PARKING TECHNOLOGY ROAD MAP

PARKING SERVICES - CITY OF OTTAWA

Prepared For: **City of Ottawa**

December 2024

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1.0 INTRODUCTION

Parking planning, design, and management is being affected by new technologies as they continue to emerge at a rapid pace. People are increasingly expecting their parking experience to be stress-free, convenient, and safe. Parking operators are expecting to achieve more efficient parking processes, reduced costs, and increased revenues. City planners are expecting increased mobility options and reduced parking footprints.

On October 9, 2019, Ottawa City Council approved the Municipal Parking Management Strategy (MPMS). The 2019 MPMS identified a requirement to account for the pace of technological change in parking and transportation-related technology. To plan from a strategic and operational perspective, it is important to understand opportunities and impacts that technological change might create in the short, medium, and long-term future. The first Technology Road Map (2020) was utilized to guide and direct strategic planning and the Capital Program Plan for Parking Services. The MPMS requires a regular update to the Technology Road Map once per term of City Council. This update will fulfill this requirement and support the pending parking equipment procurement process.

The Municipal Parking Management Strategy sets out the mandate for the Municipal Parking Management Program and it is important that any future initiatives to leverage technological solutions are tied to the objectives of the Program. Accounting for technological changes in the broader transportation sphere is also critical to ensure the Program is properly positioned from a strategic perspective.

An optimized future public parking system should account for the following technology components:

- On and Off-Street Payment Options;
- On and Off-Street Parking Management Systems;
- Parking Enforcement;
- Data Collection, Analytics & Management;
- New Vehicle Technologies

This Road Map explores the potential benefits and impacts of new technologies on the Ottawa municipal parking system across these different components.

2.0 PAYMENT SYSTEMS

Payment systems are rapidly moving to reduce the use of cash by making it easy to use credit and debit cards with tap-and-go features for small payment transactions including at parking access gates. It is also desirable to reduce credit and debit card use at parking machines and gates by having customers pay for parking with cell phone or web-based payment systems that charge their credit card or prepaid electronic wallet.

2.1 On-Street Payment Technology

Over the last twenty years, most municipalities have been replacing individual space parking meters with parking payment machines (i.e. "kiosks") that serve multiple spaces along a street block face. Each kiosk typically serves about 8 to 10 on-street spaces, although the physical context of a street layout or a specific strategic purpose may result in some locations where a kiosk will serve less or more than 8 to 10 spaces.[1] The approach to having kiosks serve more spaces reduces payment machine capital and operating costs and results in less clutter along the sidewalk edge.

Multi-space payment kiosks track individual payments using one of the following three methods:

- **Pay and Display** whereby the customer pays for parking, receives a payment receipt, and then returns to the vehicle to place the receipt inside the vehicle face up on the dashboard for inspection;
- **Pay by Space** whereby the customer provides the space number they are parking in when paying for parking, thereby eliminating the need to return to their vehicle to place a receipt on the dashboard for inspection. The pay-by-space format is rarely used in on-street locations that receive snowfall because of the need to number parking spaces with a post as seen in Victoria, Gatineau, and Montreal[2];
- **Pay by License Plate** whereby the customer provides their license plate number when paying for parking, thereby eliminating the need to return to their vehicle to place a receipt on the dashboard for inspection.

The City of Ottawa currently uses pay and display machines to collect parking revenue on-street, at surface lots, and in two garages. Customers are also able to pay by using a cell phone-based app which enforcement personnel can access in the field to verify payment. Most younger generation customers prefer to use Apps for payment because they are familiar with using them for many other purchases. As these generations increase in proportion to the total population, the use of Apps for parking should continue to grow naturally based on demographics. This in turn is leading some municipalities to reduce the number of kiosks that accept cash and, in some cases, providing fewer kiosks. This in turn is prompting some kiosk providers to reduce the size and complexity of payment kiosks resulting in significantly reduced capital costs.

When replacing old parking meters or upgrading older pay and display technology, most municipalities are changing to pay-by-license plate kiosks[3]. Using pay-by-plate kiosks eliminates the need for customers to return to their vehicles to place a ticket on the dash. They also eliminate the need for enforcement personnel to check for a dashboard ticket and the incidence of parking fines for people who forget to place the ticket on the dash or place it

[1] Some municipalities increase the number of spaces per kiosk slightly when pay by plate and pay by space technology is used because customers do not have to return to their vehicle to place a ticket on the dash.

[2] Montreal is planning to replace the on-street kiosks with pay by plate technology.

[3] Locally, the Toronto Parking Authority replaced 225 of it's old PnD kiosks with PbP kiosks in late 2023 with more to follow. Oakville, Niagara Falls and Burlington have also transitioned to PbP kiosks.

upside down (accidentally or on purpose). Pay-by-plate protocol can also harmonize with License Plate Recognition (LPR) enforcement technology and can enable the potential future adoption of mail-in infraction notices. Customers can take a picture of their license plate with their cell phone to assist in remembering their plate number. Over time, most people will remember their license plate number.

Many cities have also been implementing touchless tap-and-go card payment in response to the Covid pandemic and in some cases are not including the chip and pin card feature (i.e. using tap and go only) for operating simplicity and to reduce cost.

Ultimately, the goal should be to maximize the number of people who pay by cell or web interface and minimize the use of kiosks. Some larger municipalities are proactively encouraging the use of cell phone payment by covering the processing fee charged by private cell phone payment apps (the Ottawa cell phone provider charges a processing fee). Some are contemplating or have implemented significant reductions in the number of on-street payment kiosks as the use of cell phone payments increases because the cost-effectiveness of collecting cash and maintaining the machines becomes questionable. There is a correlation between the cost of parking and higher use of cell or credit card payment because of the amount of cash that would be required to make a payment[4]. Eliminating processing fees for cell payment transactions along with increased advertising and providing fewer payment kiosks may accelerate increased cell payment.

Public and private parking operators are implementing a cell phone payment-only policy in some of their surface lots to reduce cash collection and machine maintenance costs. The City of Toronto has begun a pilot program to test cell phone-only payment in thirteen mobile-only areas where cell phone payment already exceeds 70% and the existing payment kiosks are serving less than five spaces per machine. The City of Calgary has some locations where special promotions are offered only through their mobile app.

A comparison of the key differences between the payment interfaces described above is provided in Table 1.

Generally, the outlook for on-street payment technology appears to be an increased emphasis on cell phone payment Apps and fewer kiosks that include only tap-and-go credit card payment with coin payment at a limited number of locations. When preparing for the replacement of the current pay and display machines, the City should conduct an assessment of the quantity and payment interface requirements for the new kiosks, keeping in mind the need to minimize operating costs while maintaining reasonable service levels for customers.

[4] For example, coin payment in Ottawa is 16% on-street and only 4% off-street.

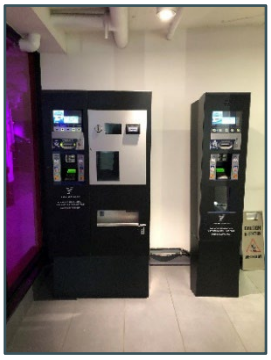
Table 1 Relative Comparison of On-Street Payment Technology Options

	Pay-and-Display	Pay-by-Plate	Pay-by-Space
Capital Cost[5]	1.0	1.05+-	1.08+-
Operating Cost[6]	1.05+-	1.0	1.0
Customer Convenience	Base Must return to vehicle with ticket	Better No return to vehicle required	Better No return to vehicle required
Paper Use	Higher	Lower No ticket for windshield, Receipt available on demand	Lower No ticket for windshield, Receipt available on demand
Zone Signage	On Machine	On Machine	Space numbering with Curbside posts
Enforcement	More time-consuming to check individual vehicles for paid receipt compliance. Ticket facing down or missing but paid challenges.	Less time-consuming because individual vehicles do not have to be checked for a paid receipt. No ticket placement or missing ticket issues. Enables potential future use of mail-in infraction notices. LPR Cameras can be used for more efficient enforcement	Less time-consuming because individual vehicles do not have to be checked for a paid receipt. No ticket placement or missing ticket issues. Enables potential future use of mail-in infraction notices.
Privacy Concerns	None	License Plate info w City	None
Data	Base	Slightly Better Provides more info re individual vehicle use	Slightly Better Provides more info re individual space use
Ticket Forgery	Possible	None	None
Motorcycles	Tickets may be stolen or lost	No tickets required	No tickets required
Payment Options			
Cell Phone APP	Yes	Yes	Yes
Promotions	Thru App	Thru App	Thru app
Tap & Go	Available	Available	Available
Chip & Pin	Available but increasingly not required	Available but increasingly not required	Available but increasingly not required
Cash (Coin)	Available but may not be required in areas with very high cell phone and credit card payment	Available but may not be required in areas with very high cell phone and credit card payment	Available but may not be required in areas with very high cell phone and credit card payment

[5] Pay by Plate and Pay by Space kiosks cost slightly more because they require an alphanumeric keyboard and pay by space kiosks require a space numbering post.

[6] Operating costs for pay and display kiosks can be slightly higher because customers have to print a ticket to place on the vehicle dash whereas pay by plate or by space customers do not have to print a ticket unless they want a receipt.

2.2 Off-Street Payment Technology



Access and revenue control at large surface lots and garages with a limited number of access driveways is typically achieved with gates at the entry/exits. The use of gates with payment kiosks inside the gated area (i.e. pay on foot) generally results in more robust revenue control and eliminates the need for payment compliance (i.e. enforcement) patrols. However, gated operations slow down traffic flow and require frequent maintenance to keep ticket dispensers and gates in good working order.

In smaller lots and garages, gates are often not used. Payment is achieved using the payment kiosks described above in Section 2.0, and payment compliance is achieved through parking enforcement patrols like the procedure used for on-street parking.

The City of Ottawa uses pay and display kiosks without gates at their surface lots whereby people pay for parking in advance and place their receipt ticket on the dashboard of their car for enforcement purposes. People can also pay by cell phone in non-gate-controlled lots.

Most City garages are controlled with access gates except the Glebe Garage and the public parking at the Gloucester Street Garage which use pay and display machines, monthly parking passes, and cell phone payments. At the garages with gates, hourly/daily customers take a ticket on entry, pay at the pay-on-foot machine inside the garage, and then leave by inserting a ticket in a reader to open the exit gate. In 2019, the City upgraded the garage equipment to allow credit and debit cards for entry and exit payment at the gates by using tap-and-go card technology. This has made it more convenient and safer for customers because they can avoid using the pay-on-foot machines. People who wish to use cash will continue to use the pay-on-foot machines.

Elsewhere, transponders have been used for many years to provide contactless entry/exit for monthly parkers but have not been widely adopted for short-term or daily parking users.

Garage customers could also be provided with the ability to have their cell phones scanned for entry and exit at the gate control. Ultimately, License Plate Recognition (LPR) or Bluetooth Technology could be deployed that will allow preregistered customers to enter and exit by driving through the gates or access lanes and be automatically charged for parking.

Some parking operators are using License Plate Recognition (LPR) cameras in conjunction with gates to control and monitor the entry and exit of vehicles in large parking garages and lots. Most large airports have been successfully using LPR for many years to accurately track parking duration given the high value of parking sessions at these locations. Recently, some private parking operators have started to test ticketless gate control to reduce the cost of tickets, and the inconvenience associated with ticket jams. People who are preregistered with a credit card are recognized at the entry/exit gates by the LPR cameras and are automatically billed for their parking use. Preregistration provides the increased convenience of not having to use a credit card, ticket, proximity card, or cell phone to enter/exit each parking session and eliminates or minimizes the issue of lost tickets. Some of the more advanced LPR systems record pictures of distinctive features (e.g. decals, dents, scratches, vehicle colour, model) other than license plates to accurately track vehicles if license plates are unreadable or only partially readable.

The Calgary Parking Authority eliminated regular access gate control at its parking garages when it implemented its proprietary Park Plus on and off-street parking system with LPR access and revenue control, using the gates only when they find it necessary to restrict access to maintain availability for monthly contract parkers. Many large hospitals in Calgary have also implemented gateless parking access in conjunction with a combination of foot patrols and vehicle-mounted LPR readers for enforcement. In Alberta, parking infraction notices do not have to be placed on the vehicle but can be mailed which greatly improves the logistics of issuing tickets.

A more recent form of contactless parking access and revenue control is the use of Bluetooth technology that reads a driver's cell phone signal to open/close gates, computes the parking charge, and collects the fee from a preregistered credit card or electronic wallet/purse. If the customer's cell phone is on, the gates will activate, and a parking fee will be calculated. Some shopping centres in the United States have implemented this system to speed up entry/exit and link customers to a rewards program that includes free valet parking and other incentives. Bluetooth-enabled gate access eliminates plate-read errors with LPR systems. It is likely that blue tooth technology parking apps will eventually be embedded directly into vehicle dashboard systems without the need for separate devices. Vancouver's public parking corporation – "Easypark" has implemented both Bluetooth-enabled and LPR-enabled gate control in its garages for customer convenience and to increase parker preference for their facilities. They also allow Bluetooth payment at un-gated lots. To date, the Bluetooth feature is one of the most popular forms of payment.

2.3 Cell Phone Payment

Many cities have arranged with private cell phone/mobile app providers to allow their services to be used for parking payment at on-street parking and surface lots. The private mobile app providers work with the municipality to integrate the payment system with the local enforcement system. The mobile app provider adds a service fee to each parking transaction to cover its costs and earn a profit. Some large municipal parking operations create their own app (e.g. Toronto Parking Authority) and absorb the cost of implementation and operation so that customers do not pay extra for the service. Other large municipal operators (e.g. Vancouver's Easy Park) have created their own app but will also allow customers to pay with other apps like Apple Pay, PayPal, and WePay. The goal should be to provide a seamless back-end operation that provides maximum flexibility for customers on the front end. Most of the largest municipal parking operations in Canada are achieving approximately 70% or higher mobile payment use for parking transactions and have some facilities that accept only mobile payments[7].

Most cell phone payment operators will also allow people without an account to use their cell phone to scan a QR code on a sign that will direct them to the operator's website where they can make a one-time payment using their credit card.

Ottawa Parking Services has had cell phone parking since 2012 for its surface lots, on-street parking, and two garages that operate without gates by using pay and display kiosks (i.e. Glebe and Gloucester Street). Customers are charged a $0.30 transaction charge to use the service. Customers can also opt-in for a text notification message for an additional $0.10 per transaction (increasing to $0.15 on January 1, 2025). Cell phone payment transactions for on-street parking in Ottawa have increased from approximately 15% in 2019 to approximately 24% in 2022 and then 33% in March 2024. Many large cities in Canada are achieving cell phone payment rates of 50% to 70%. Potential barriers to increased uptake is awareness and the extra cost of the transaction fee. As mentioned earlier in Section 2 some cities absorb the cost of the transaction fees which accelerates the adoption of cell phone payment. Some municipalities allow multiple cell phone payment apps that increase options for customers and provide some

[7] Toronto, Montreal, Vancouver and Winnipeg are all higher than 70% of transactions.

redundancy if one provider goes down. The City should develop strategies to increase cell phone payment use to the 50% level or higher.

3.0 PARKING GUIDANCE SYSTEMS

Parking guidance systems are becoming more prevalent in large public and private parking garages and surface lots to guide and direct customers to vacant parking, thereby reducing traffic congestion and increasing customer convenience. Most large regional shopping centres in Canada include parking guidance systems in their parking facilities. Many large airports are also utilizing such systems.

At a minimum, a parking guidance system (PGS) should indicate the number of vacant spaces available in a facility. Sophisticated systems also include information for each parking level, a specific parking area, and specific parking aisles or spaces. PGS with individual parking space sensors are much more accurate than systems which use in ground loops or sensors to measure traffic flow in/out of an area. The systems with specific space sensors provide a rich database of parking utilization characteristics that can be used to optimize occupancy levels, develop pricing strategies, and assist in auditing parking revenues. Camera-based PGS systems can provide more detailed utilization info by license plate as well as provide additional security surveillance and enable customers to find the location of their parked vehicle, subject to privacy regulations. The occupancy/vacant parking availability information can also be relayed to a website or mobile parking app so customers can check availability before searching for parking.

Ottawa Parking Services completed the installation of PGS in each of its five garages in 2018. The Ottawa systems include individual space sensors, total facility, and individual-level vacant space availability information. The City provides the occupancy information in open data format to enable the development of private mobile parking apps and is already feeding the information to the City's interactive traffic map which would benefit from more visibility and easier access.

Parking Services has also begun investigating the feasibility of collecting real-time occupancy data for their surface lots and on-street parking by using camera technology. Some cities have provided surface lot and on-street parking monitoring by using in ground sensors and loops. However, to date, the reliability and cost of using camera-based sensors and the accuracy of using loops are less than desirable.

Many cities in Europe and some in the United States have installed downtown area-wide PGS that provide information regarding parking availability for each of their major garages or lots with directional arrows guiding people in the general direction of the facility. These systems would be beneficial in tourist areas, stadiums/concert venues, and in business areas that have several garages. The Byward Market area with two garages might benefit from an area-wide PGS.

Ottawa Parking Services should continue its feasibility study regarding the use of on-street and surface lot occupancy monitoring because it would increase customer convenience and provide a rich database of parking information for future planning and revenue control purposes.

4.0 PARKING SYSTEM WEBSITE

Most municipal parking systems have a web presence with at least basic information on parking locations, rates, and regulations. Some websites include an interactive map where a customer can put in an address and then see the location and pricing of municipal parking facilities nearby. They may also include information re parking studies, parking system financial history, new projects, and alerts regarding facility closures and temporary parking prohibitions (e.g. on-street parking bans for snow clearance). Some also include an online application form for monthly parking. A few websites include real-time parking availability (i.e. vacancy) information and online registration for a mobile app and payment system. A few also include the ability to pay parking tickets or courtesy notices or provide a link to the city's enforcement website. Links to and from the local BIA websites and perhaps major tourist attractions, sporting and cultural venues should be considered. The website should also be made available as an app for use on cell phones and other mobile devices. The more comprehensive websites are created as part of a branding exercise for the municipal parking operation (e.g. Green P-Toronto Parking Authority, EasyPark-Vancouver Parking Corporation, Park Plus – Calgary Parking).

The City of Ottawa parking website provides basic information regarding parking locations and pricing as well as occupancy information from the PGS systems in each of its five garages as part of a separate interactive traffic map. Various background studies and reports are also available. It also provides information regarding monthly parking permit availability and on-street parking permits. On-street permits can be purchased online but off-street permits are still manual based. The parking web page is accessed through the City of Ottawa's main website.

As described above, the largest municipal parking operators provide a one stop website for customers to search for available parking, open an account, purchase monthly or special event/overnight on-street permits, obtain temporary on-street parking permits, enroll in a waitlist, and other functions. Residential on-street parking permits can also be integrated with these systems. The website can typically be accessed via computer, tablet, or cell phone. Providing people with the ability to pay for permits online at any time increases customer convenience and reduces administrative overhead. The goal for Ottawa should be to create a branded full-service easy to navigate website like those found in Calgary, Toronto, and Vancouver.

5.0 DATA COLLECTION AND ANALYTICS

To effectively manage a parking system, it is important to collect current data regarding utilization characteristics on a regular basis. Detailed information regarding utilization patterns can be used to adjust pricing to attract new customers and identify how to maximize the utilization of expensive parking facilities. Because of the logistical and cost constraints, many municipalities do not collect enough data or have current information for comparative analysis.

The Municipal Parking Management Strategy for Ottawa requires extensive data collection for the Local Area Parking Study (LAPS) process and to support the Rate Setting Guidelines. This includes information on; occupancy patterns, duration of stay, people in violation of parking regulations (e.g. duration of stay time limits), and other characteristics. The City also conducts extensive parking utilization studies across the entire downtown area approximately every five years in order to proactively keep ahead of the need for detailed information. This process is conducted manually and is, therefore, labour intensive and expensive. It also takes a long time to collect, summarize, and analyse the data captured. Ottawa Parking Services has been testing ALPR vehicles for data collection purposes to reduce the cost of manual methods and facilitate custom data collection when the need arises.

Some cities have been using License Plate Recognition (LPR) technology to collect data more efficiently and less expensively than manual data collection[8]. For example, camera systems mounted on vehicles to read license plates for enforcement purposes can also be used to collect data regarding occupancy and duration. These systems are becoming more reliable and less expensive than in the past, but they still require labour to collect (i.e. a driver), process, and manage the data. Other cities are using in-ground sensors to detect the presence of vehicles in individual parking spaces and automatically provide information on parking utilization characteristics[9]. The reliability, accuracy, and cost of in-ground systems are improving but require further refinement, especially for locations with winter climates. There are also accuracy challenges for on-street spaces that are not individually delineated but in-ground sensors can be used for marked loading, tour bus, accessible, and EV spaces. More recently, technology providers are developing above-ground sensors and camera-based systems that can detect the presence of vehicles in parking spaces and create customized databases for analysis. The sensors would be mounted on poles or mast arms independently or shared with streetlights and/or hydro poles.

The increasing competition for curb-side space between vehicle and motorcycle parking, loading/deliveries, ridesharing, bike sharing, tour bus zones, and cycling lanes has led some municipalities to start testing parking sensor and curbside vehicle detection technologies to understand their current capabilities and limitations. They are also trying to understand the opportunities for integrating real-time and historical parking occupancy data into digital curbside management platforms. The information generated by such technology could in turn be used to develop pricing strategies and plan for the most effective use of curbside space, alert enforcement personnel to various infractions, and collect fees from some users of the curbside space. There are privacy issues associated with camera-based systems, particularly high-resolution ones that can also provide the most data, that need to be considered.

The City of Ottawa has already made progressive steps in advancing the use of new technology and data collection with the installation of parking guidance systems in its garages. The next step is understanding and advancing the feasibility of collecting real-time data for the on-street and surface lot parking. Parking Services conducted a pilot project using overhead cameras from 2020 to 2022, concluding that the systems currently available need some refinement before they can be effectively used in the Ottawa context. The next step would be to test in-ground

[8] Examples of Cities using LPR for data collection include Oakville, Niagara Falls, Alliston, Montreal, Saskatoon and Calgary.

[9] Examples include Oakville, Burlington, Guelph and Stratford.

sensor systems, especially for specialty spaces used for loading, accessible parking as well as short-term pick-up and drop-off spaces.

The increasing use of parking guidance systems and LPR technology in garages, surface lots, and on-street provide parking operators with an incredible amount of data regarding parking utilization characteristics that can be mined to improve customer service, increase parking utilization, guide pricing decisions, and conduct future planning. However, it could easily result in information overload. This does not negate the other benefits associated with data analytics – the challenge is not getting lost in the data and using it strategically to make effective decisions. To date, there are few technology providers that can cost-effectively provide a seamless flow of data to meet specific customer needs accurately. In most cases, a customized database system needs to be created.

6.0 PARKING ENFORCEMENT

The City currently has almost 3,800 on-street parking spaces and approximately 1,150 spaces in thirteen surface lots and garages that require parking enforcement patrols. Enforcement is provided through a separate department.

As the adoption of cell phone payment technology and pay by plate payment kiosks for on-street parking and surface lots increases, many municipalities are adopting license plate recognition (LPR) technology to improve the operational efficiency of conducting parking enforcement. For example, handheld enforcement devices can be used to scan license plates and automatically identify vehicles that are not in compliance with parking time limits or have not paid for the parking session, eliminating the need to look up separate lists. LPR enforcement can also be accomplished with vehicle-mounted cameras that speed up the process for issuing tickets, especially for on-street parking. The same LPR vehicles could also be used to collect and produce parking utilization statistics rather than using costly manual survey techniques.

The enforcement division of the City is currently in the process of implementing a new parking enforcement system which includes handheld computers and printers to issue tickets. It is understood the system can incorporate license plate recognition features in the future.

The cost of enforcement can be further automated and reduced if the Province of Ontario creates regulations that allow for the issue of mailed infraction notices rather than require personal service or hand placement on vehicle windshields. Calgary for example, automatically issues mailed citations based upon the use of mobile handheld or vehicle ALPR identification.

7.0 VEHICLE TECHNOLOGIES

7.1 Electric Vehicle Charging

The promise of extensive electric vehicle use has not materialized as predicted by many. It has been increasing modestly each year and is projected (once again) to substantially improve over the next ten years.

Many garage operators have been experimenting with electric vehicle charging stations in modest quantities. The key challenge is planning new parking facilities so that charging stations can easily be added in the future as demand increases. This involves preplanning or installing the conduit and electrical outlets. However, the most difficult issue is preplanning for the substantially increased electrical supply requirements.

Ottawa Parking Services currently has the following EV charging stations in place in their off-street parking facilities:

- 70 Clarence (Lot 4) – 1 terminal on Level 2;
- 141 Clarence (Lot 5) – 1 terminal on Level 2 and 1 DC Fast terminal;
- 687 Somerset (Lot 11) – 1 DC Fast terminal;
- 170 Second (Lot 8) – 2 terminals on Level 2
- City Hall (Lot 6) – 1 terminal at street level on Lisgar Street side.

Parking Services should continue to monitor use and incrementally increase supply as demand warrants.

As of 2022, Ottawa has put in place eleven on-street stations with two terminals at each location and will monitor the use and operational feasibility before expanding the supply on the street. The City of Montreal has launched an ambitious program to install EV charging stations at some on-street parking spaces starting with over 100 spaces and intends to add more.

New garages and surface lots should be planned to meet current demand and allow for future expansion when required.

7.2 In-Vehicle Applications

Vehicle manufacturers are regularly enhancing and increasing the use of in-vehicle applications for many uses including parking.

For example, in 2019 BMW and then Mercedes began to incorporate cell phone app features into its new vehicles so that people will be able to locate parking availability and pricing information for all facilities associated with an app by using the dashboard touchscreen interface instead of their cell phone.

It is expected that in-vehicle apps and communications systems will soon allow vehicles to automatically open and close access gates for parking facilities using Bluetooth technology. For example, as per above, people who have an in-vehicle app and account would be able to enter/exit parking facilities fitted with blue tooth readers, with or without gates.

These applications will markedly reduce the need for people to use physical tickets for entry/exit and payment and increase the number of parking facilities without access gate control. They will also make it easier for customers to view parking availability and pricing information.

7.3 Car Sharing

Car sharing is an important service that has enabled more people to use public transit or cycle for most trips while being able to rent a car for long-range trips where utilizing transit is not practical. An important part of the car share service is providing parking spaces either curbside or in surface lots and garages within convenient walking distance for people's place of residence and place of employment. At present, Ottawa Parking Services has eleven car-share vehicle parking spaces across all their lots.

7.4 Ride Sharing

Ride sharing, as an alternative to owning an automobile or taking transit, has grown substantially over the last decade, leading to increased demand for curbside pick-up and drop-off zones and less demand for parking. The potential impact of autonomous vehicles on parking is dependent on the use of such vehicles for ridesharing as described in more detail below.

7.5 Autonomous Vehicles

A few years ago, there was a regular stream of news articles about how the fast-approaching world of autonomous vehicles (AVs) would change the way we travel, impact transportation-related infrastructure - especially parking, and influence planning and design for urban real estate development. Some articles implied that AVs would be significantly deployed by now which has not been the case. There is a divergence of opinion on when and how the impacts might occur, but it is unlikely that significant deployment will happen for at least ten years. Nevertheless, an increasing number of developers as well as public sector agencies are concerned about the potential long-term impacts and the risks associated with building new infrastructure that may not be suitable for the future.

The increased use of ride-hailing services like Uber and Lyft is already reducing parking demand in varying degrees. For example, hotels in urban areas are reporting substantial reductions in parking demand because people are increasingly using ride-hailing services in place of rental cars. Some airports are also reporting significant declines in parking demand. More businesspeople are using ride-hailing services in place of driving in some congested urban areas because it allows them to work while travelling and avoid the frustration of finding a parking space. Although these examples do not apply universally, it is an indication of how business-related travel is changing when it comes to mobility in congested urban areas. Therefore, the issue is a result of the increased use of ride-hailing services whether they are in autonomous vehicles or not.

Increasingly, both public and private sector developers are asking questions such as:

- Do we really need this much parking?
- What is the risk that we will be stuck with a stranded parking asset?
- Can parking be designed for conversion to another use to mitigate the risk?
- Can valet (i.e. tandem type) parking be used to minimize the space required for parking?
- Can increased use of common shared parking facilities by different developers mitigate future risk?
- Will a lot more space be required for people being dropped-off and picked up?

Although most of the attention regarding AV's has been focused on the technological aspects, the major impacts on transportation infrastructure will depend upon the degree to which individual vehicle ownership is replaced with ridesharing services (i.e. people buying rides versus buying vehicles). All the predictions regarding a dramatic decrease in vehicle ownership and parking demand assume that virtually everyone will embrace ridesharing in some form. These predictions assume that every shared AV replaces anywhere between six and twelve privately owned vehicles. However, it is possible and perhaps even more likely in the near term, that the availability of fully automated vehicles will increase vehicle travel and parking demand because many people who currently use public transit will find it more convenient and efficient to switch to a privately owned AV[10]. It is also quite possible that most people will continue to use private (but autonomous) vehicles because they would be free to perform more productive activities than driving (e.g. working, communicating, studying, etc.), therefore making the time spent travelling much more tolerable. To mitigate the congestion, environmental, and land use impacts that reduced transit use and predominantly private AV use would produce, governments may implement road pricing to induce reduced AV use during peak periods, although the political challenges of doing so are considerable. The outcome in terms of reduced parking demand will depend on the proportion of private AV use compared to shared AV use. Estimates that assume 66% private AV use and 33% shared AV use imply that parking demand could decline by up to 40% by the year 2050, assuming all the current impediments to full deployment of AV's have been resolved[11]. The decline would be higher than 40% in downtown urban areas but less in suburban areas with regular bus transit service where it is likely that transit riders will switch to using AV's.

A University of Michigan Transportation Research Institute study that estimates the potential for multiple car households to reduce their ownership to only one car by using AV ridesharing for some trips, suggests a 43% drop in vehicle ownership is possible if everyone were to do so[12]. Another study by Columbia University, using computer simulation models of travel demand, implies that a 54% reduction in private vehicle ownership is possible[13]. Another study suggests that private auto ownership levels could decline in varying degrees depending on urban density; by 46% to 60% in a very dense urban area like New York, 36% to 44% in a medium-density urban area like Los Angeles and 21% to 31% in a low-density urban area like Dallas[14]. A webinar presentation for the Urban Land Institute suggests a decline in parking demand of 50% in 30 years is a reasonable outlook for real estate investors to consider[15].

[10] People living and working within close walking distance of high order transit service (i.e. subway, commuter rail, LRT) will be much less likely to switch to AV travel than those who rely on regular surface bus transit. People who access high-capacity transit service via bus will be likely to replace the bus service with AV ride hailing service.

[11] Walker Consultants January 2018 Webinar for the National Parking Association, based on AV sales projections by McKinsey & Company in 2016.

[12] "Potential Impact of Self Driving Vehicles on Household Vehicle Demand and Usage" University of Michigan Transportation Research Institute, February 2015

[13] "Transforming Personal Mobility", Columbia University, August 2012

[14] "Driverless Future – A policy Road Map for City Leaders", by Arcadis/HR&A/Sam Schwartz, 2017

[15] The Transportation Revolution: The Impact of Ride-Hailing and Driverless Vehicles on Real Estate, Green Street Advisors, 2017

While these are all estimates that rely on many assumptions that could be quite variable, they all imply parking demand reductions ranging from 21% to 60%, compared to the other studies mentioned earlier that claim a 90 to 95% reduction.

From a risk management perspective, it is reasonable to be concerned that 35% to 50% of the existing occupied parking supply in most of the large urban Cities in Canada might not be necessary in 25 years time (i.e. by 2050), based upon the factors and estimates described above. The dense downtown core areas of these cities might experience drops in existing parking demand at the higher end of the range (i.e. 50%+).

To mitigate the risk associated with substantially reduced parking demand induced by the eventual deployment of fully automated AV's and increased use of ridesharing/hailing over the next 25 years, the following solutions should be considered:

1. Recover the capital and operating costs for new parking over a period of 20 to 25 years.
2. Avoid overbuilding parking by creating a much tighter supply-demand balance.
3. Maximize the use of shared parking between different land uses and separate property owners.
4. Implement parking/transportation demand management techniques to gradually reduce parking demand before AV deployment creates a larger drop in demand.
5. Reduce the amount of parking provided in garages versus surface lots.
6. Reduce the amount of parking provided in underground garages versus above-ground garages.
7. Use valet parking to minimize the amount of space devoted to parking.
8. Design garages for conversion to other uses (i.e. office/retail/institutional uses).
9. Design garages for conversion to reduced parking space sizes and increased pick-up/drop-off.
10. Use temporary above-grade garages.

These solutions minimize future parking garage construction by reducing demand and increasing the efficient use of new and existing garages. The use of new temporary above-ground garages and building surface lots instead of garages are unlikely alternatives for downtown Ottawa. Recovering the costs of building new parking in a shorter timeframe will lead to higher parking pricing that will also have the effect of reducing parking demand.

8.0 SUMMARY OF TECHNOLOGY CONSIDERATIONS FOR OTTAWA

Based upon the foregoing discussion, the Municipal Parking Management Program should:

1. Focus on increasing cell phone and web-based payment from the current 33% rate to 50% or more within the next three years.

2. Improve the Parking Services website to include all things parking such as real-time parking occupancy information, downloading of parking Apps, purchase of virtual monthly and residential on-street parking permits, and payment of parking fines.

3. Conduct a business case regarding the use of pay-by-plate payment instead of pay and display payment when replacing the existing on-street and surface lot kiosks.

4. Develop a protocol for determining the quantity of and payment interface features for new payment kiosks given the trend towards increased cell phone payments and fewer cash payments.

5. Test alternatives (e.g. in-ground sensors) to camera-based parking sensor technology for surface lots and on-street parking to expand the parking guidance system and increase the availability of utilization data.

6. Assess LPR/Bluetooth technology for future parking access and revenue control system upgrades in the garages to increase customer convenience (e.g. LPR/Bluetooth technology, mobile entry/exit without tickets or bar code scanners).

7. Consider a vehicle-based LPR system for enforcement.

8. Continue to test and evaluate the use of vehicle-based LPR systems for data collection

9. Plan new parking for increasing EV use and evaluate the effectiveness of the on-street EV stations installed to date.

10. Assess the potential for expanding the existing garage-based Parking Guidance System to provide on-street directional signage at key routes into the downtown to provide advance guidance regarding the locations where parking is available.

11. Include potential Autonomous Vehicle impacts and best practices regarding parking supply needs when considering future new garages.

Table 2 summarizes the key considerations described in this whitepaper by time frame.

Table 2 Key Parking Technology Considerations

	Next 3 Years	Medium-to-Long-Term
On-Street	Increase cell/web-based payment from 33% to 50% Consider the adoption of pay-by-plate features when replacing the existing pay-and-display kiosks Test in-ground occupancy sensors and monitor the feasibility of aerial/pole-mounted sensors Continue installation of on-street EV charging stations	Increase cell/web-based payment from 50% to 75% Implement occupancy sensor systems
Off-Street	Test in-ground and camera-based occupancy sensor systems for surface lots to expand parking guidance system app re available parking Implement cell phone parking in gated garages Investigate feasibility for Bluetooth parking App in lots and garages Consider adoption of pay by plate features when relacing the existing pay and display kiosks	Implement occupancy sensor systems in surface lots Implement LPR and/or Bluetooth access and revenue control features in garages Monitor the use of existing EV chargers and incrementally increase supply as demand increases
System-Wide	Test and utilize LPR vehicles for parking occupancy surveys – replacing manual surveys Add LPR enforcement vehicles to supplement individual enforcement officers Develop a protocol for determining the quantity of and payment interface features for new payment kiosks for both on and off-street parking facilities	Create a branded website for all things parking including virtual monthly and residential on-street parking permits Implement parking database analytics system that is fully integrated with other system components
New Garages	For future garages, consider/assess implementation of gateless operation with cell phone payment option and pay-by-plate kiosks	Consider smaller scale above grade garages with adaptive reuse to mitigate longer-term risk of redundant supply