TASK 4: ITS PARKING STRATEGIES

NEXT GENERATION ITS

Prepared for:

SDOT

Seattle Department of Transportation

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Executive Summary

Executive Summary

Parking plays a key role in a multimodal transportation system. The strategies and policies related to parking often directly impact the system as a whole. Whether on-street, off-street or in private garages, parking plays a significant part in the support of businesses, tourists, offices, freight, and commercial vehicles. Typically, the focus of the transportation system is spent on the one to two hours that vehicles are on the road, but to manage and operate an efficient transportation system, it is necessary to address parking issues, which work hand-in-hand with managing traffic congestion.

The City has already made a significant effort in terms of parking wayfinding projects through implementation of the e-Park Phase 1 (now complete) and Phase 2 (currently being deployed). In the same token, robust policies and procedures are in place to govern parking with time of day restrictions, hourly restrictions, commercial vehicle loading zones and multi-use parking / transit lanes.

Managing and enforcing parking policies and procedures has traditionally been carried out manually. This is resource intensive and requires ongoing coordination efforts between different agencies. A more effective parking management mechanism that some cities have recently explored or deployed includes applying technology to manage parking throughout an urban area. With network traffic and parking demand anticipated to shift over the next 12 to 24 months due to the major construction projects planned for the next eight years, it is opportune for the City to adopt similar applications to monitor and manage their parking more effectively.

The City has already developed and implemented robust plans to mitigate the effect of some of these construction projects (e.g., the effect of the SR-99 project on the on-street parking is being mitigated through implementation of e-Park Phase 2).

This task specifically focuses on ITS strategies related to parking and how to integrate them into the overall ITS strategy for the City. Although parking is a complex and diverse field, this task focuses on the following parking elements:

- e-Park assessment and expansion feasibility
- Parking technology strategies
- Dynamic curb space management

This report provides recommendations on the parking management techniques available in the market to meet the City's aspirations for better parking management. The report concludes that the current mitigation strategies adopted by the City along with the current methods of managing parking are adequate for construction mitigation.

Section 1:

e-park System Assessment and Expansion Feasibility

1. e-Park System Assessment and Expansion Feasibility

e-Park is an important component of the City's transportation system and parking strategy. It is a dynamic parking guidance system that provides travelers to Downtown Seattle with real-time parking availability information. It was conceived as a means to efficiently guide downtown visitors to available parking spaces in privately-owned garages, eliminating the uncertainty of finding a parking space, and to continue attracting visitors to downtown. This includes a system of dynamic message signs strategically placed at critical decision points for drivers as well as a mobile web interface allowing users to access more detailed information for participating garages including rates, access location, and current availability.

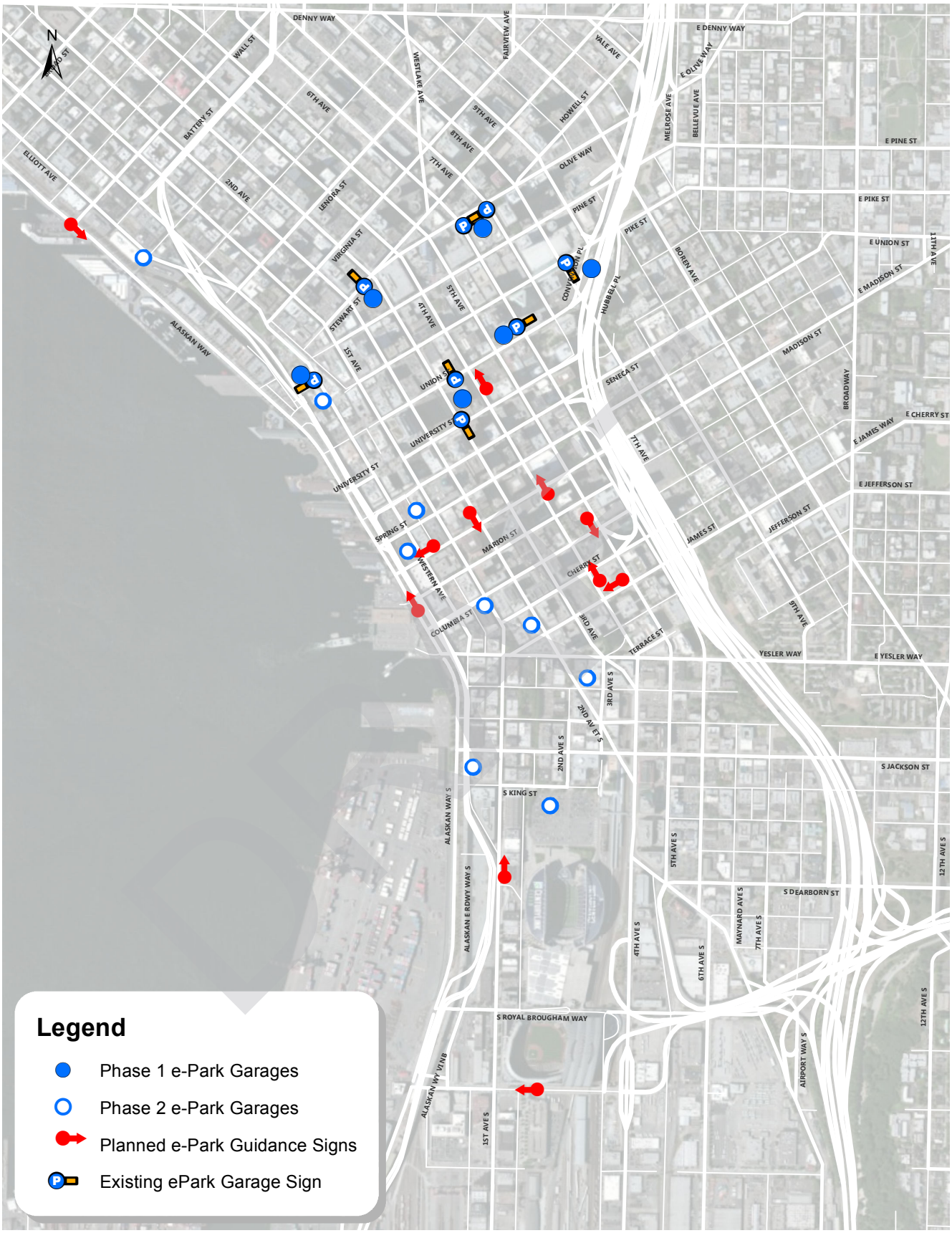
The primary benefits of implementing a real time parking guidance system include:

Provides drivers with information to navigate directly to available parking

- Addresses perception of parking shortfalls in downtown without building more parking
- Reduces driving time related to searching for available parking
- Alleviates traffic congestion along local streets by minimizing vehicles circulating for parking
- Lowers vehicle emissions and decreases greenhouse gases into the environment as a result of less circulation
- Changes perceptions that parking is not available in the downtown area
- Eliminates driver frustration related to finding parking
- Markets the use of private garages that are part of the program
- Provides a positive experience for new patrons to the area due to the ease of finding parking
- Supports the economic vitality of the area served by making it an attractive destination with easy to locate short-term parking
- Allows drivers to make a parking choice prior to commencing their trip by using the mobile application

Phase 1 of the e-Park system was launched in September 2010 as a pilot project to determine if a parking guidance and wayfinding system would provide benefit in Downtown Seattle. The system uses technology and marketing to directly guide customers and visitors to available parking. This initial phase included six privately-owned garages throughout downtown and five dynamic message signs within the downtown. The system has been successful and is being expanded to provide a more comprehensive network of available parking throughout downtown. Figure 1 illustrates the existing e-Park system that represents Phase 1.

Figure 1: Existing (Phase 1 and 2) e-Park System



Expanding e-Park

Several significant construction projects are occurring that will change the transportation and parking systems within the City of Seattle and e-Park is one of the systems being implemented to mitigate parking and traffic impacts.

As explained above, e-Park can provide significant benefits in helping reduce traffic congestion and ease access to available parking in a busy urban environment. This is accomplished through providing direct guidance at key decision points to available parking garages, minimizing the amount of traffic circulation related to finding parking and allowing more capacity to accommodate increased congestion related to construction impacts. In addition, parking in nearby e-Park garages can provide parking options for areas where parking is being eliminated or temporarily closed due to construction.

Phase 2 Expansion

The SR 99 Tunnel Project Parking Mitigation Plan (July 2012) identified improving wayfinding to parking and destinations in the Pioneer Square and Central Waterfront areas. It is anticipated that the Alaskan Way Viaduct Replacement Program will result in a loss of approximately 640 short-term parking spaces, primarily in the Pioneer Square and Central Waterfront areas. Phase 2 of the e-Park system is in direct response to this and helps mitigate the loss of parking in the Central Waterfront and Pioneer Square areas. This specifically includes six to nine additional parking garages (see Figure 1) and eleven additional dynamic message signs.

As shown in Figure 2, Phase 2 will incorporate e-Park garages within close proximity to areas where parking is being lost by construction projects as well as near many of the impacted corridors.

In addition to the field equipment upgrades within the e-Park Phase 2 expansion project, it is recommended that SDOT integrate the e-Park data with the current Traveler Information Map (TIM) system and deploy a common communication network with the ITS systems to enable central management from the TMC. This will allow the e-Park system to be integrated into a comprehensive citywide ITS system where a variety of transportation data sources can be disseminated from SDOT's central data management platform, Data Manager. This will both save the City time and, in the future, budget and resources. The integration is also important to enable the City to best balance the multi-modal needs of the travelling public.

Expanding Beyond Phase 2

There is a need to continue to expand the e-Park system beyond Phase 2 as the impacted corridors extend to all areas of the City. Primary candidate areas for expanding the e-Park system include those areas that have large supplies and underutilized off-street parking, and areas that have traffic congestion. Given these criteria, areas to the south around the SODO/Stadium District and areas to the north around Seattle Center would be ideal targets for expansion, which are described further below.

SODO/Stadium District

Targeting SODO for Phase 3 of the e-Park system would be beneficial to alleviate impacted corridors in the south end of Seattle. This is a prime area for the system given the number of large garages, number of impacted corridors related to construction activity, and the high volume of new visitors related to special events at the large venues: Safeco Field and CenturyLink Field and Event Center. In addition, an environmental review process is currently under way for an Arena south of Safeco Field on the northeast corner of 1st Avenue S and S Holgate Street. This Arena would seat 18,000 to 20,000 people and increase the number of and frequency of large events occurring in the Stadium District. With large events in SODO, finding parking can become difficult and the roadway system will only become more congested due to the large influx of visitors as well as drivers searching for parking. Providing an e-Park system in this neighborhood would minimize circulation by vehicles searching for parking and alleviate some of the traffic congestion. Vehicles could be directed from major travel routes such as I-5, I-90, 1st Avenue S, 4th Avenue S, and S Holgate Street directly to the closest available parking, which would minimize the vehicle miles travelled and circulation on the local street network. There are several large parking garages in SODO including Union Station, CenturyLink Field, Safeco Field, and Home Plate. These garages are the primary resource for event parking and would be well-suited for e-Park expansion.

Seattle Center

For the areas north of the City, Seattle Center would be a good target for a potential future phase. Seattle Center hosts numerous events, activities, and attractions within a variety of venues. The Center's many venues include the Pacific Science Center, Experience Music Project, Space Needle, Children's Theater, McCaw Hall, and many others in addition to the 17,072-seat Key Arena that all attract visitors and hold special events. In addition, there are a few large festivals with attendances of 30,000 to 60,000 people that occur annually including Folklife over Memorial Day

weekend, the Bite of Seattle during July, and Bumbershoot over Labor Day weekend. Off-street parking in this area is primarily provided by three garages operated by the Seattle Center (Mercer, 1st Avenue North, and 5th Avenue North). These garages would be prime locations for e-Park to guide visitors with signs along Mercer Street, Denny Way, Queen Anne Avenue, SR 99, and I-5 directly to available parking at the Center. This would help alleviate congestion along many of the impacted corridors in the north part of the City.

South Lake Union/Denny Triangle

South Lake Union and the Denny Triangle are areas within the City that are experiencing a significant amount of growth related to recent zoning changes that increased height and density regulations. This has already spurred many new development towers with future plans for many more including a large campus to house Amazon. These neighborhoods are impacted by the Mercer Corridor and Alaskan Way Viaduct Replacement – North Portal projects. New development in South Lake Union and Denny Triangle will bring new privately-owned and publicly-available parking garages that would serve as viable locations for implementation of e-Park. Like the other areas of the City, provision of e-Park can minimize frustration related to searching for parking and alleviate congestion on the street network. In addition, SR 99 currently creates a barrier separating South Lake Union from the Seattle Center and future improvements, related to the Alaskan Way Viaduct Replacement, will provide connections across SR 99 allowing for better pedestrian access between the Seattle Center and South Lake Union. This may increase the viability of parking in South Lake Union for Seattle Center events.

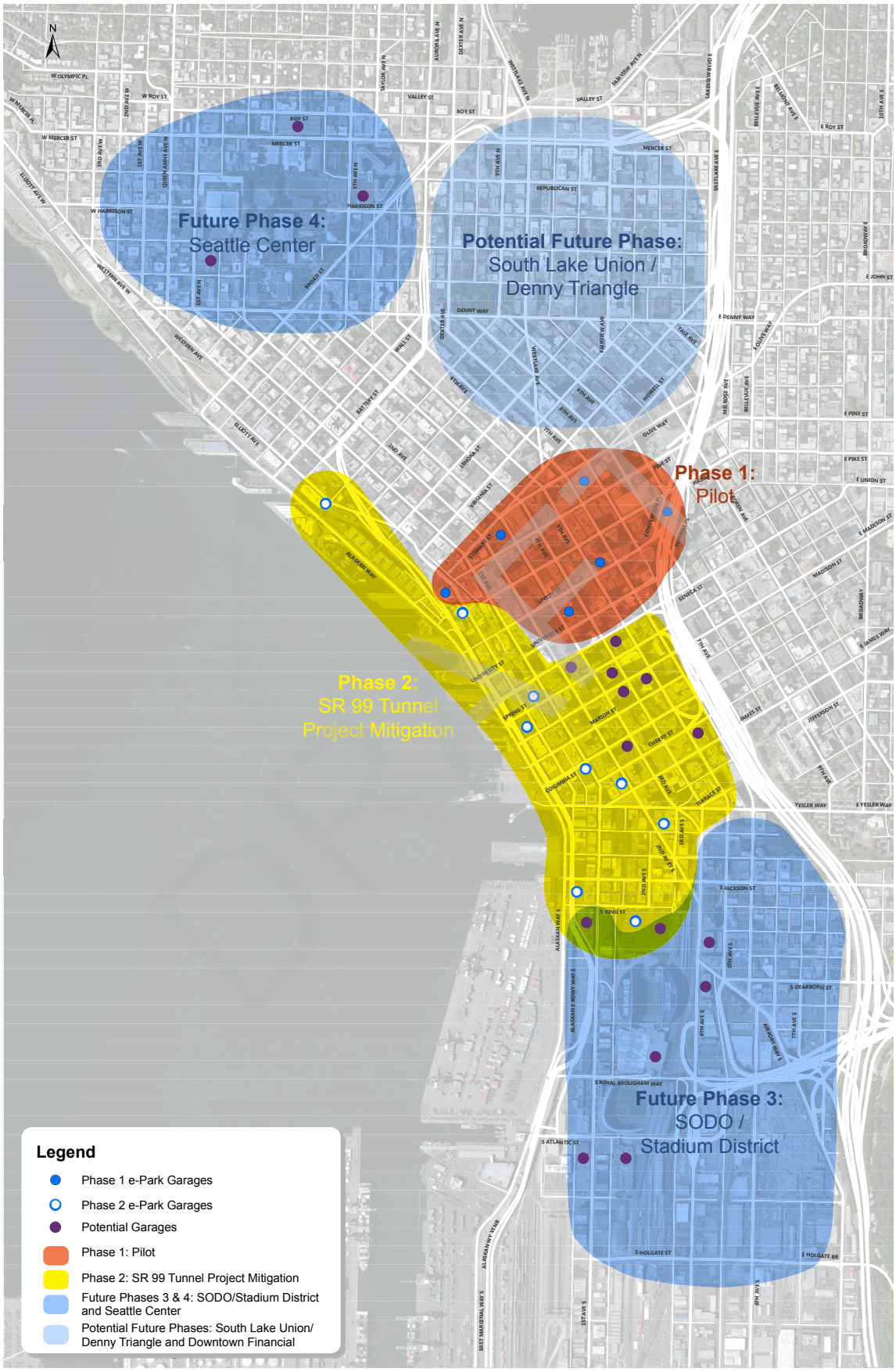
Downtown/Financial District

There are a number of large parking garages in the Financial District that could be included as a natural expansion to the garages already incorporated in the downtown e-Park program. This could include Olympic Garage(415 Seneca Street), 901 Fifth (901 4th Avenue Garage), 4th Avenue Plaza(1001 4th Avenue), 4th and Madison (925 4th Avenue), 1201 3rd Avenue Parking (1201 3rd Avenue), Sea Park Public Parking (609 6th Avenue), and Cherry Street Garage (213 Cherry Street). All of these locations could help to alleviate the impacted corridors in the downtown area. This area is being targeted as part of Phase 2, but continued focus in this core area of the City will be needed as the system grows and matures.

The success of expanding e-Park depends on developing Public/Private partnerships between the City and privately owned garages. e-Park benefits the City by alleviating traffic congestion and improving economic development and private garages can often benefit as customers are routed directly to their garages.

Figure 2 illustrates the potential areas for consideration related to e-Park expansion.

Figure 2: Potential e-Park Expansion Areas



e-Park Integration

As discussed in the Task 2 Next Generation TMC report, there is a desire to move to a more integrated approach in managing the traffic and transportation network from the Transportation Management Center (TMC). An integrated multi-modal approach to travel demand management considers the needs of passenger vehicles, transit, pedestrian and cyclist. As it relates to the e-Park system, information regarding the availability of parking is useful for the travelling public to make an informed decision on their travel plans.

SDOT's current Traveler Information Map (TIM) provides information to the public on roadway conditions and provides selected camera views for trip planning purposes, helping travelers avoid congested areas. The TIM's front end Graphical User Interface (GUI) runs off a back-end data warehouse platform called Data Manager. Consistent with the recommendation presented in the Task 2 Next Generation TMC report, integrating the e-Park system into Data Manager allows parking information to be available to the same users as the TIM. Complemented with the recommendation to integrate information for other modes of transportation, it is envisioned that the TIM will function as a dependable tool to further assist the public with trip planning.

In addition to the users, e-Park also provides the TMC operators with information on available parking, which will allow them to leverage this information when assisting with network management.

e-Park Cost

Building parking is both cost-prohibitive (at approximately $60,000 per space for structured parking) and contrary to progressive policies that discourage the construction of parking and support commute trip reduction. e-Park not only helps mitigate the impact of a pending acute shortage of short-term parking due to construction impacts, but also helps resolve enduring need to enhance the perception of parking availability and alleviate traffic congestion. Implementation of e-Park encompasses both physical and technological complexities.

The components to e-Park that require funding include installing a counting/detection system in the garage and installing guide signs. A counting/detection system in the garage consists of a gate and ticket dispensing system combined with upgraded software to push information to the message signs. This costs approximately $10,000. The guide signage typically includes an exterior sign on the garage and dynamic routing signs throughout the City. A static sign for the garage typically costs about $2,500 and dynamic routing signs costing about $75,000.

Section 2:
Parking Technology Strategies

2. Parking Technology Strategies

Parking is truly an integral part of the overall transportation system, and ITS and technology can play a key role to help manage parking and traffic congestion. e-Park, described in the previous chapter, is one important existing piece of technology. This chapter focuses on identifying new technology related to on-street sensors and dynamic curb lane management that might be considered as part of the Next Generation ITS System. Using technology to efficiently direct travelers to their intended destination and nearby available parking facilities is an important component to alleviating roadway congestion that will be exacerbated by construction impacts. Technologies that would significantly benefit SDOT's parking operations are systems that provide a real-time understanding of available parking facilities and systems that employ wayfinding tactics using the data captured.

The following sections provide some insight into sensor technologies and dynamic curb space management that are expected to meet these objectives.

On-Street Sensor

When looking at sensor technology for on-street parking, it is important to understand the purpose and customer needs. Sensors can be used to assist authorities with managing and enforcing parking uses as well as to provide customers' benefits. The needs and benefits for authorities differ based on specific guiding policies and management practices. Sensors can be utilized to help manage parking in the following ways:

- Provide real-time information for demand-based pricing strategies
- Guide users to underutilized parking areas and away from congested areas
- More efficiently enforce violations
- Improve revenue at pay stations by resetting meters upon vacancy

Based on coordination with SDOT staff, the main purpose for considering sensors would be to provide guidance and wayfinding to available on-street parking.

System Needs

The system needs are directly related to the intended purpose and experience the end user desires.

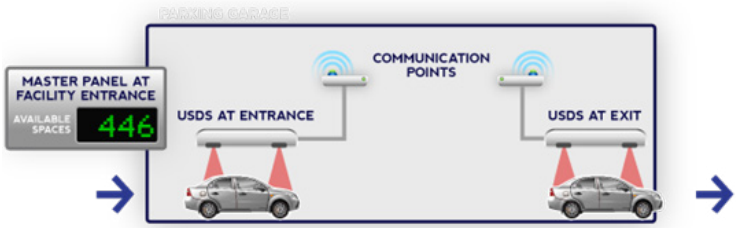
Most parking programs utilize a suite of complementary products that work together to achieve the overall goals and objectives. When sourcing technology, it is critical to understand where each piece fits in to the overall operation puzzle, and to understand what need it is intended to fill. The Next Generation ITS Program is intended to be a multimodal program that includes parking so adopting technology that can be integrated with the complete SDOT ITS system is important.

A sensor system refers to any access or information management tool that uses an electronic sensor switch to trigger an action, and send information to activate a control device, increase or decrease a stall count number, or send an instruction to another system or sign display.

Sensor systems are most often used for wayfinding or signaling space availability to prospective parking customers. They utilize many sensor units and replace manual and semi-manual means of gathering information. They impact the ability of a provider to anticipate and measure demand for space, and to provide more accurate financial and service level reporting. These applications have been used in European garages, municipalities and institutions, as well as airports worldwide, for about 10 years; most of them rely on installation of a small switch sensor in parking spaces, or in key locations, to send a signal to a display light or sign and advertise stall availability and location. These sensor systems are most effectively used on individual demarcated spaces or at entry/exit points to confined parking garages or lots.

The e-Park program utilizes general gate sensors to calculate occupancy of parking garages that is then relayed to message signs to alert drivers to available off-street parking garages. The current system tracks parking availability for each garage and communicates this information to the signs via a wireless network (see Figure 3). The communication system at each location is tailored to the technologies available and the relative cost of implementing the preferred option – a flexible approach maximizing efficiency while minimizing City cost.

Figure 3. Illustration of Gate Sensor Technology for Off-Street Parking



In relationship to off-street parking sensors, on-street parking stall sensors have been slower to mature because the requirement to self-power, the different behavior of customers, durability related to weather and environment, and the proximity to electronic interference introduces new variables. Exterior sensors have been used for tolling and other related traffic management technologies, but they are still relatively new and in test phases until the technology matures. On-street sensors are mostly utilized in areas with single space meters or individually marked spaces where a sensor can be optimally placed to detect a parked vehicle.

With the recent focus on creating more sustainable communities, stakeholders have become more aware of the need to manage parking demand, and influence parking professionals to pursue new solutions aggressively. On-street parking sensor system are being slowly introduced around the world and most notably in San Francisco, Los Angeles, and San Jose with several other cities experimenting with sensor systems.

Sensor Devices

Sensors can be categorized into three primary areas: in-pavement sensors, on-meter radar sensors, and video analytics. Within each sensor category there are different technologies that are utilized for sensing including magnetic field, radar, photo cell, and inferred detection. There are pros and cons for each application and many of the devices are relatively new and not well tested. Most of these sensing technologies would require the use of more modern pay stations that would have capabilities to communicate to a central database for monitoring and operating the system.

Pavement Sensors

Pavement parking sensors typically use ultrasonic, magnetometer, or photocell technology to determine if a space is occupied. The reliability of these technologies differs depending on the environment and some sensor systems utilize more than one technology in each sensor. The current generation of in-pavement roadway sensors are mounted as a flush or blister profile. Most are either self-powered through a solar cell, a long duration lithium battery, or a combination of the two. Figure 4 shows some of the typical sensors used for parking applications.

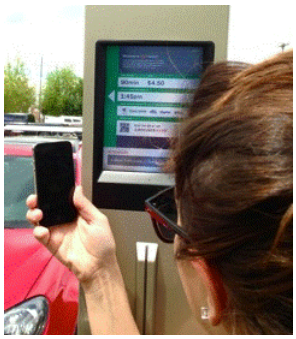
Some of the solar units can be surface mounted but most are mounted by boring into the pavement. The longer duration and more powerful batteries are larger and typically require a deeper pavement installation. Figure 5 below shows typical setup of parking sensors.

Most of the products on the market have approximately a five year life span and require either full replacement or battery replacement at that time. Some of the solar technologies claim to have a longer 10 year life but, as yet, these are untested and can only be considered as claims.

Figure 4. Examples of In-Pavement Parking Sensors

Figure 5. Examples of Parking Sensor Setups

Figure 6. Meter Sensor



Meter Sensors

Sensors are also being installed on single space or dual space meters and typically use radar for vehicle detection (see Figure 6). These sensors are either externally mounted to a pole or other existing infrastructure or built into the pay station/meter itself. These systems provide an alternative to mounting to or in the pavement.

Video Detection

Newer digital-camera parking sensors use video analytics, license plate recognition, and infrared technology for detection with some systems able to determine vehicle type, color, and license plate number. This video detection allows for uses such as finding a person's vehicle such that a person can enter basic details about their vehicle and a video detection system can guide you to where a vehicle is parked.

Sensor Limitations

There are limitations on the current generation of external sensors:

- The current cost of space sensors keeps them beyond the financial reach of most cities and parking facility operators. Costs can vary significantly depending on the type of detection used, but given that each space requires a detection device a lot of hardware is necessary that also requires maintenance.
- In-pavement sensors can allow water to flow behind them, negatively impacting the life of paving materials.
- Although the sensing technology appears to work in winter temperature and weather conditions, some profiles are not low enough to avoid sensor destruction by a snow plow blade; this makes the units inoperable in winter climates. In addition, some sensors will not work when covered with snow or hail.
- Most sensors are only able to focus on an individual stall to accurately count vehicles. Where a "pay and display" multi-space system is in use (like most parts of Seattle), and spaces are not defined, an accurate count is not possible. Current tests are being conducted on some pay and display blocks of New York and they have not found a reliable set up as of yet. After initial testing, spaces were striped and even after individual spaces were striped vehicles would not always park in designated spaces, providing inaccurate detection.
- When vehicles are counted so as to attract parkers in real time, available spaces are also filled in real time. During heavy parking periods, parkers have no window of opportunity to go to the available space before it is filled by another parker. This results in the "cruising for parking space" effect the system is supposed to eliminate.
- Sensors communicate wirelessly on a variety of radio frequency bands. In many urban locations, frequencies are consumed by inaudible street noise from electrical transmissions, resulting in interference with the sensors transmissions, and data errors in the system.
- Privacy concerns may also be raised with the use of camera sensors that record license plate information.

On-Street Sensor Pilot Project

In addition to the Commercial Vehicle Load Zone Pilot Project, which will test sensor technology, it is recommended that SDOT conduct a neighborhood pilot project to test different types of on-street sensor technology and integration capabilities with the TMC. The pilot project would allow the City to test in-pavement, meter, and video sensors and evaluate the ability of each technology to monitor every parking space within the selected area; deliver real-time 24/7 continuous data stream; collect parking occupancy, turnover, vehicle size (length, height, and classification); sense violations such as double parking; and be implemented with minimal street infrastructure requirements. It is recommended the pilot be conducted for a period of no less than one year given the unique climate in Seattle – in particular if solar power is used. This evaluation period will ensure the City is provided with a comprehensive trial report that covers all aspects of the technology used and the suitability for the Seattle environment.

During the pilot project, data collected by the sensors would be rerouted to the TMC (via a cloud environment,

Wi-Fi Mesh, GSM, or Fiber). For ease of installation in a pilot project setting, cellular communication can be used to relay information back to the TMC if physical communication is not available. This data should be processed through the data manager system responsible for disseminating information to the public through SDOT's TIM. This should allow for real-time parking availability, and should integrate with roadside pay stations to collect pricing data to disseminate to the public.

The following provides specifics related to in-pavement and roadside (meter/video) detection that should be considered when implementing the pilot project.

In-Pavement

Typically, in-pavement sensor would use radar technology and would communicate to either a roadside receiver & transmitter or to a Cloud. For the pilot project, it is recommendation that roadside above ground wireless detection be installed. This can also be used for the roadside technology described below.

Roadside

The pilot should consider magnetometer sensors, which use wireless technology to communicate to receivers and transmitters. It is recommended that the City mount the roadside transmitter and receiver unit at a minimum height of 20 feet. This would provide a range of 150 feet that would effectively provide detection for about 15 demarcated parking stalls, depending on the parking configuration (angled, perpendicular, or parallel). The transmitter and receiver unit should have the capability to communicate with roadside pay stations to collect pricing information.

An ideal location for the pilot project would be some of the redeveloped areas of South Lake Union, which has demarcated diagonal on-street parking spaces along Terry Avenue, or within the Stadium District with the potential construction of an arena. In selecting a location for the pilot project, the City should consider a corridor with mostly flat topography for the initial testing. The shape of the magnetic fields emitted by the sensors' steep terrain often prevents reliable communication to roadside transmitters and receivers. The selected location(s) should also provide a clear line of sight between the transmitter, receiver unit, and sensors. The pilot project should be conducted for no less than four to five block faces within close proximity. This will provide for testing of the sensor integration with TIM and data to be provided to the public, allowing drivers to make an informed decision related to on-street parking availability within the pilot project area.

Alternatives to Sensor Systems

Sensor systems intended to fill a need for more efficient inventory management of parking stalls and conveyance of availability information directly to customers have not achieved 100 percent accuracy or widespread acceptance in all conditions.

Alternative methods of gathering vehicle location information include:

Data Collection

Data can be collected manually or through mobile license plate recognition cameras by enforcement officers, data collectors or other manual means to monitor general activity and trends. This can require a significant amount of effort including time and cost depending on the size of the study area and whether enforcement officers collect data or specific data collectors are hired. Typically, the accuracy of the data received is higher and other characteristics besides simply occupancy can be collected such as turnover and permit information. This data can be utilized to identify general trends and patterns that can be used and evaluated in software analytics to estimate forecasted demands. ParkMe and Parkopedia are examples of software analytics that can be used to provide general indications of available parking that can be pushed to customers through mobile applications.

Park by GPS

Global positioning system (GPS) units mounted in a vehicle can monitor the location of all vehicles parked in the city and remotely calculates fees, transferring costs to a vehicle driver's pre-authorized credit/debit card, and depositing fees in the City's bank account.

Video Monitoring

Closed circuit television (CCTV) cameras could also be used to generally monitor levels of parking congestion on City streets to either support or verify historic data trends and provide a general indication of space availability without detailed analytics being processed.

Section 3:
Dynamic Curb Space Management

3. Dynamic Curb Space Management

The use of Dynamic Curb Space Management was explored to determine if on-street parking lanes could be dynamically converted to vehicular travel lanes to offset traffic impacts anticipated from construction activity along key corridors. This would provide a flexible system that could be changed dynamically during certain hours of the day to allow for more vehicular capacity in a corridor and alleviate congestion.

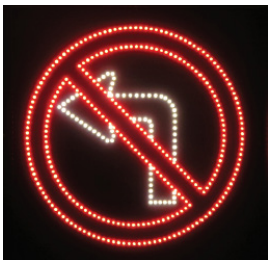
Curb space management practices of restricting on-street parking to allow vehicular travel is already being utilized along many corridors in Seattle, but the restrictions are static and consistent each day. This typically includes restricting parking during specific AM and PM peak period to either allow additional vehicular or transit capacity.

There are very limited applications that utilize Dynamic Curb Space Management and all are customized solutions for the specific condition. The difficulty with creating a dynamic solution is being able to communicate effectively with the drivers to avoid confusion and violations. This typically requires the use of signage and dynamic message systems to convey information. The use of overhead or curbside dynamic message signs is likely the most effective communication method but dynamic lane markings using in-pavement lighting is another option that has been identified. To provide a glimpse into the future possibilities of ITS and roadway design, future visions of solar roadways are also briefly described.

Blank Out Signs

Blank out signs are an ITS applications that are often used to convey information dynamically or on a part time basis. A blank out sign is one that is black (blank) when not in use and is illuminated when information needs to be broadcast. These technologies are often used on urban roads to convey messages of additional restriction such as train crossing, No Left Turn, or reinforce current restrictions such as No Right On Red. Figure 7 shows an example of blank out signs. For curb space management, these signs could be mounted over curb lanes to identify the use of the lane.

Figure 7. Examples of Blank Out Signs



Dynamic Message Signs (DMS)

DMS signs have been in use for decades to convey information to the travelling public. These are often used on highways to provide advance warning to drivers regarding lane closures, collisions, travel times, even amber alerts. For curb space management these signs could be mounted over curb lanes to identify the use of the lane.

Case Study – Minneapolis, Minnesota

Minneapolis currently utilizes a combination of DMS, static signs, and smart meters to dynamically change the use of the parking lane to a travel lane when extra vehicular capacity is needed during peak hours and event conditions. This includes a series of DMS mounted over the lane that are tied into the City's overall ITS dynamic message system (see Figure 8). The City has over 80 DMS that alert the drivers when large events and other conditions are anticipated to impact traffic conditions. The dynamic nature of the curb lane is part of the City's event program, which alerts drivers via the DMS over the curb lanes at times when parking is not allowed, and pay stations and meters are synched to not accept payment. This provides a great way to accommodate dynamic lane assignment as part of an overall citywide ITS and event management system.

Figure 8. DMS Over Curb Lane

Dynamic Lane Markings

LED and in-pavement lighting techniques such as those used on airport runways or for some pedestrian crosswalks can be utilized to simulate lane markings on the pavement. This would include installing a series of lights that are coordinated and synched together that could be programmed and managed from a transportation management center, turning travel lane arrows on and off as well as demarcating parking stalls (Figure 9). This technology has been used in Europe with mixed results. The lighting is fairly intuitive but to make the lanes dynamic, information must be provided in advance using DMS or other signage to alert drivers when conditions change. The lighting also requires a number of LED lights to be installed in the pavement that degrades the life of the pavement, requires on-going maintenance, and can create unwanted tactile responses for drivers.

Corridor Evaluation

Given that the Next Generation ITS project is evaluating solutions from a multimodal perspective, solutions and recommendations need to consider applying a balanced approach to all transportation modes. A dynamic curb space management corridor is intended to provide flexibility to shift the priority use of the curb side lane from parking to either vehicular or transit priority. This typically provides additional roadway capacity to handle high traffic flows but eliminates parking. This is often beneficial to accommodate short-term peak conditions during the peak commute hours or impacts generated by events.

To evaluate corridors where dynamic curb space management could be considered, focus was given to the corridors that were determined to be impacted by construction projects. The primary north-south impacted corridors through downtown Seattle included 1st Avenue, 2nd Avenue, and 4th Avenue. When evaluating each of these corridors for potential dynamic curb space management, consideration was given to where parking is available, parking restrictions, identifying transit priority, location of e-Park garages to mitigate loss of parking, location of loading zones, where parking is manually closed for event management, and where curb-bulbs exist indicating pedestrian priority.

Figure 10 provides a summary of the current corridor restrictions and functions. Portions of 1st, 2nd and 4th Avenues already have curb space management in place with peak hour parking restrictions occurring during the AM and PM peak hours to allow either vehicular or transit use when traffic volumes are at their highest levels during the day. This is set at static or fixed periods each day typically between 7:00 a.m. – 9:00 a.m. and/or 4:00 p.m. – 6:00 p.m. This is managed through standard static signs and regular enforcement. Applying a dynamic condition to theses corridors would allow a more flexible use of these corridors to other periods of the day; however, it would

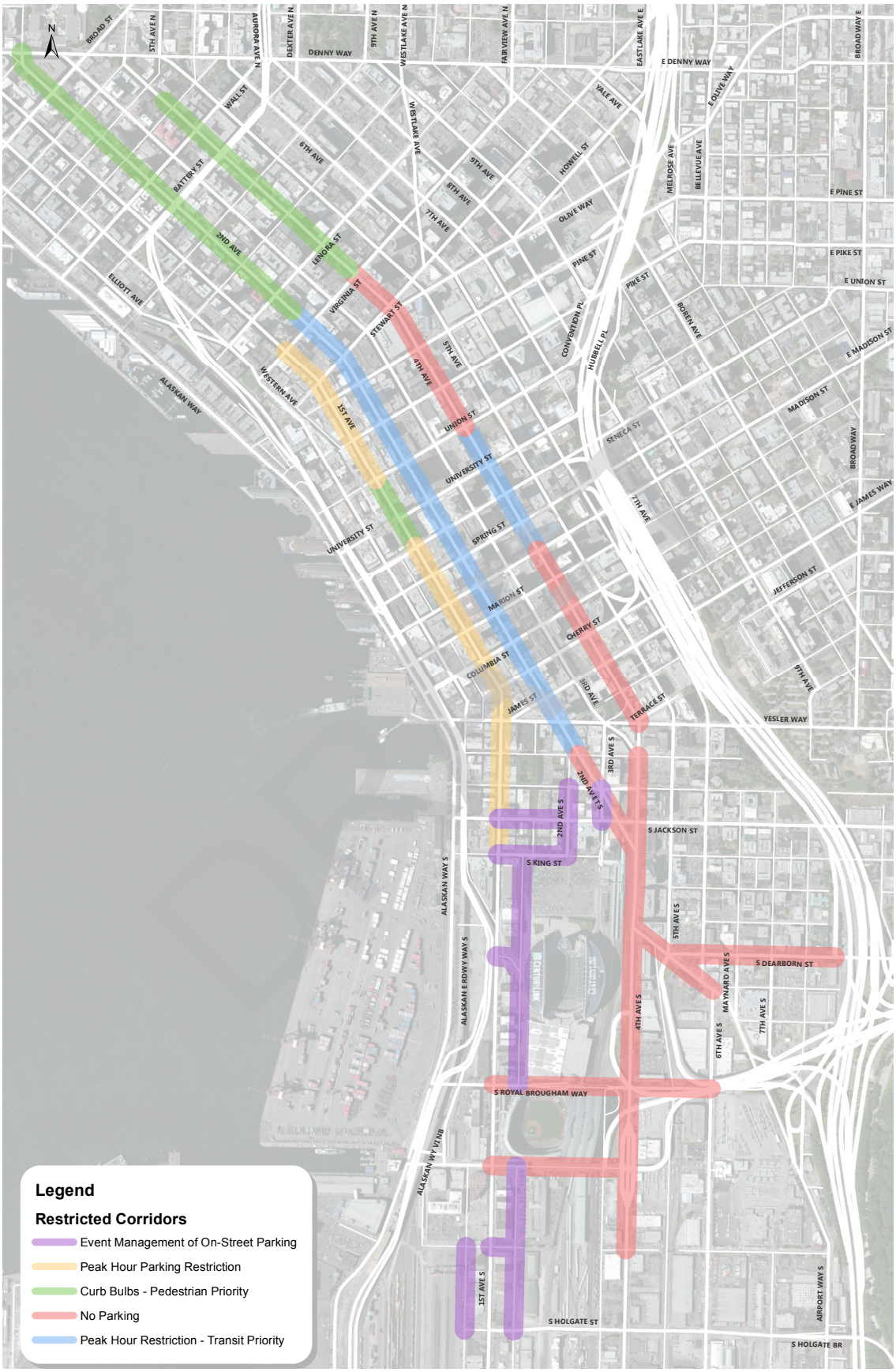
Figure 9. Dynamic Lane Markings

come at a cost to parking availability including loading zones that are a vital component in the middle of the day.

When looking at specific corridors, 1st Avenue is a two way corridor and 2nd and 4th Avenues act as one way couplets. Second and Fourth Avenues would be better suited for adding additional capacity as they are already designated as primary north-south routes through the City. Extending curb space management along 2nd Avenue to the north through Belltown is not feasible as the areas between Lenora and Denny provide curb-bulbs to provided improved pedestrian safety and access through Belltown. The curb-bulbs would need to be removed to utilize the parking lane for travel.

The dynamic use of the curb lane is best suited for areas where transportation conditions are dramatically changed due to events and unusual activity. As shown in Figure 10, parking is manually closed as part of a road closure or event management strategy around a number of corridors surrounding the Stadium District. These areas require cumbersome A-frame signs be placed along city streets to provide advanced notice to parked vehicles. These signs are fairly effective but deployment is labor intensive and they are often located in prime pedestrian areas and are unsightly on City streets. A more automated system could be considered to replace the manual closures through dynamic messaging and smart meters that are managed from a central command center. This would require installing black out signs or DMSs overhead or along the curb along with smart meters that could be linked and programed from the City's TMC.

Figure 10: Dynamic Curb Space Management Evaluation



Section 4:
Recommendations

4. Recommendations

The following provides a summary of recommendations related to parking strategies for the Next Generation ITS. These strategies are targeted at mitigating parking impacts related to construction projects.

e-Park

- Integrate e-Park system into the City's Transportation Management Center to incorporate parking and the e-Park infrastructure as part of the overall TIM system. This will provide valuable information to both the travelling public and TMC operators.
- Expand e-Park to areas with large parking garage facilities in the south and north end of the City. This would include significantly sized garages around the Stadium District to the south and Seattle Center to the north. The expansion would help alleviate congestion on corridors impacted by construction as well as benefit event conditions.
- Seek expansion of e-Park garages through requiring mitigation funds from new event generators such as a new arena facility, other public and private projects that require mitigation for transportation impacts, and major transportation or other infrastructure projects.
- Expand existing partnerships (like those with the Seattle Downtown Association) to organizations that can help promote and facilitate e-Park expansion.

Parking Technology Strategies

- Test the use of different sensor technologies as part of the Commercial Vehicle Load Zone Pilot Project and look for other opportunities to implement future neighborhood pilot applications in areas with demarcated parking spaces such as Westlake, South Lake Union, the Waterfront, developing areas in the Stadium District, and other areas that occasionally experience high parking volumes due to tourist activity.
- The City's ongoing efforts to upgrade current pay station technology should allow the on-street parking system to be managed from the City's TMC. During implementation, it is recommended that SDOT require vendors to develop specific application programming interfaces (API's) to provide information such as transactions, rates, location, and other statistical information into the data manager housed within the TMC. This information could be used in conjunction with an algorithm to estimate parking availability that can be communicated via the TIM.
- Newly upgraded pay stations should be "forward compatible": equipped to communicate with roadway sensors and share transaction data with the TMC.
- Utilize TIM to provide parking availability to the general public after new pay stations are installed. The data would be based on transaction data from new pay station technology as compared to actual counts.

Dynamic Space Management

- Replace manual event management parking closures with an ITS based solution that included dynamic message/blank out signs and smart meters or pay stations that could be controlled at the City's TMC should be considered. This would improve communication in areas with many new visitors and could be integrated with the Citywide DMS system. Figure 10 highlights the corridors with event management, which are mainly along 1st Avenue S.
- Static peak hour restrictions are working in the downtown core, primarily to provide additional transit capacity. Installing expensive infrastructure and systems to provide additional vehicular capacity during other periods dynamically in the urban core would impact transit, loading zone, and parking priorities. Expanding the areas to the north would also impact pedestrian priorities and safety desired in Belltown and is therefore not recommended.

Section 5:
Cost Estimates

5. Cost Estimate

The following provides general cost information for e-Park, sensors, and dynamic curb space management systems. Cost of deploying these systems vary depending on the deployment size, type, and potential civil work that may be required. Many of these systems will have significant economies of scale with larger deployments. Accurate costs are not possible until further analysis is completed and a firm decision is made on locations and the type of system to use. The tables below depict typical cost estimate for various ITS components related to e-Park, parking sensors, and dynamic curb space management systems, and are intended to provide the City with a general idea on budget requirements for an initial deployment of the equipment. These estimates do not consider longer-term operations and maintenance costs.

Table 1. e-Park Cost Estimates

Item Description	Unit	Per Unit Cost
Static Sign	EA	$2,500
Garage Sign	EA	$20,000
Garage Vehicle Detection System	EA	$10,000
Garage Software Updates	LS	$15,000
Dynamic Message Sign (DMS)	EA	$75,000
DMS Power	EA	$20,000
DMS Site Design	EA	$10,000
System Software Updates and Enhancements	LS	$200,000
e-Park - TIM Integration	LS	$250,000
e-Park expansion - Design & Planning	LS	$100,000

Table 2. Parking Sensors Cost Estimates

Item Description	Unit	Per Unit Cost
Wireless Sensor (including wireless transmitter/receiver) *	Per Space	$2000
Wireless Sensor Control Equipment & NEMA Cabinet	EA	$6,500

* Cost per space decreases with additional sensor deployment per wireless transmitter/receiver

Table 3. Dynamic Curb Space Management Cost Estimates

Item Description	Unit	Per Unit Cost
Dynamic Message Sign on New Pole	EA	$75,000
Dynamic Message Sign on Existing Pole	EA	$20,000
Blank Out Sign	EA	$3,000
In-Pavement Lighting	Per Space	$8,000