating the clear impact of the King Street Pilot. Whereas prior to the pilot project travel was highly variable, observations since the pilot began are tightly clustered within a range between 15 and 20 minutes.

When customers describe the pilot's benefit to travel time, the estimated time being saved is often greater than the overall average travel time change observed. Taking into account the reduced variability in travel, many customers are no longer experiencing the travel time extremes observed prior to the pilot. As Figure 2 shows, travel times since the pilot rarely exceed 20 minutes, whereas prior to the pilot, travel times were regularly exceeding 25 minutes.

Figure 1: Monthly Pilot Area Travel Time – Peak Periods

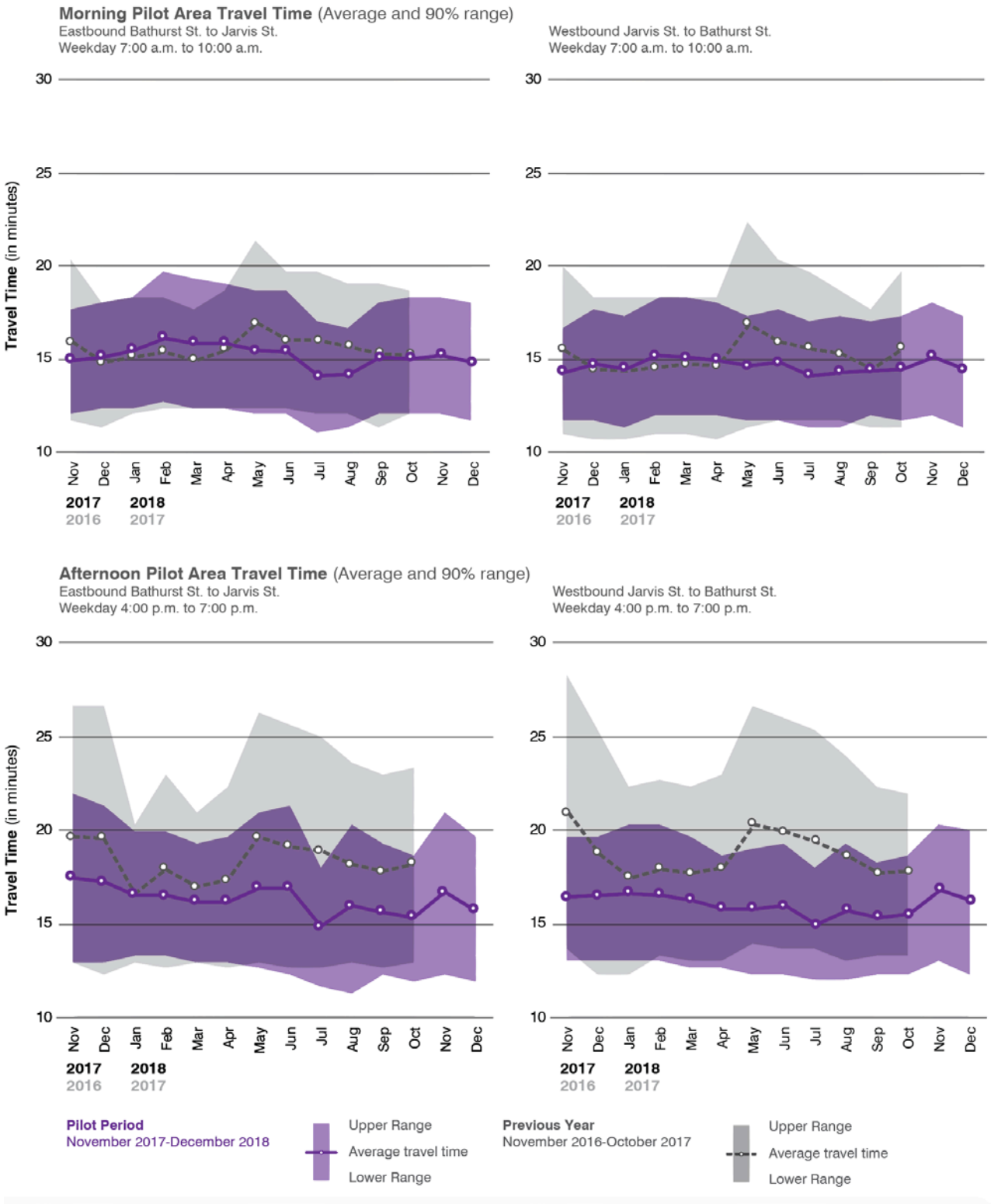
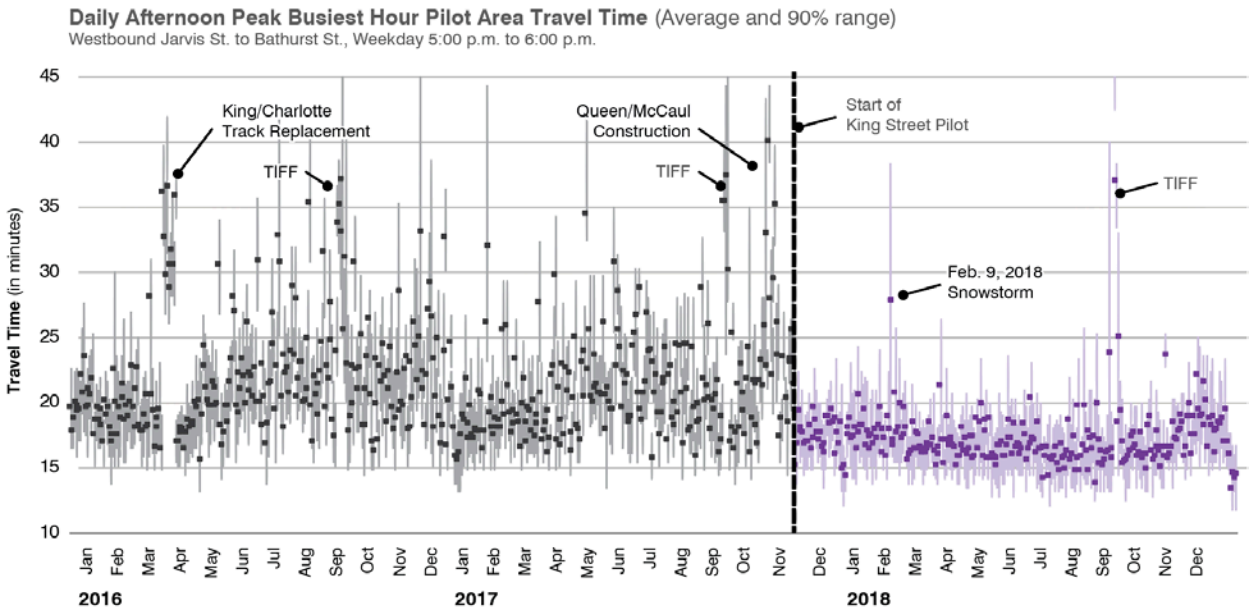


Figure 2: Daily Pilot Area Travel Time – Afternoon Busiest Hour/Direction



Late evening taxi exemption contributes to continued variability in streetcar travel times

One of the conditions for the approval of the King Street Transit Pilot was to exempt taxis from through-traffic restrictions between 10:00 p.m. and 5:00 a.m. daily. Between 10:00 p.m. and 1:30 a.m., streetcar service remains very frequent, scheduled to operate every 5 minutes within the pilot. However, customers and operators observe that travel times in the late evening, particularly on weekends, remain unpredictable and lengthy.

Figure 3 shows the impact of relaxed traffic restrictions, which results in more vehicular traffic on King Street. After 10:00 p.m., two-way through vehicular traffic increases between 100% to 300% at Bathurst and at Spadina, compared to early evening hours. Observations from operators and route supervisors indicate that most of the increased traffic volumes are taxis and ride share vehicles (ride share vehicles are not exempt from traffic restrictions).

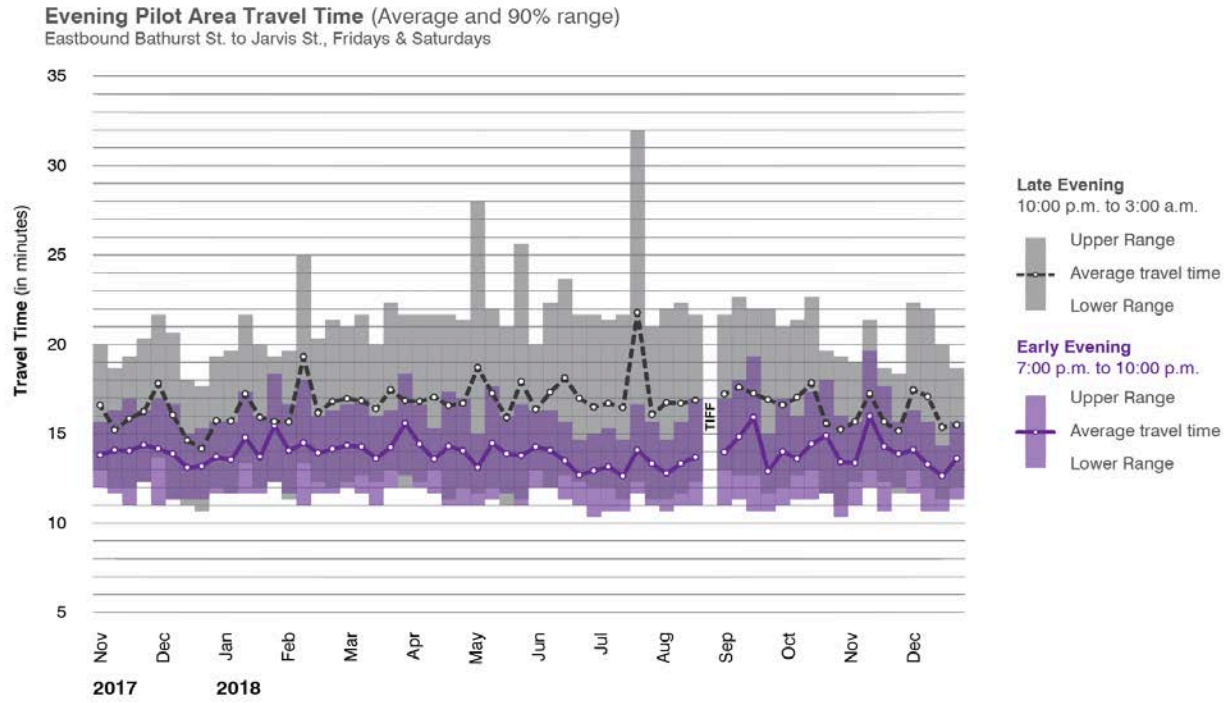
Figure 4 illustrates the impact of this increased traffic on streetcar travel times. It shows weekend travel times during the early evening (in purple) and late evening (in gray) on a weekly basis through the pilot. While there is overall improvement compared to before the pilot began, the late evening travel times are approximately 30% higher than in the early evening.

Figure 3: Average Two-Way Through Volumes

	Friday			Saturday		
	9:00 p.m.	**10:00p.m.**	**11:00 p.m.**	**9:00 p.m.**	**10:00p.m.**	**11:00 p.m.**
King/Bathurst	120	280	280	110	260	270
King/Spadina	120	390	400	130	390	370

Data from January to April 2018

Figure 4: Pilot Area Travel Time – Weekend Evenings



Approximately 2,400 customers use the 504 King streetcar service after 10:00 p.m. daily. While not all customers are travelling through the pilot area, the unpredictability of travel conditions during the late evening impacts service on the entire route. This negatively impacts the attractiveness of transit service on King Street and travellers are more likely to use other services such as taxis and ride shares. Ridership counts during the pilot showed little growth during the late evening compared to other periods of the day. Therefore, TTC staff recommend that the City further monitor late night performance, particularly through the Entertainment District and King West, to inform potential future changes to traffic restrictions.

b) Improved efficiency and reliability of streetcar operations

In general, the King Street Transit Pilot has resulted in more reliable, productive and efficient operation of streetcar service in the corridor. This results primarily from reduced travel time variability.

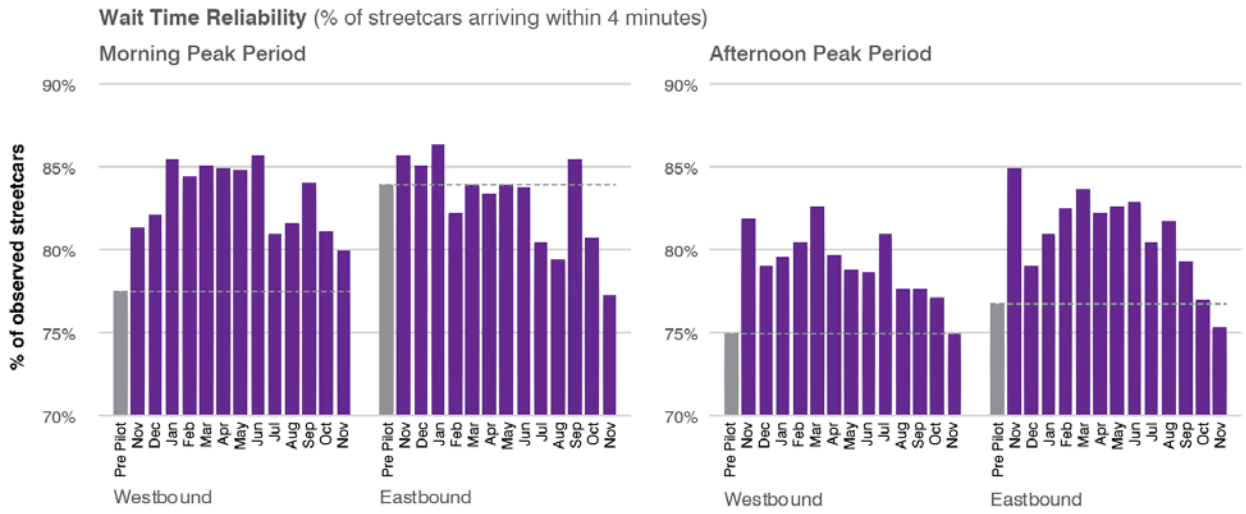
Streetcars generally arrive within 4 minutes during peak periods on King Street

The measure selected for wait time reliability during the King Street Pilot was the percentage of observed streetcars arriving within 4 minutes during peak periods. This was chosen based on the likelihood that a gap longer than four minutes in streetcars would result in a greater likelihood the next vehicle would become overcrowded. The four-minute measure remained unchanged through the pilot, even though scheduled peak headways were widened by 25% to 30% to reflect the higher capacity of low-floor streetcars on the 504 King route starting in the summer of 2018.

Figure 5 shows the waiting time reliability measure compared to the pre-pilot period on a monthly basis through the end of 2018. In general, morning peak performance remained generally unchanged through the pilot period with some reduction in performance in the summer due to construction and late fall due to the change in route structure.

Afternoon peak period performance did significantly improve upon the start of the pilot, with westbound waiting time performance consistently above pre-pilot levels.

Figure 5: Wait Time Reliability



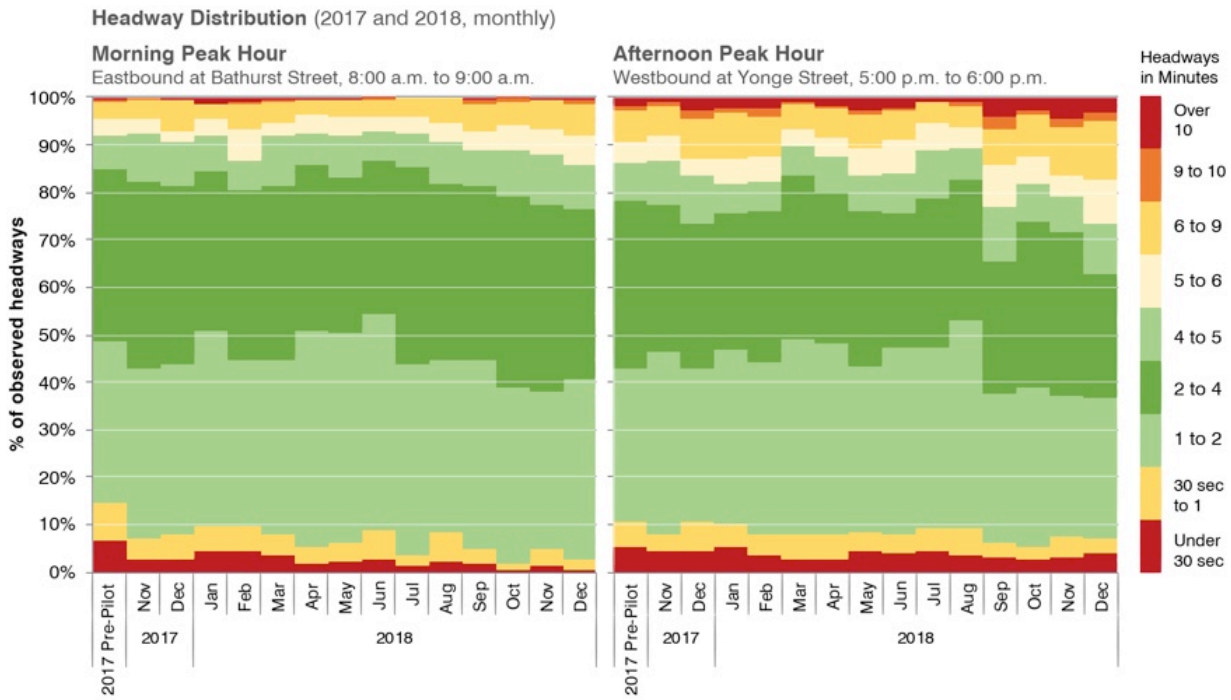
Data indicates that bunching of streetcars has reduced

To measure whether or not the pilot has improved the regularity of streetcars during the busiest times, all observed headways are plotted in Figure 6 on a monthly basis from the start of the pilot through the end of 2018. This graph shows an acceptable range (in dark green) of headways between 2 and 4 minutes as well as bunching and gapping (in dark red) of headways of less than 30 seconds or in excess of 10 minutes.

During the morning peak hour, bunching of streetcars has improved through the pilot year. Substantial improvement is observed starting in July 2018, when a new transit signal priority algorithm was implemented to help space out streetcars entering and within the pilot area. Through the pilot period, the incidence of long gaps over 10 minutes was rare, averaging less than 1%.

The afternoon peak hour showed some improvement mid-way through the pilot, when the proportion of streetcars arriving within 5 minutes increased above the pre-pilot average. The proportion of streetcars observed bunching at Yonge Street decreased slightly but remained around 2% of observed trips. This is expected at this stop due to the connection to Line 1, which sees higher customer volumes and dwell times makes it more likely for a following streetcar to arrive before the first leaves. An increase in the proportion of longer waits beyond 5 minutes is observed starting in September 2018. This is primarily due to challenges with route management unrelated to the pilot, resulting in a higher number of service adjustments that affect headway regularity.

Figure 6: Headway Distribution



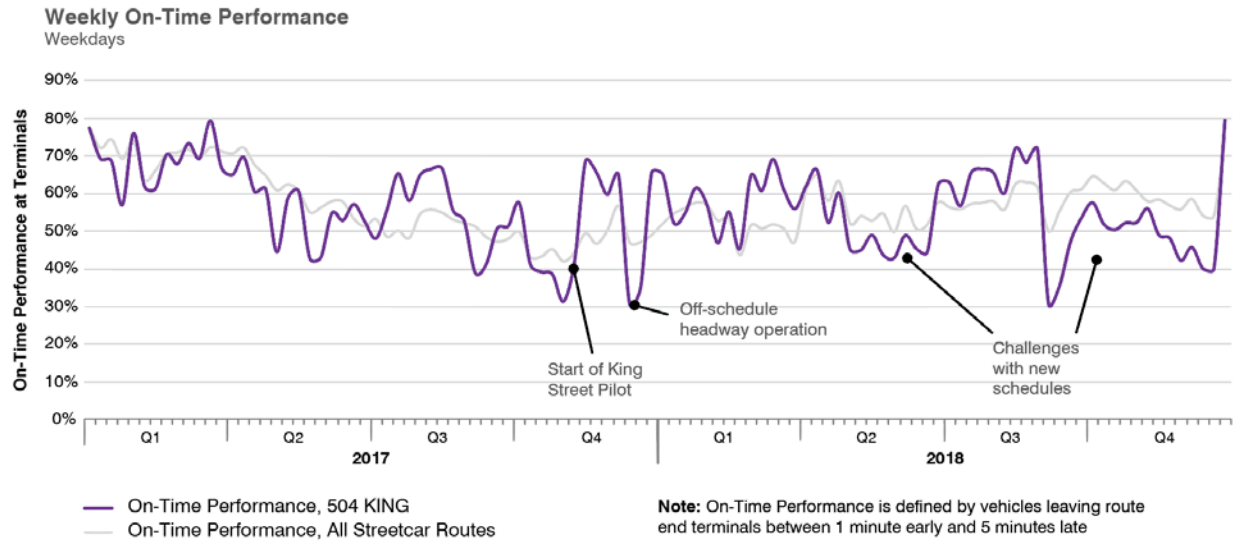
On-time performance on King improved relative to other streetcar routes

TTC defines on-time performance by departures at end terminals. An “on-time” departure is a vehicle that leaves no more than 1 minute early or 5 minutes late from its scheduled time. Figure 7 illustrates the weekly on-time performance of the 504 King streetcar compared to all streetcar routes from 2017 to the end of 2018.

Until the start of the pilot, the performance of the 504 King streetcar tracked closely with the on-time performance of all other streetcar routes. Upon the start of the pilot, on-time performance improved primarily due to reduced travel times and increased route supervision. The improved performance relative to other streetcar routes was sustained through to the beginning of the second quarter of 2018 demonstrating the success of the pilot.

Schedule adjustments were made in May 2018, June 2018, and October 2018 based on collected data to better align to pilot-period operating conditions. The schedule changes were implemented to pilot new approaches to improve on-time performance, as well as other reliability measures. These schedule adjustments have had varied success and have provided valuable lessons learned. The results of the schedule change are not related to the pilot project, but due to increased ridership, a change in route structure in October 2018 and different operating characteristics of low-floor streetcars. Based on lessons learned, further adjustments are planned in spring 2019 to improve on-time performance and related performance measures.

Figure 7: Weekly On-Time Performance, 504 King Streetcar



Route productivity increased with more riders per service hour

A common measure for cost-efficiency and productivity of transit service is the number of customers per hour of service operated. Overall, TTC is one of the most productive transit agencies in North America, with approximately 80 boardings per hour of service.

TTC's streetcar service is, in general, highly productive from a combination of high ridership through denser urban corridors and lower operating requirements from the higher capacity of the vehicles. As outlined in Figure 8, increased ridership during the pilot has increased route productivity by 25% to approximately 125 boardings per hour of service. Some of this gain is a result of efficiencies resulting from the full deployment of low-floor streetcars on the route in October 2018.

Figure 8: Route Productivity

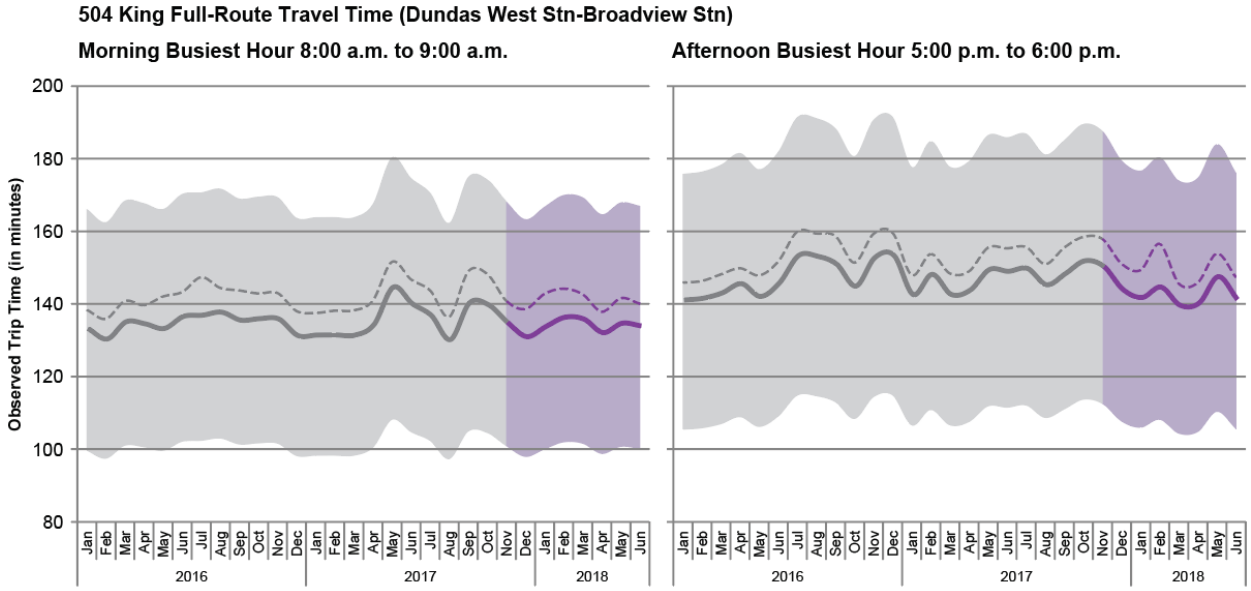
	King Streetcar Corridor			**Other Routes**		
	Pre-Pilot	**March 2018**	**October 2018**	**510 Spadina**	**501 Queen**	**29 Dufferin 929 Dufferin**
Daily Ridership	72,000	81,000	84,000	40,000	55,100	42,300
Scheduled Revenue Hours	710	780	670	270	820	530
Boardings per Revenue Hour	101	104	125	148	67	80

Operating Cost Savings

The cost of operating transit service is directly related to the operating speed and scheduled running time. In general, TTC schedules routes to provide adequate running time between the 85th and 95th percentile of observations. Therefore, if variability can be reduced, significant savings can result, particularly on high-frequency routes. For example, on 504 King, where service operates every 3 to 4 minutes, every equivalent reduction in 85th percentile travel time results in one streetcar saved.

During the pilot, low-floor streetcar were introduced on 504 King, resulting in slower average travel speeds compared to the smaller, CLRV streetcar that operated at the start of the pilot. The low-floor streetcar has different operating characteristics, including different door operation, periodic accessible ramp deployment, and higher customer volume. On other routes, TTC has observed that low-floor operation is approximately 10% slower than CLRV and ALRV operation. This is offset by the benefit of accessibility and higher capacity provided by the low-floor streetcar. It is therefore likely that the travel time savings on King are understated, as low-floor operation occurred after the pilot began and travel times are being compared to operation with different vehicles. In general, 85th percentile travel times with low-floor streetcars have remained unchanged compared to CLRV operation.

Figure 9: 504 King Full Route Travel Time



NOTE: Full-route running time is comparable to pre-pilot conditions only until June 2018, when 504 King route structure was changed to accommodate construction and again in the fall to restructure service on the corridor

The risk if the King Street Pilot Project is not made permanent is that travel times would increase, resulting in the need to operate more streetcars to provide the same capacity. Assuming increased average travel times of between 2 to 4 minutes in each direction and an increase in variability of 25% in peak periods and 10% in off-peak periods, this would result in an increased operating cost of approximately $660,000 per year at current service levels. This cost would be reduced if increased demand returns to pre-pilot levels, at which the additional cost of service would be approximately $132,000 per year.

c) More people taking transit in the King Street corridor

Ridership on streetcars on King Street immediately increased upon the implementation of the pilot project in mid-November 2017. Increases were observed at all times of the day, including in off-peak periods and on weekends. The early consequence of the increased demand was crowding on streetcars and despite the introduction of low-floor streetcars and increased service, crowding remains a concern during the busiest periods of the day.

All-day streetcar boardings increased by 17% to 84,000 per day

Figure 10 shows the weekday route-wide ridership totals for the 504 King and 514 Cherry streetcar routes. Overall, weekday ridership has increased by nearly 17% between September 2017 and October 2018 to approximately 84,000 customers per day. The lower values observed in March and June are consistent with observed seasonal variation in ridership system-wide.

Figure 10: Streetcar Ridership in King Street Corridor

	Pre-Pilot	November 2017	March 2018	June 2018	October 2018
Daily Ridership	72,000	84,000	81,000	80,000	84,000

NOTE: Daily ridership prior to October 2018 includes boardings for 504 King and 514 Cherry streetcar routes

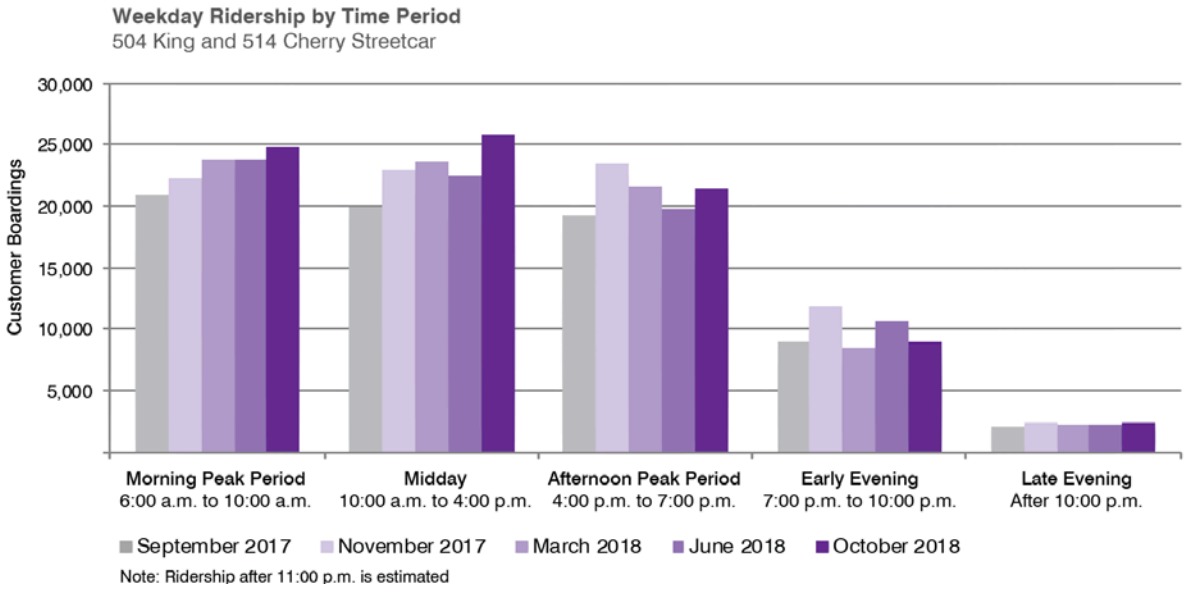
Ridership increases also observed in off-peak periods

As shown in Figure 11, ridership increases are consistently observed at most times of the day, particularly in the midday, where ridership has increased between 10% and 25%. Early evening ridership fluctuates depending on time of year due to special events occurring in the downtown and weather. For example:

- the November 2017 count was taken during the Distillery District Christmas Market, which resulted in major increase in off-peak ridership between the subway and the Distillery District;
- the March 2018 count was taken during a period of cold weather, which would have reduced discretionary trips made in the corridor; and,
- the June 2018 counts is likely a result of reduced ridership during the warmer months when some streetcar customers walk or bike instead. This is consistent with walking and cycling volume data that showed a 15% increase in pedestrian volumes between March and June.

Late evening ridership remains largely unchanged.

Figure 11: Weekday Ridership by Time Period

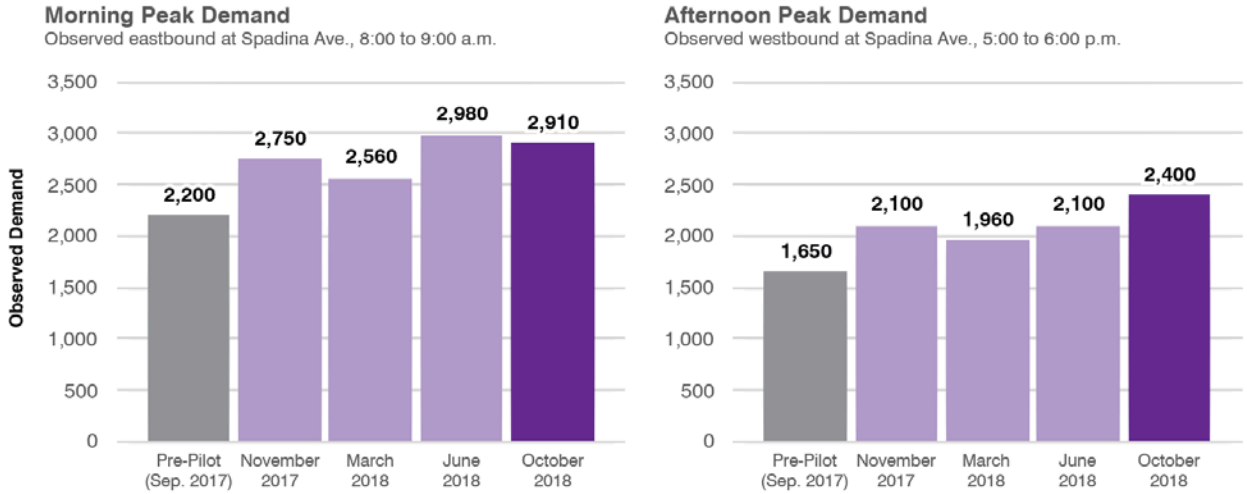


Peak hour demand has increased by 30% and 45% in the morning and afternoon, respectively, responding to more reliable travel.

The peak point, peak hour demand for the surveyed periods is provided in Figure 12 for the AM and PM peak hours. The location of this count is eastbound departing Spadina Avenue in the morning, while it is westbound approaching Spadina Avenue in the afternoon. In October 2018, AM peak hour demand increased by over 30% while the PM peak hour demand increased by 45% from the September 2017 baseline.

Improved and more reliable service delivery, particularly in the afternoon rush hour, likely contributed to greater demands. As discussed later in the report, the implementation of the new low floor streetcars on the King routes has significantly increased the capacity of the corridor meaning that more passenger trips can be accommodated when passengers need and use the service most. The combination of improved reliability and additional capacity illustrates the amount of latent demand on the corridor that was previously unserved.

Figure 12: Peak Demand



Note: Observed peak demand is the number of customers observed in the busiest direction, at the busiest location, in the busiest hour.

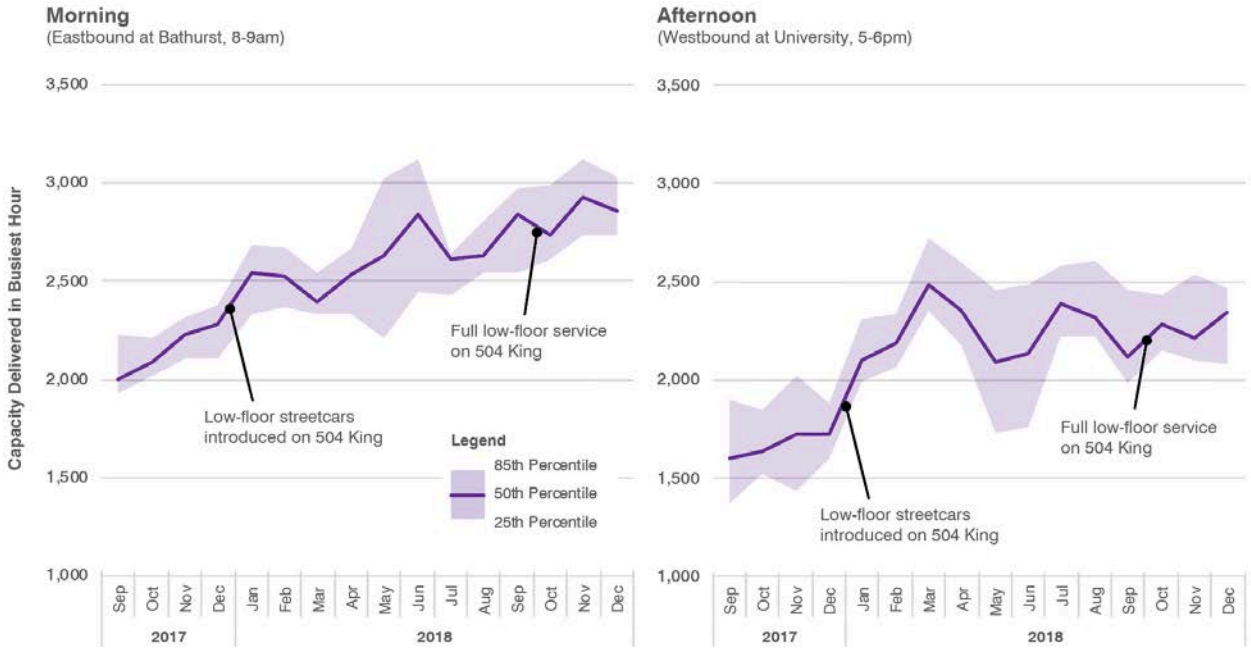
Capacity was increased significantly on King Street through pilot period, but crowding remains a challenge

The capacity scheduled on all TTC routes is based on the observed peak demand and the average number of customers per vehicle compared to the service standards approved by the TTC board. On streetcars, during peak periods, the standard is 74 customers for CLRVs and 130 for low-floor streetcars. Most streetcar routes operate at approximately 95% of crowding standard and prior to the start of the King Street Pilot, the service scheduled reflected the pre-pilot demand.

At the start of the pilot, the increase in peak demand resulted in consistent overcrowding on CLRV streetcars. Low-floor streetcars had been introduced on 514 Cherry in fall 2016 to provide increased capacity in the busiest section of the route, however, this was not sufficient to meet the new demand. Consequently, low-floor streetcar introduction began on 504 King in early December 2017, ahead of schedule, with full deployment in late October 2018.

Figure 13 illustrates the monthly average and range of streetcar capacity delivered at the peak point in the morning and afternoon peak periods. Since the start of the pilot, delivered capacity has increased from approximately 2,000 customers per hour in the morning peak period to approximately 2,900 customers per hour. In the afternoon peak period, it has increased from approximately 1,600 customers per hour to approximately 2,400 customers per hour. Despite this increase, overcrowding is still observed at the busiest times. Further measures to increase capacity will be explored, including adding more streetcars or reintroducing supplemental bus service at the busiest times.

Figure 13: Peak Capacity



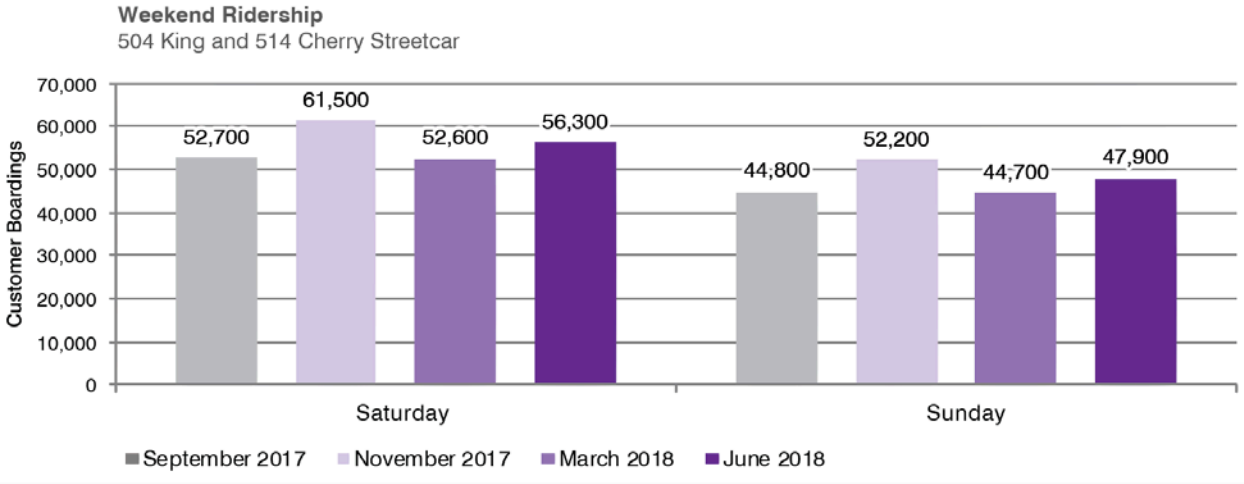
Note: Capacity delivered calculated based on vehicle capacity as defined by TTC Service Standards.
Peak period standards for bus (51), CLRV streetcar (74), ALRV streetcar (108), and low-floor streetcar (130)

Weekend Ridership

Weekend ridership was estimated based on PRESTO taps and trends. The estimates are presented in Figure 14. A weekend estimate for October 2018 is unavailable due to the large growth in PRESTO penetration after the implementation of the two-hour time-based transfer in August 2018. Weekend ridership is highly variable on streetcar routes downtown – special events, road restrictions, and subway closures all have significant impacts on ridership on a week-over-week basis.

Generally, weekend ridership has increased since the implementation of the pilot. In November 2017, an increase of approximately 16% was observed from September 2017. This can be attributed to the Distillery District Christmas Market and the Santa Claus Parade. A further sample in June 2018 showed an increase of 7% over pre-pilot levels. A minor decrease was observed in March 2018, however, the decrease was still less than the overall system wide ridership difference of approximately -5% for weekends when comparing November 2017 and March 2018 data.

Figure 14: Weekend Ridership



d) Greater customer satisfaction with King streetcar service

The King Street Transit Pilot has improved perceptions of customer satisfaction with transit service in the King Street corridor. The TTC conducts a quarterly Customer Satisfaction Survey (CSS) that provides an insight on perceptions of TTC service and operations.

Figure 15 illustrates the trend in the CSS results for the King streetcar service between the start of 2016 through the end of 2018. Since the start of the King Street Transit Pilot, satisfaction has increased significantly on two key measures that can be attributed to the pilot: overall satisfaction and trip duration. In 2018, perceptions of trip duration, a

key driver of overall customer satisfaction, averaged 88%, which is the highest of all streetcar routes.

Perceptions of crowding and wait time improved at the start of the pilot, which is reflective of a period where low-floor streetcars were replacing CLRV streetcars one-for-one, resulting in more capacity being operated.

Another measure tracked in the CSS is “value for money”, which increased from 58% in the pre-pilot period in 2017 to 71% in 2018. Of all streetcar routes, 504 King had the second highest “value for money” score in 2018, with only the 512 St Clair, which operates in its own right-of-way, performing better (72%).

Figure 15: Customer Satisfaction Survey Results – 504 King Streetcar