BA Group

PARKING TECHNOLOGY ROADMAP

Ottawa Municipal Parking Services

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1.0 INTRODUCTION

Parking planning, design and management are being challenged 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.

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.

Looking ahead, the development of an optimized public parking system needs to account for the following technology components:

- Payment Technologies & Systems – On-Street/Off-Street;
- Parking Guidance Systems;
- Web site and mobile apps;
- Data Collection & Analytics;
- Electric Vehicle Charging;
- Autonomous Vehicles

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

2.0 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 may result in some locations where a kiosk will serve less than eight spaces. Generally speaking, this approach reduces payment machine capital and operating costs and results in less clutter of the sidewalk edge.

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

- Pay and Display whereby the customer pays for parking, receives a payment receipt and places this 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;
- 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 pay by space format is rarely used in on-street locations that receive snowfall because of the need to number parking spaces with a sign.

The City currently uses pay and display machines to collect revenue for using on-street parking in paid parking areas. As described above, this requires people to go to the machine, pay for parking and then return to their car to place the payment receipt on their dashboard for compliance enforcement purposes. Customers are also able to pay by using a cell phone based app which enforcement personnel can access in the field to verify payment.

When replacing old parking meters or upgrading older pay and display technology, many municipalities are using pay by license plate kiosks. 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 upside down (accidentally or on purpose). 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.

Ultimately, the goal should be to maximize the number of people who pay by cell 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 even contemplating significant reductions in the number of on-street payment kiosks as the use of cell phone payment increases. Public and private parking operators are implementing a cell phone payment only policy in some of their surface lots in order to reduce cash collection and machine maintenance costs.

3.0 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 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 the gates in good working order.

In smaller lots and garages, gates are often not used and payment is achieved through the use of the payment kiosks described above in Section 2.0 and payment compliance is achieved through parking enforcement patrols similar to 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 the lots.

Most of the 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 and monthly parking passes. 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. The City just finished upgrading the garage equipment to allow credit and debit card on entry and exit payment at the gates by using tap and go card technology. This will make it more convenient 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. Garage customers could also be provided with the ability to have their cell phone scanned for entry and exit at the gate control. Ultimately, License Plate Recognition (LPR) or Bluetooth Technology could be deployed that will allow pre registered 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. People who are preregistered with a credit card are recognized at the entry/exit gates and are automatically billed for their parking use. This provides people with the increased convenience of not having to use a credit card, ticket, proximity card or cell phone to enter/exit and eliminates or minimizes the issue of lost tickets. Airports have been successfully using LPR for many years.

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 in order to maintain availability for monthly contract parkers. Enforcement in the garages occurs with a combination of foot patrols and vehicle mounted LPR readers.

A more recent form of contactless parking access and revenue control is the use of Bluetooth technology that reads a drivers cell phone signal to open/close gates, compute the parking charge and collect the fee from a pre registered 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 Unites 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. It is likely that blue tooth technology parking apps will eventually be imbedded directly into vehicle dashboard systems without the need for separate devices.

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.

4.0 PAYMENT SYSTEMS

Payment systems are rapidly moving to reduce the use of cash by making it easy to use credit and debit cards through the use of 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 the point of parking by having customers sign up for cell phone and web based payment systems that automatically charge for parking against a prepaid electronic wallet.

4.1 CELL PHONE PAYMENT

Many cities have made arrangements 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 in order 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 EasyPark) 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. Some municipal parking operations are achieving 40% to 50% mobile payment use for parking transactions and have some facilities that accept only mobile payments.

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 operated without gates by using pay and display kiosks (i.e. Glebe and Gloucester Street). Customers are charged a $0.25 transaction charge to use the service. Currently, approximately 15% of the parking transactions are made by cell phone. Potential barriers to increased uptake is awareness and the number of apps that can be used for payment at City parking facilities as well as the extra cost of the transaction fee. The City should explore and develop strategies to increase cell phone payment use to the 50% level or higher.

4.2 WEB BASED PAYMENT

Many parking operators provide a one stop web site 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 wait list and other functions. The website can typically be accessed via computer, tablet or cell phone. Providing people with the ability to pay for permits on line, at any time increases customer convenience and reduces administrative overhead costs to do what customers could do themselves.

5.0 PARKING GUIDANCE SYSTEMS

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

At 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 specific 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 data base of parking utilization characteristics that can be used to optimize occupancy levels, develop pricing strategies and assist in auditing parking revenues. The occupancy/vacant parking availability information can also be relayed to a web site or mobile parking app so customers can check on 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 parking website.

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 sensors and the accuracy with using loops is 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, stadium or 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 their feasibility study regarding the use of on-street and surface lot occupancy monitoring because it would increase customer convenience and provide a rich data base of parking information for future planning and revenue control purposes.

6.0 WEBSITE AND MOBILE APPS

Most municipal parking systems have a web presence with at least basic information on parking locations, rates and regulations. Some web sites include an interactive map that 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 re facility closures and temporary parking prohibitions (e.g. on-street parking bans for snow clearance). Some also include an on line application form for monthly parking. A few websites include real time parking availability (i.e. vacancy) information and on line 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 web site. The ultimate goal should be to create a one stop shopping website for all things parking. Links to and from the local BIA websites and perhaps major tourist attractions, sporting and cultural venues should be considered. The more successful 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). The website should also be made available as an app for use on cell phones and other mobile devices.

The City of Ottawa parking website provides basic information regarding parking locations and pricing as well as an interactive map. Various background studies and reports are also available. It also provides information regarding monthly parking permit availability and on-street parking permits but does not allow people to apply and pay for the permits directly from the website. The parking vacancy information from the PGS in each of the five garages is made available on the City web site. The parking web page is accessed through the City of Ottawa main website. The ultimate goal should be to create a branded full service website.

7.0 DATA COLLECTION & ANALYTICS

In order to effectively manage a parking system, it is important to collect current data regarding utilization and customer preferences on a regular basis. Detailed information regarding utilization patterns can be used to adjust pricing in order 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.

Some cities have been using License Plate Recognition (LPR) technology to collect data more efficiently and less expensively than manual data collection. 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 parking utilization characteristics. The reliability, accuracy and cost of these systems is improving, but still requires further refinement, especially for locations with winter climates. 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 streetlight and/or hydro poles.

The City of Ottawa has already made progressive steps in advancing the use of new technology and data collection with the installation of the 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. With this in mind, Parking Services has been reviewing the options for advancing the use of overhead sensors and hopes to test some pilot projects shortly.

The increasing use of parking guidance systems and LPR technology in garages, surface lots and on-street provides 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 plan for the future. 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 if any technology providers that can cost effectively provide a seamless flow of data to meet specific customer needs in an accurate manner. In most cases, a customized database system needs to be created.

8.0 PARKING ENFORCEMENT

The City currently has almost 4,000 on-street parking spaces and more than 1,000 spaces in fourteen surface lots and garages that require parking enforcement patrols. Enforcement is provided through another department.

As the adoption of cell phone payment technology increases and the prevalence of 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 lookup 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 can 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. Apparently, the system is able to incorporate license plate recognition features in the future.

9.0 VEHICLE TECHNOLOGIES

9.1 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 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 electric 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:

- 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.

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 intend to add more. Ottawa is planning to add approximately 12 on street stations by the spring of 2021 and monitor the use and operational feasibility before expanding the supply on the street.

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

9.2 IN VEHICLE APPLICATIONS

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

For example, BMW has recently begun to incorporate the Parkmobile[1] 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 Parkmobile using the dashboard touch screen interface instead of their cell phone. This type of service could be expanded to include other parking payment system providers.

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

[1] At the time of writing this paper, Parkmobile is owned by BMW.

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 for 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.

9.3 AUTONOMOUS VEHICLES

It seems that almost every week there is a news article about how the fast approaching world of autonomous vehicles (AV's) will change the way we travel, impact on transportation related infrastructure - especially parking, and influence planning and design for urban real estate development. There is a wide divergence of opinion on when and how the impacts might occur and many unsubstantiated pronouncements. Nevertheless, an increasing number of developers as well as public sector agencies and municipalities are becoming concerned about the potential 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 business people 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. We therefore prefer to think of the issue as 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?

In order to understand the eventual deployment patterns for autonomous vehicles, the Society of Automotive Engineers has developed the five level classification system outlined below to describe the increasing levels of automation that will eventually be achieved for vehicles, ranging from Level 0 (no automation) up to Level 5 (full self driving automation). A more fulsome description follows below:

Level 0 – No Automation

The driver is in complete control at all times

Level 1 – Function Specific Automation

There are one or more specific control functions such as cruise control, stability control, automated braking systems, but the driver can regain control.

Level 2 – Combined Automation Functions

Automation of at least two primary control functions working in unison such as adaptive cruise control in combination with lane changing.

Level 3 – Limited Self Driving Automation

All safety critical functions are automated including steering, throttle and brakes but the driver must be available to take over controls when the vehicle system alerts the driver to do so.

Level 4 – High Self Driving Automation

The vehicle can perform all safety critical functions and monitor road conditions for an entire trip, *but it can only be operated in particular conditions or in certain areas that are predetermined*. A driver is not expected to take control at any time.

Level 5 – Full Self Driving Automation

The vehicle can perform all safety critical functions and monitor road conditions for an entire trip under all conditions that a human can traditionally drive.

Automation Levels 0 to 3 already exist to varying degrees. The news articles and great expectations relate to the future deployment of Level 5 vehicles that are still being tested and refined in limited areas. Although the technophiles have been predicting for the past ten years that deployment of Level 5 vehicles in unrestricted conditions is imminent, some people who have studied the matter in depth think Level 5 unrestricted use everywhere is unlikely to happen for at least fifteen and probably twenty years. However, Level 4 deployment may be achieved by 2025 in limited areas.

The successful operation of fully autonomous vehicles without restriction (Level 5) is actually more complex than fully automated aircraft flight. This will require very robust safety protocols and an extremely high degree of system reliability that will significantly increase the cost of producing the vehicles until such time economies of scale are achievable. Level 5 Automation is likely far off in time because despite the hype, it is apparent that the current vehicle prototypes have significant difficulty achieving full functionality under adverse weather conditions (especially winter ice and snow) and in congested conditions with conventional vehicles including drivers. Impediments remain regarding AV sensing and interaction with pedestrians, bicycles and atypical situations such as construction zones. There are also significant issues related to cybersecurity, insurance liability and vehicle/driving regulations that need to be resolved. In addition, there are also substantial infrastructure related improvements required to fully enable the ultimate deployment of fully autonomous vehicles such as vehicle to infrastructure (V2I) (e.g., traffic signal and other intersection control communications) and vehicle to vehicle (V2V) communications, that will take many years to implement due to funding and logistical constraints. All of these issues support the notion that AV's will likely be restricted to limited areas or uses (i.e. ride hailing only) for many years until the issues are conclusively resolved.

The conventional vehicle fleet will take many years to replace once all of the issues described above have been resolved and AV's are available at reasonable cost. At least ten and more likely fifteen to twenty years will likely be required, during which time there will have a mix of semi-automated and fully automated vehicles in operation that will challenge both the operational efficiency benefits attributed to fully automated vehicles and the insurance and regulatory environment.

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 of 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[2]. 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. In order to mitigate the congestion, environmental and land use impacts that reduced transit use and predominantly private AV use would produce, government 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 of the current impediments to full deployment of AV's have been resolved[3]. 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[4]. Another study by Columbia University, using computer simulation models of travel demand, implies that a 54% reduction in private vehicle ownership is possible[5]. 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

[2] 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.

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

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

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

medium-density urban area like Los Angeles and 21% to 31% in a low-density urban area like Dallas[6]. 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[7]. While these are all only estimates which 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 would be 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 2045), 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%+).

It is worth noting that a reduction in parking demand does not imply a commensurate reduction in traffic generation, because the people using shared AV's will still be dropped off and picked up at the site. In fact, people who arrive/depart in shared AV's who were previously transit riders will actually result in an increase in vehicular traffic. This in turn, will require increased pick-up and drop-off facilities to accommodate the demand. In some cases, increased site access capacity will be required as well.

In order 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 to reduce parking 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 in order 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 essentially involve minimizing future parking garage construction by reducing demand, increasing the efficient use of new and existing garages, minimizing the use of underground parking and designing garages for future conversion to other uses. 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.

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

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

10.0 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 15% rate to 50% or more.

2. Improve the Parking Services website to include all things parking including the purchase of virtual monthly and residential on-street parking permits.

3. Evaluate the benefits of implementing pay by plate technology for the existing pay and display machines.

4. Test and implement overhead 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.

5. Consider LPR/Bluetooth technology for future parking access and revenue control system upgrades.

6. Consider a vehicle and handheld based LPR system for enforcement.

7. Test and evaluate the potential for vehicle based LPR systems for data collection

8. Plan new parking for increasing EV use and test EV stations for on-street parking.

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

Table 1 summarizes the key considerations described in this whitepaper by time frame.

TABLE 1 KEY PARKING TECHNOLOGY CONSIDERATIONS

	Next 3 Years	Medium to Long Term
On-Street	Increase cell/web based payment from 15% to 50% Evaluate the benefits of using new payment kiosks with pay by plate features Conduct camera based occupancy sensor test case Test on-street EV charging stations	Increase cell/web based payment from 50% to 75% Implement camera based occupancy sensor systems
Off-Street	Install camera based occupancy sensors in surface lots to expand parking guidance system app re available parking Implement cell phone parking in garages Investigate feasibility for Bluetooth parking App in lots and garages Evaluate the impacts of using new payment kiosks with pay by plate features in surface lots	Implement camera based 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	Create branded website for all things parking including virtual monthly and residential on-street parking permits Test and utilize LPR vehicles for parking occupancy surveys – replacing manual surveys Add LPR enforcement vehicles to supplement individual enforcement officers	Implement parking data base analytics system that is fully integrated with other system components
New Garages	For any future garage, implement gateless operation with cell phone payment option and pay by plate kiosks	Consider smaller scale above grade garages with adaptive reuse in order to mitigate longer term risk of redundant supply